PART 3
Village Food Production Systems

R. Michael Bourke and Bryant Allen

3.1  Staple food crops .......................................................... 194
3.2  Vegetables ................................................................. 201
3.3  Fruit ................................................................. 208
3.4  Nuts ................................................................. 215
3.5  Stimulants .............................................................. 223
3.6  Intensification of agriculture .............................................. 230
3.7  Soil fertility maintenance techniques .................................. 232
3.8  Fallowing ............................................................... 235
3.9  Soil retention and benching ............................................. 242
3.10  Tree planting and legume rotations .................................... 245
3.11  Tillage, mounds, beds and green manuring .......................... 251
3.12  Other agricultural techniques ........................................... 260
Sweet potato, sago, banana, yam, taro, Chinese taro, cassava, sugar cane, coconut, Irish potato and corn are the main staple foods eaten by rural villagers in PNG. They are grouped into three classes according to their relative importance in any given location – ‘most important food’, ‘an important food’, and ‘grown for food’ (see note, Table 3.1.1). The main vegetables, fruits, nuts and stimulants grown in PNG are described in Sections 3.2 to 3.5. Production per person of the main staple food crops is discussed in Section 2.2.

**Sweet potato** is grown by almost all rural villagers in PNG (99%), the exceptions being people living in a limited number of locations in East Sepik and Western provinces where land is subject to regular flooding. Sweet potato is the most important food for 66% of the rural population and an important food for a further 15% of the rural population. Thus it is the most important food or an important food for more than 80% of the rural population (Tables 3.1.1, 3.1.2). Sweet potato is especially important for food production at locations above 1500 m altitude. It is also important on Bougainville, New Ireland, New Britain and on coastal and inland areas in Madang, Morobe, Oro, Milne Bay and Central provinces (Figure 3.1.1, Table 2.2.2). Sweet potato is grown in a wide range of environments in PNG: from sea level to 2700 m altitude (Figure 1.13.3); in locations where the mean annual rainfall ranges from 1000 mm to 6500 mm per year; and on most landforms and soils. 

Sweet potato was introduced and adopted in the PNG highlands around 1700 AD (see History of agriculture). It displaced taro as the most important food in the highlands so that, by the early colonial period (1880–1940), it provided an estimated 40% of food energy from locally grown staple foods. This proportion grew to 66% by 2000 as production expanded (Figure 3.1.2).

**Sago** (*Metroxylon sagu*) is grown by a third of the rural population and is the most important food for 11% of people. It is grown in all provinces except East New Britain. Sago grows to an altitude of 1150 m, mostly in places with extended or permanent flooding (Figure 1.11.1), but also in local sites that are poorly drained, such as near creeks and rivers and in depressions in slopes (slump hollows). The total quantities of sago produced did not change greatly between 1960 and 2000 (Figure 2.2.3), but the relative contribution of sago to food energy has

---

1 The proportion of people for whom a particular crop is the most important or an important food crop can be compared with consumption data from the 1996 PNG Household Survey. The figures from the two sources are reasonably close. For example, sweet potato was consumed by 65% of rural villagers in the Household Survey period (Table 2.1.1), while the MASP data indicates that sweet potato is the most important food for 66% of rural villagers (Table 3.1.1).

2 Altitudinal ranges quoted in Sections 3.1 to 3.5 are mean figures for the usual range in PNG (Bourke 1989). Data were recorded in 1979–1984 before current climate change was significant (see Section 1.8). The ranges are likely to have increased slightly since the early to mid 1980s.
decreased over time. A different species, *M. salomonense*, is grown and eaten on Bougainville, but is only a minor food there.

**Banana** is grown by most rural people (96%), except by those living at very high altitudes. It is the most important food crop for 9% of the rural population. A further 32% of rural people grow it as an important food. It is eaten cooked and as uncooked fruit, depending on the variety and maturity when harvested. More fruit is eaten cooked than uncooked. Banana is grown from sea level to an altitude of 2150 m. There is a large variation in rainfall between locations where it is the most important food. It is an important food in locations with a marked dry season each year and relatively low annual rainfall, such as in coastal Central Province and the Markham and Ramu valleys in Morobe and Madang provinces (Figures 1.5.1, 1.5.2, 1.5.3). It is also an important food in locations with no rainfall seasonality and very high annual rainfall, such as some places in inland Gulf and Western provinces. Banana is also an important food where the rainfall is neither particularly high

### Table 3.1.1 Rural population growing staple food crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Most important food</th>
<th>An important food</th>
<th>Grown for food</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Population</td>
<td>Population</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>2,785,005</td>
<td>66</td>
<td>633,791</td>
</tr>
<tr>
<td>Banana</td>
<td>385,748</td>
<td>9</td>
<td>1,341,922</td>
</tr>
<tr>
<td>Colocasia taro</td>
<td>265,094</td>
<td>6</td>
<td>1,026,171</td>
</tr>
<tr>
<td>Greater yam (<em>Dioscorea alata</em>)</td>
<td>–</td>
<td>–</td>
<td>167,122</td>
</tr>
<tr>
<td>Cassava</td>
<td>42,847</td>
<td>1</td>
<td>515,140</td>
</tr>
<tr>
<td>Chinese taro</td>
<td>129,061</td>
<td>3</td>
<td>779,783</td>
</tr>
<tr>
<td>Coconut</td>
<td>1,662</td>
<td>&lt;1</td>
<td>1,488,561</td>
</tr>
<tr>
<td>Sago</td>
<td>459,831</td>
<td>11</td>
<td>145,703</td>
</tr>
<tr>
<td>Lesser yam (<em>D. esculenta</em>)</td>
<td>271,968</td>
<td>7</td>
<td>237,093</td>
</tr>
<tr>
<td>Irish potato</td>
<td>–</td>
<td>–</td>
<td>120,881</td>
</tr>
<tr>
<td>Taro (<em>Alocasia</em>)</td>
<td>–</td>
<td>–</td>
<td>315,154</td>
</tr>
<tr>
<td>Queensland arrowroot</td>
<td>–</td>
<td>–</td>
<td>184,334</td>
</tr>
<tr>
<td>Taro (<em>Amorphophallus</em>)</td>
<td>–</td>
<td>–</td>
<td>139,707</td>
</tr>
<tr>
<td>Swamp taro</td>
<td>680</td>
<td>&lt;1</td>
<td>3,466</td>
</tr>
<tr>
<td>Aerial yam (<em>D. bulbifera</em>)</td>
<td>–</td>
<td>–</td>
<td>21,538</td>
</tr>
<tr>
<td>Yam (<em>D. nummularia</em>)</td>
<td>–</td>
<td>–</td>
<td>7,391</td>
</tr>
<tr>
<td>Yam (<em>D. pentaphylla</em>)</td>
<td>–</td>
<td>–</td>
<td>3,436</td>
</tr>
</tbody>
</table>

Note: Populations were allocated to the first class (‘most important food’) where a crop occupies 33% or more of the land devoted to staple food crops in a given agricultural system; the second class (‘an important food’) where a crop occupies 11–32%; and the third class where a crop occupies 2% or more. The third class (‘grown for food’) includes the populations in the first two classes. These three classes correspond to ‘dominant staple’, ‘subdominant staple’ and ‘all staple crops’ in the MASP database (see Section 1.15). There can be either one or two crops in the class ‘most important food’ and up to six crops in the class ‘important food’. Sago and coconut are not planted in food gardens, so estimates for the population growing them were based on the estimated food energy derived from these two crops in each agricultural system.

Percentages are the proportion of the total rural population (4,192,561) who grow each crop in each class. Column totals add up to more than 100% because people are counted more than once where they grow more than one crop in that class.

Sources: NSO (2002), MASP.
### Table 3.1.2  Rural population growing staple food crops in combinations

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sweet potato</th>
<th>Sago</th>
<th>Banana</th>
<th>Lesser yam (D. esculenta)</th>
<th>Chinese taro</th>
<th>Colocasia taro</th>
<th>Cassava</th>
<th>Coconut</th>
<th>Swamp taro</th>
<th>Total population using crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potato</td>
<td>2,425,435</td>
<td>19,753</td>
<td>91,047</td>
<td>38,890</td>
<td>33,926</td>
<td>150,615</td>
<td>25,339</td>
<td>2,785,005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sago</td>
<td>19,753</td>
<td>431,283</td>
<td>8,264</td>
<td>20499</td>
<td>11,789</td>
<td>1946</td>
<td>459,831</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>91,047</td>
<td>8,264</td>
<td>252,203</td>
<td>20499</td>
<td>11,789</td>
<td>1946</td>
<td>385,748</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesser yam (D. esculenta)</td>
<td>38,890</td>
<td>20,499</td>
<td>141,473</td>
<td>17,195</td>
<td>71,106</td>
<td>271,968</td>
<td>385,748</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese taro</td>
<td>33,926</td>
<td>11,798</td>
<td>51,474</td>
<td>25,647</td>
<td>6,216</td>
<td>129,061</td>
<td>129,061</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colocasia taro</td>
<td>150,615</td>
<td>531</td>
<td>71,106</td>
<td>25,647</td>
<td>17,195</td>
<td>265,094</td>
<td>265,094</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassava</td>
<td>25,339</td>
<td>1,946</td>
<td>6,216</td>
<td>9,346</td>
<td>42,847</td>
<td>1,662</td>
<td>42,847</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconut</td>
<td>680</td>
<td>–</td>
<td>982</td>
<td>680</td>
<td></td>
<td>1,662</td>
<td>1,662</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swamp taro</td>
<td>680</td>
<td>–</td>
<td>–</td>
<td>680</td>
<td></td>
<td>–</td>
<td>680</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: These figures are for the population growing a staple food crop as their most important food crop. There can be either one or two most important (dominant) staple food crops in any agricultural system in the MASP database. The total population in this table is greater than the total rural population as people are counted twice where they grow two most important crops.

Sources: NSO (2002), MASP.
nor low but is moderately seasonal, such as on the Gazelle Peninsula in East New Britain Province. The relative importance of banana has declined over time as has that of the other Pacific staple food crops (taro, sago and yam) because of the adoption of a number of crops from the Americas, particularly sweet potato, cassava, Chinese taro and corn.

**Yam** species are grown by 60% of the rural population. Greater yam (*Dioscorea alata*) is more widely grown than lesser yam (*D. esculenta*), but greater yam is not the most important food anywhere and is an important food for only 4% of the rural population. Lesser yam is the most important food or an important food for 13% of rural villagers. It is the sole most important food in inland East Sepik Province and the southern part of Western Province (Figure 3.1.1). Greater yam is grown up to 1900 m above sea level and lesser yam up to 1550 m, but most production for both species occurs in the lowlands. Yam is usually more important in seasonally dry climates, such as inland East Sepik, but it is sometimes an important crop in locations where rainfall is well distributed throughout the year, such as the northern islands of Milne Bay Province. Total production seems to have increased between 1960 and 2000 (Figure 2.2.3), but yam’s contribution as a proportion of total staple food energy has declined over this period (Figure 3.1.2).

**Colocasia taro** is grown by most rural villagers (95%) in PNG, but it is now the most important food for only 6% of the rural population, with a further 25% growing it as an important food crop. Despite being grown by many people in most parts of PNG, by 2000 taro was the sole most important food in only a few locations, including the inland Kandrian area of West New Britain Province and most of the Telefomin area of Sandaun Province. Taro is widely grown from sea level to an altitude of 2400 m, although monocultures of taro are not grown above 2200 m. There is a wide range in annual rainfall at these locations (1500 mm to over 7000 mm). In the past, taro was the sole staple food in wetter and less seasonal environments, and where rainfall seasonality was greater it was grown with other staples. (See Figure 1.13.1 for an example of food crops grown in a location where rainfall distribution is moderately seasonal.) Prior to the introduction of sweet potato, *Colocasia* taro provided an estimated half of food energy from the staple foods. Production has declined since 1940, so that by 2000 it provided only 4% of food energy from locally grown staple foods. The use of taro as a food has been affected by taro blight (*Phytophthora colocasiae*), which caused a sudden and severe loss of production in some lowland areas after 1940. Production has also been affected by declining soil fertility associated with more intensive land use, virus infection and taro beetle damage.

**Chinese taro** is grown by more than half the rural population and is the most important food or an important food for 22% of the rural population. It is the most important food on its own or with one other crop in parts of the Baining Mountains of East New Britain Province, on the north and south of the Huon Peninsula in Morobe Province and in the Adelbert Range and Gogol Valley in Madang Province. Chinese taro grows from sea level to 2000 m altitude. It is a more important crop at intermediate altitudes and lower highland locations (500–1500 m altitude) and in places where rainfall is higher and not seasonal. Chinese taro was introduced into PNG in the late nineteenth century. It increased in importance from 1940 until the 1980s and then declined somewhat as production was affected by a root disease, possibly caused by a fungus (*Pythium* sp.).

**Cassava** is grown by more than half the rural population, but is the most important food for only 1% of rural people. It is the most important food on its own or with one other crop in some places in West New Britain Province, including the Cape Hoskins and Talasea areas, and in a number of locations in Milne Bay, including the Cape Vogel area and parts of Goodenough Island. In Milne Bay Province, more cassava is produced than any other staple food (Table 2.2.2). Cassava grows from sea level up to 1800 m, but is only an important food in the lowlands. It is an important food in locations with a wide range of rainfall, including weakly seasonal and high annual rainfall, and markedly seasonal and relatively low annual rainfall. Cassava was introduced into PNG in the nineteenth century, but only started to become widely grown after 1950. Production is expanding rapidly, with a threefold increase in its relative importance as a food between 1960 and 2000 (Figure 3.1.2).
Figure 3.1.1 Distribution of the most important staple food crops. Note: There can be either one or two ‘most important’ (dominant) staple food crops in any agricultural system in the MASP database. Source: MASP.
Figure 3.1.2  Estimated contribution to food energy of staple food crops at six different periods, 1660 to 2000 AD.

Note: The year 1660 was chosen to represent the period prior to the Long Island volcanic eruption and subsequent adoption of sweet potato by about 1700 (see History of agriculture). Sources: 1660, 1880, 1940, 1980: author's reconstruction based on historical information; 1960: Walters (1963); 2000: Bourke and Vlassak (2004).
Sugar cane is one of the most widely grown food crops in PNG, with 99% of the rural population growing it. People suck the juice from the chewed cane. Production estimates are not available that are comparable with estimates for the other staple foods. The 1996 Household Survey estimated production as 190 000 tonnes of cane per year or 35 kg/person/year (Table A2.1.1). Sugar cane is grown almost everywhere in PNG up to its altitudinal limit at 2600 m. There are no reliable data indicating trends in production over time, but this is likely to have increased with population growth.

Coconut is an important food for 36% of the rural population. It is widely grown on islands, coastal locations and some inland locations on the New Guinea mainland up to 950 m above sea level. No reliable data are available for changes over time. However, it is likely that more coconut became available for consumption following widespread planting of palms for copra production from the late 1800s (see Section 5.6).

Irish potato is grown by 16% of the rural population. It produces tubers between 700 m and 2750 m altitude in PNG. It is most commonly grown for subsistence purposes above 2000 m but is also grown for sale in parts of the highlands. Irish potato was introduced into the highlands in the 1930s. Production increased for both subsistence and sale after about 1970, but declined following an outbreak of potato late blight (a fungal disease) in early 2003.

Corn (maize) is not an important food compared with the main root crops, banana and sago. Nevertheless, it is grown by 94% of the rural population (Table 3.2.1). It grows from sea level up to 2450 m. It is often more significant in seasonally dry locations, such as the Henganofi area in Eastern Highlands Province, where it produces food about three months after planting, before other crops mature. Production in the highlands is markedly seasonal (Figure 1.13.2). Corn was introduced into PNG in the nineteenth century. It has increased in importance since then, particularly since the introduction of superior varieties after 1970.

Minor root crops. A number of minor root crops are eaten, including Queensland arrowroot and three species each of yam and taro. The quantities grown and the number of people growing these crops are generally small (Tables 2.2.1, A2.2.2). Swamp taro is the only minor root crop that is a most important food or an important food crop. It is the most important food on three atoll groups in Bougainville Province and important on a few small islands, such as those west of Manus Island.

Other grain crops. Rice is grown by villagers in a number of locations. It has been and continues to be promoted widely, but only a very limited quantity is grown (see Section 2.5). Experimental plantings of a number of other grain crops including wheat, oats and buckwheat have been made, but these crops have not been adopted by villagers.

Sources


3.2 Vegetables

About 150 plant species are grown in PNG that have an edible part which can be classed as a vegetable. These include leafy greens, plants with other edible parts such as beans, stems or flowers, spices and flavourings. Leafy green vegetables are eaten with most main meals in both urban and rural areas. Green vegetables were recorded as being eaten in 75% of households in the PNG Household Survey in 1996 (Table 2.1.1).

Data are presented here on the proportion of rural Papua New Guineans growing vegetables. Thirty species are grown by 1% or more of the rural population (Tables 3.2.1, A3.2.1). Fifteen species that are grown by more than 20% of the rural population are described below.

**Pumpkin** is grown very widely. More than 70% of the population in the highlands and lowlands eat the cooked tips of the youngest leaves and vines (Table 3.2.1, Figure 3.2.1). Pumpkin fruit is grown by 17% of the rural population and is an important food in some highlands locations, for example on the Nembi Plateau in Southern Highlands Province. Pumpkin grows in a wide range of environments and is tolerant of reduced soil fertility. The most commonly grown species (*Cucurbita moschata*) bears both leaves and fruit from sea level to 2350 m, although other minor species bear higher. Production of tips is non-seasonal. Fruit production in the intermediate and highlands altitudes is seasonal, with the best supply between September and April. Pumpkin was first introduced in 1847 to Woodlark Island in Milne Bay Province and again in 1871 on the Rai Coast of Madang Province (see History of agriculture). It was subsequently introduced to other locations and widely adopted.

**Aibika** is grown by more than 60% of the rural population. The leaves and stems are eaten cooked. *Aibika* grows from sea level to 1900 m, although it is more common in the lowlands and intermediate population (Tables 3.2.1, A3.2.1). Fifteen species that are grown by more than 20% of the rural population are described below.

---

1. See French (1986) for a comprehensive listing of major and minor vegetables in PNG. In this volume Tables 1, 2, 3 and 4 list more than 60 vegetable species according to their likely period of domestication or introduction into PNG.

2. The data are from the Mapping Agricultural Systems of PNG Project (MASP; see Section 1.15). Figures are the number of rural villagers living in agricultural systems where each vegetable was classed as important only (in contrast to the classification of staple crops, for which three categories are used – see Table 3.1.1). Because the number of plants per household is small and the plants are dispersed, relative importance is not easy to assess in the field and the figures are subject to large errors. Nevertheless, the ranking of the relative importance of the species is likely to be fairly accurate.

3. Corn was classed as a vegetable in the MASP database. However, it is generally eaten when it is semi-dried and high in food energy in PNG, so it is included with staple foods in this book (Section 3.1).
Vegetables are grown in various altitudes classes than in the highlands. Production is mildly seasonal in the highlands and lowlands, with the best supply between January and March. *Aibika* was probably introduced to PNG thousands of years ago, but may have been domesticated in the New Guinea area. Consumption was estimated as 40,000 tonnes per year in the 1996 PNG Household Survey. No data are available on production trends, but it is likely that production has not expanded as rapidly as population growth has over the past 50 years.

*Amaranthus* is grown by 60% of the rural population. The leaves are eaten cooked. Three species, all of South-East Asian origin, are common in the lowlands through to the highlands: *Amaranthus tricolor* (0–1950 m), *A. dubius* (0–1800 m) and *A. blitum* (0–2050 m). Two other species, both of which were domesticated in Central or South America, are grown at high altitudes: *A. cruentus* (1350–2300 m) and *A. caudatus* (1600–2400 m). *Amaranthus tricolor* and *A. cruentus* are probably the two most widely grown species in PNG. All species grow best where soil fertility is high and are tolerant of a wide range in rainfall. Production is markedly seasonal in the highlands (Figure 1.13.2).

*Highland pitpit* is grown by over half the rural population. The stem is consumed after cooking. It is important in the highlands, but is also commonly grown in the Momase and Southern regions. Despite its English common name, *highland pitpit* grows from sea level to 2700 m, although it is more prevalent above 500 m. It can be grown in a wide range of environments, including in low fertility soils. Production is usually non-seasonal, but it is somewhat seasonal in some highland locations. *Highland pitpit* was domesticated in the New Guinea area a long time ago.

### Table 3.2.1 Rural population growing the most important vegetables

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Rural population</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>3,957,678</td>
<td>94</td>
</tr>
<tr>
<td>Pumpkin tips</td>
<td>3,001,792</td>
<td>72</td>
</tr>
<tr>
<td><em>Aibika</em></td>
<td>2,609,661</td>
<td>62</td>
</tr>
<tr>
<td><em>Amaranthus</em></td>
<td>2,520,389</td>
<td>60</td>
</tr>
<tr>
<td>Highland pitpit</td>
<td>2,247,783</td>
<td>54</td>
</tr>
<tr>
<td>Lowland pitpit</td>
<td>2,197,462</td>
<td>52</td>
</tr>
<tr>
<td>Common bean</td>
<td>2,008,173</td>
<td>48</td>
</tr>
<tr>
<td>Cucumber</td>
<td>1,832,626</td>
<td>44</td>
</tr>
<tr>
<td>Rungia</td>
<td>1,768,336</td>
<td>42</td>
</tr>
<tr>
<td>Winged bean</td>
<td>1,654,668</td>
<td>40</td>
</tr>
<tr>
<td>Tulip</td>
<td>1,553,334</td>
<td>37</td>
</tr>
<tr>
<td>Snake bean</td>
<td>1,537,139</td>
<td>37</td>
</tr>
<tr>
<td><em>Kumu musong</em> leaves</td>
<td>1,395,531</td>
<td>33</td>
</tr>
<tr>
<td>Peanut</td>
<td>1,366,074</td>
<td>33</td>
</tr>
<tr>
<td>Oenanthe</td>
<td>1,334,096</td>
<td>32</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1,043,222</td>
<td>25</td>
</tr>
<tr>
<td>Ferns</td>
<td>758,567</td>
<td>18</td>
</tr>
<tr>
<td>Rorippa</td>
<td>751,940</td>
<td>18</td>
</tr>
<tr>
<td>Pumpkin fruit</td>
<td>691,851</td>
<td>17</td>
</tr>
<tr>
<td>Chinese cabbage(\text{a})</td>
<td>671,896</td>
<td>16</td>
</tr>
<tr>
<td>Choko leaves</td>
<td>642,636</td>
<td>15</td>
</tr>
<tr>
<td>Taro leaves</td>
<td>318,662</td>
<td>8</td>
</tr>
<tr>
<td><em>Karakap</em></td>
<td>317,321</td>
<td>8</td>
</tr>
<tr>
<td>Spring onion</td>
<td>275,192</td>
<td>7</td>
</tr>
<tr>
<td><em>Valangur</em></td>
<td>229,185</td>
<td>6</td>
</tr>
<tr>
<td>Lablab bean</td>
<td>199,520</td>
<td>5</td>
</tr>
<tr>
<td>Tomato</td>
<td>101,771</td>
<td>2</td>
</tr>
<tr>
<td>Kangkong</td>
<td>92,975</td>
<td>2</td>
</tr>
<tr>
<td><em>Kalava</em></td>
<td>77,732</td>
<td>2</td>
</tr>
<tr>
<td>Lima bean</td>
<td>57,980</td>
<td>1</td>
</tr>
</tbody>
</table>

\(\text{a}\) Chinese cabbage covers all types of oriental cabbage, including pak choi.

Sources: NSO (2002), MASP.
**Lowland pitpit** is grown by over half the rural population. The edible portion of lowland pitpit is the inflorescence (flower), which is eaten cooked. Lowland pitpit is widely grown in most environments in lowland and intermediate altitude locations. It is occasionally grown in highland valleys up to 1800 m. Production tends to be seasonal, with crops maturing sometime between November and May, particularly in January to March. It was domesticated in the New Guinea area a long time ago.

**Common bean** is grown by almost half the rural population, mostly in the highlands. The edible part is the bean, which is commonly harvested and cooked when reasonably mature. It grows from sea level to 2350 m, but it is rarely grown below 400 m altitude and is less common between 400 m and 1200 m. Beans are available throughout the year in most highlands locations, but production is seasonal with the best supply between September and April. Common bean was first introduced into PNG in the 1800s, with the first recorded introduction in 1847. Production has increased in the highlands over the past 50 years.

**Cucumber** is grown by more than 40% of the rural population in all environments up to 1950 m altitude. The edible portion is the fruit, which is eaten uncooked, often as a snack food. Cucumber is a seasonal crop. Seasonality of production is greater in the highlands than in the lowlands. It is typically planted during the drier months in May–July in the highlands, presumably to avoid fungal damage in the wetter part of the year. The period of best supply varies between locations, but is generally between November and March. Cucumber is a pre-European crop, but because new types have been introduced since 1870 it is sometimes assumed to be a post-European introduction. It was probably introduced from South-East Asia thousands of years ago.

**Rungia** is grown by more than 40% of the rural population, mainly in the highlands (Figure 3.2.2). The young leaves are edible and are usually cooked, but can be eaten raw. Rungia grows in all highland environments over an altitudinal range of 950–2700 m, although it is more common between about 1400 m and 2300 m. Production is non-seasonal. Rungia is an ancient crop in PNG and was probably domesticated in New Guinea.
**Winged bean** is grown by 40% of the rural population. The green bean is eaten in the lowlands and the green bean, young leaves and tubers are eaten in the highlands. All edible parts of the plant are eaten cooked. The crop grows from sea level to 1900 m, with tuber production over the range 1200–1900 m (Figure 1.13.3). It is most common in locations that have a seasonally drier climate in Eastern Highlands, Western Highlands, East Sepik and Simbu provinces. Production of tubers, green beans and leaves is seasonal in all environments. In parts of the highlands, tubers are produced from plantings made in the drier months of the year on well-drained sites. The seasonal pattern varies between locations. In the Kainantu area of Eastern Highlands Province, gardens intended to produce tubers are planted in May–August and tubers are harvested in January–March. Plantings intended for bean production (in mixed vegetable gardens) are made in September–December, with young leaves available in January–March and green beans in March–April. Winged bean was introduced from South-East Asia some hundreds to thousands of years ago. Plantings for tuber production in the highlands appear not to be expanding with population growth and production may have decreased in recent decades.

**Tulip** is a significant vegetable for more than a third of the rural population. The young leaves of this tree are an important vegetable, particularly in sago-growing locations where only limited areas of food gardens are planted. The leaves are eaten cooked; young flowers (cooked) and fruit (raw or cooked) are also eaten. **Tulip** is widely grown in the lowlands (Figure 3.2.3). It bears leaves, flowers and fruit from sea level to 1100 m altitude. The best supply of young leaves occurs about November–December and the best supply of fruit in December–February. **Tulip** was probably introduced from South-East Asia a long time ago.

---

4 The Tok Pisin name (*tulip*) is derived from ‘two leaf’ as the leaves are produced in pairs opposite each other. Tulip bark is used to make string bags (*bilums*).
Snake bean is grown by more than a third of the rural population in a wide range of lowland environments. It is most common in New Ireland, Oro, East New Britain, Milne Bay, Central and East Sepik provinces. It bears from sea level to 1600 m, but is uncommon above about 1000 m. The semi-mature or immature bean is cooked and eaten. The production pattern is not known, but seems to be non-seasonal. Snake bean was introduced to PNG after 1870.

Kumu musong leaves are grown by about a third of the rural population. Young leaves (cooked) and raw fruit of a number of fig-bearing trees are eaten, with kumu musong being the most commonly eaten. The cooked leaves are eaten more often than the fruit. The species grows from sea level to 2200 m, but it is less common above about 1200 m altitude. It is found in secondary forest in lowland locations and self-sows in newly cleared gardens, where it is protected from burning. It is most common in Bougainville, West New Britain, East New Britain, Manus, Sandaun, Milne Bay and Oro provinces. In the highlands the young leaves are most abundant in September–November. In Milne Bay Province, leaves are most abundant in January–March and fruit in January–February. This species was probably taken into cultivation in the New Guinea area, although it could have been introduced from Indonesia a long time ago. Consumption of both leaves and fruit has probably declined with the availability of various introduced vegetables and fruit.

Peanut is grown by about a third of the rural population. The edible part is the kernel (nut), which is eaten raw or roasted. Peanut is grown in both the lowlands and highlands, up to the crop’s altitudinal limit of 1850 m (Figure 3.2.4). The greatest volume is grown in the Markham and Ramu valleys of Morobe and Madang provinces. Production there is partly mechanised, with tractors used to till large plots. A significant proportion of the crop is sold in local markets. The Markham and Ramu valleys

---

5 The Tok Pisin name (kumu musong) means ‘hairy vegetable’, named because of raised bristles on the leaves and stems.
crop is mainly sold to middlemen who retail peanut throughout the highlands. Peanut has replaced winged bean in sweet potato–legume rotations in parts of the highlands where sweet potato is grown for long periods on the same land (see Section 3.10).

The environments where peanut is most common have a seasonally dry climate; mean annual rainfall in the range 1500–2500 mm; flat or gently sloping land; and reasonably fertile and friable soil. Production is mildly seasonal in most lowland locations, with the best supply typically in January–February, but the pattern varies between locations and between years. Production is more seasonal in Eastern Highlands Province, with the best supply in January–March.

Peanut was introduced into PNG after 1870. It was grown as an export cash crop in the Markham Valley in the 1950s and 1960s and on a smaller scale in the Goroka area in the 1960s and early 1970s. It was promoted for village production in the Markham Valley as raw material for a peanut butter factory from the early 1970s to the mid 1980s. Peanut was heavily promoted in the highlands in the 1960s to improve the protein intake of villagers. Production was estimated as 21 000 tonnes per year in the 1996 PNG Household Survey. The quantity grown has increased over the past 30 years, particularly in the Markham Valley.

**Oenanthe** is grown by about a third of the rural population, mainly in the highlands and highlands fringe. The leaves are generally eaten cooked, but occasionally people eat them raw as a snack. It is grown in a wide range of environments, but grows best in moist sites. It was grown over an altitudinal range of 1050–2700 m until about 40 years ago, but highland migrants now grow it in coastal locations. Production is non-seasonal. Oenanthe is an ancient crop that was probably domesticated in New Guinea. There are no data on production trends, but it is likely that production has declined or not kept up with population growth as other vegetables have been adopted in the highlands.

**Cabbage** is grown by a quarter of the rural population, with most production in the highlands provinces and in the mountains of Morobe Province. The head (leaves) is the edible part and is generally

---

**Figure 3.2.4** Distribution of peanut as an important vegetable. Source: MASP.
Eaten cooked. In the highlands, cabbage grows over a wide environmental range. It is grown between 700 m and 2700 m altitude, although it is more common above 1700 m. Crops are planted in some lowland locations and sold at nearby urban food markets. These plantings use modern varieties and are grown from seed, in contrast to the highlands where propagation is by the stems of old plants. Production seems to be weakly seasonal in parts of the highlands. For example, in the Kainantu area cabbage is more abundant in September–December. Cabbage was introduced into PNG after 1870. It was promoted as a cash crop for local markets in the highlands from the 1950s onwards. Production has increased rapidly over the past 50 years, particularly at high-altitude locations.

**Sources**


3.3 Fruit

About 100 plant species that have an edible fruit are grown in PNG.1 Many fruits are grown in small quantities in only a limited number of locations. Production of fresh fruit (excluding banana) was estimated as 59,000 tonnes per year by the 1996 PNG Household Survey. More than 20 fruit species are grown in sufficient quantity to be classified as ‘important’ (Tables 3.3.1, A3.3.1).2 Half are indigenous species and the others were introduced by foreigners during the nineteenth century. Ten of these ‘important’ species, which are grown by more than 10% of the rural population, are described below.3

Four fruits – mandarin, mango, mangosteen and rambutan – have significant potential for expanded production for the domestic market, particularly for sale in the highlands and in major urban centres.4 Five well-established species could also be developed and marketed in greater volume. These are avocado, orange, pawpaw, pineapple and ton. Another group have some potential for further production and marketing. In the lowlands, these are carambola, custard apple (sweetsop), durian, guava, langsat, longan, pomelo, pulasan, rockmelon (cantaloupe) and watermelon. Highland species in this group are banana passionfruit, cape gooseberry, cherimoya, naranjilla, purple passionfruit, black raspberry, strawberry, *zuga pru* and tamarillo (tree tomato).

Pawpaw is an important fruit for about two-thirds of the rural population (Table 3.3.1). The ripe fruit is consumed, often as a snack while people work in food gardens. The immature fruit is occasionally cooked and eaten, particularly as an emergency food. This happened, for example, during the 1997 drought. Pawpaw is less commonly eaten in highlands locations. Many plants grow in newly established food gardens after seed is dispersed by animals, but some trees are deliberately planted. Pawpaw is grown in most lowland environments and bears from sea level to 1700 m altitude (Figure

---

1 See French (1986) for a comprehensive listing of fruit in PNG. In this volume Tables 2, 3 and 4 list more than 60 fruit species according to their likely period of domestication or introduction into PNG.

2 The data are from the Mapping Agricultural Systems of PNG Project (MASP; see Section 1.15). Figures are the number of rural villagers living in agricultural systems where each fruit species was classed as important only (in contrast to the classification of staple crops, for which three categories are used – see Table 3.1.1). Because the number of plants per household is small and the plants are dispersed, relative importance is not easy to assess in the field and the figures are subject to large errors. Nevertheless, the ranking of the relative importance of the species is likely to be fairly accurate.

3 Banana was classed as a staple in the MASP database as banana fruit are more often eaten cooked than uncooked (Section 3.1). Breadfruit is described under nuts (Section 3.4).

4 See papers presented at the Papua New Guinea Fruit and Nut Workshop, University of Vudal in 2005, in particular those on introduced fruit by R.M. Bourke, T. Nevenimo and B.J. Watson. These papers are scheduled to be published by NARI.
1.13.3), although fruit are of poorer quality and less sweet when grown above 1200 m altitude. Production is non-seasonal in the lowlands and intermediate altitude classes. Fruit is available seasonally in Eastern Highlands Province, with fruit ripening in August–October. The first recorded introduction of pawpaw was to the Rai Coast of Madang Province in 1871, where it was rapidly adopted (see History of agriculture). As with other introduced foods, there are likely to have been multiple introductions at different locations. Pawpaw fruit is commonly sold in lowland fresh food markets and sometimes in urban food stores.

*Marita pandanus* is an important fruit for almost 60% of the rural population. The fruit is cylindrical in shape, up to a metre long, usually red in colour, but sometimes yellow. The pericarp (outer layer) of the fruit is rich in oil. The fruit is cut into pieces then boiled, roasted or cooked in a stone oven. The pulp and seeds are removed from the core, mashed with water and strained to produce a thick, rich red sauce used to flavour other foods such as sweet potato, banana and green vegetables. Marita is widely planted on the New Guinea mainland, but is uncommon in the Islands Region (Figure 3.3.1). It is not usually grown near the ocean, but grows from low altitudes in inland locations (10–50 m altitude) up to 1700 m. It is most common over the range 500–1500 m above sea level. It is an important food in intermediate altitude locations where coconut does not bear well and vegetable oil or animal fat in villagers’ diets is limited. Marita grows best in moist locations, often under shade, and tolerates waterlogged soils. It is frequently grown with other fruit and nut bearing trees in ‘orchards’ on fallow land in secondary forest.

There is a clear relationship between the length of the marita fruiting season and altitude in PNG. Near sea level, production is continuous and non-seasonal. With increasing altitude, the producing period becomes shorter. Near the top of its altitudinal range at 1500–1700 m, fruit ripens over a four-month period, usually January to April (Figure 1.13.4). Marita was domesticated in New Guinea a long time ago. It is commonly sold in fresh food markets in the producing areas, particularly in the highlands, although production has probably not kept pace with population growth.

**Pineapple** is grown by more than half the rural population. It is widely grown in most environments in the lowlands, intermediate altitudes and lower highland valleys. The fruit is eaten raw. Pineapple grows and bears up to 1800 m altitude, but the smooth leaf type is more common in the highlands above 1500 m and the rough leaf type is more common in the lowlands and intermediate altitude classes. The sweetest fruit is grown over the altitudinal range 400–1200 m. Production is seasonal, with the best supply usually between October and March,

### Table 3.3.1 Rural population growing the most important fruit

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Rural population</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pawpaw</td>
<td>2,642,804</td>
<td>63</td>
</tr>
<tr>
<td><em>Marita pandanus</em></td>
<td>2,465,476</td>
<td>59</td>
</tr>
<tr>
<td>Pineapple</td>
<td>2,197,921</td>
<td>52</td>
</tr>
<tr>
<td>Mango</td>
<td>1,962,731</td>
<td>47</td>
</tr>
<tr>
<td>Watermelon</td>
<td>1,090,010</td>
<td>26</td>
</tr>
<tr>
<td>Ton</td>
<td>1,046,111</td>
<td>25</td>
</tr>
<tr>
<td>Malay apple</td>
<td>985,150</td>
<td>23</td>
</tr>
<tr>
<td>Guava</td>
<td>723,650</td>
<td>17</td>
</tr>
<tr>
<td>Orange</td>
<td>503,488</td>
<td>12</td>
</tr>
<tr>
<td>Passionfruit</td>
<td>327,880</td>
<td>8</td>
</tr>
<tr>
<td>Avocado</td>
<td>245,103</td>
<td>6</td>
</tr>
<tr>
<td>Bukabuk</td>
<td>231,559</td>
<td>6</td>
</tr>
<tr>
<td>Mon</td>
<td>217,778</td>
<td>5</td>
</tr>
<tr>
<td>Golden apple</td>
<td>179,985</td>
<td>4</td>
</tr>
<tr>
<td>Mandarin</td>
<td>175,972</td>
<td>4</td>
</tr>
<tr>
<td>Banana passionfruit</td>
<td>127,472</td>
<td>3</td>
</tr>
<tr>
<td>Parartocarpus</td>
<td>102,484</td>
<td>2</td>
</tr>
<tr>
<td>Rukam</td>
<td>100,966</td>
<td>2</td>
</tr>
<tr>
<td>Tamarillo</td>
<td>74,522</td>
<td>2</td>
</tr>
<tr>
<td>Pomelo</td>
<td>61,851</td>
<td>1</td>
</tr>
<tr>
<td>Pouteria</td>
<td>56,591</td>
<td>1</td>
</tr>
<tr>
<td>Coastal pandanus</td>
<td>55,367</td>
<td>1</td>
</tr>
</tbody>
</table>

Sources: NSO (2002), MASP.
although the period of peak production varies from year to year. Pineapple was introduced after 1870. Fruit is commonly sold in fresh food markets in the lowlands. It has become a popular fruit in urban centres in recent decades and production for sale has subsequently increased. This is partly because pineapple is less easily damaged than softer fruits, the poor handling of which inhibits sales in distant urban markets.

*Mango* (*Mangifera indica*) is grown by almost half the rural population and is widespread in most lowland locations. The fresh fruit is eaten either partly or fully ripe. Mango bears from sea level to 1600 m altitude, although the quality of fruit is poorer above about 1200 m. Mango bears more, better quality fruit in lowland locations that have a marked dry season each year, such as coastal Central Province, southern Western Province, the Rabaraba–Cape Vogel area of Milne Bay Province, the upper Markham Valley, the Sialum area on the Huon Peninsula, and north-eastern parts of the Gazelle Peninsula of East New Britain Province (Figure 3.3.2).

Production is markedly seasonal, with most fruit ripening from October to January. It is commonly sold in fresh food markets in the producing areas. Significant quantities are transported from the Markham and Ramu valleys into the highlands for sale. Mango was introduced to PNG after 1870. Virtually all trees in PNG have been derived from seedlings rather than from selected clones. Thus fruit quality is only moderately high. A number of selected clones are available from research stations, but planting material has not been widely distributed.

An indigenous species, *Mangifera minor*, is also grown and eaten in PNG. It is more common in locations where rainfall is continuous throughout the year. In these places, such as the interior of New Britain, the introduced mango does not bear. Total

5 See Bourke et al. (2004:27–29) for a detailed discussion on variation in the production pattern of *Mangifera indica* between locations in PNG and the relationship with environmental factors, particularly rainfall.
production of the indigenous species is much less than that of *M. indica*. The indigenous species has fibrous fruit with a strong turpentine flavour.

**Watermelon** is grown by about a quarter of the rural population. The flesh is eaten raw. It is most common in lowland locations with a marked dry season each year, such as coastal Central Province, parts of Milne Bay Province, the Gazelle Peninsula in East New Britain Province, and the Markham and Ramu valleys. It is uncommon in locations that are continuously wet throughout the year. Watermelon grows from sea level to 1700 m, but is uncommon above 1200 m altitude. Production is seasonal, with the best supply occurring between November and March. It was first introduced to Woodlark Island in 1847, with the next recorded introduction to the Rai Coast in Madang Province in 1871. It was rapidly adopted in seasonally dry lowland environments. It is commonly sold in lowland markets and significant quantities are transported from the Ramu and Markham valleys to the highlands for sale during the producing season.

*Ton* is an indigenous fruit from large trees that belong to the same botanical family (Sapindaceae) as the litchi, rambutan and pulasan. *Ton* trees are planted from seed in fallow land, along paths and on the edges of villages. The fruit is eaten raw and has a similar taste and texture to litchi. It is consumed by about a quarter of the rural population. *Ton* is common along the New Guinea north coast and in the Islands Region (Figure 3.3.3). The tree grows from sea level to about 1700 m, but the fruit is eaten only up to 800 m. Above that altitude, villagers say that the tree bears fruit, but the fruit is ‘not sweet’ and they do not eat it. Fruit is available seasonally for about two or three months sometime between August and April each year, most commonly in the period November–February. *Ton* was domesticated in the New Guinea area a long time ago. A small quantity of fruit is sold in markets in the Momase

---

6 *Taun* is an alternative spelling for its common name, but *ton* is adopted here as this better reflects the pronunciation in Tok Pisin.
and Islands regions. Some observers consider that *ton* has excellent potential for commercialisation for sale within PNG and possibly overseas.

**Malay apple** is eaten raw and is grown by about a quarter of the rural population. Malay apple grows from sea level to 850 m altitude. It is common in coastal and inland locations in the Islands Region and Milne Bay Province (Figure 3.3.4). A related species, watery rose apple, is grown and eaten occasionally in the lowlands and intermediate altitude classes up to 1600 m, mainly in New Ireland, East New Britain, West New Britain and Milne Bay provinces. Malay apple ripens sometime between September and February, particularly in December–January, but the seasonal production pattern is not well defined. It was probably introduced from South-East Asia some thousands of years ago. In the producing areas it is commonly sold in fresh food markets, where it is a popular fruit.

**Guava** is grown by about a sixth of the population. Fresh fruit is eaten when partially or fully mature, often by children. Guava grows to 1850 m altitude. It is a minor fruit in many lowland environments and is rarely grown in the highlands. Fruiting is non-seasonal in the lowlands, but seasonal in Eastern Highlands Province, with the best supply in February–May. The first documented introduction of guava to PNG is to the Duke of York Islands in 1875. Minor quantities are marketed in lowland fresh food markets.

**Orange and mandarin** are grown by about a sixth of the population. Fruit is consumed fresh. Mandarin is a convenient snack food as the fruit is easy to peel and less messy than oranges. Orange is grown in small quantities in the lowlands, intermediate altitudes and lower highland valleys. It is more common in the lowlands south of about 5° latitude. Mandarin is grown in the same broad environment, but is more common at intermediate altitudes. Both species bear from sea level to 1800 m altitude; the best fruit are produced at 800–1400 m.

The main producing season for orange is April to August, but the pattern varies a lot from year to year and fruit is available throughout most of the

---

**Figure 3.3.3** Distribution of *ton* as an important fruit. Source: MASP.
year. Mandarin has a more well-defined producing season, with most fruit maturing in May–August. Orange, mandarin and other citrus were introduced after 1870, with the first recorded introduction for orange to the Rai Coast in 1873 and to the Duke of York Islands in 1875. Limited quantities of orange are sold in lowland and highland fresh food markets. Greater quantities of mandarin are grown for sale in intermediate altitudes. It is a significant cash crop for villagers in some locations, for example, in the Arona Valley in Eastern Highlands Province, in the Bulolo–Wau area and parts of the Huon Peninsula in Morobe Province, and the Kokoda Trail area of Central Province.

Passionfruit is grown by about a tenth of the rural population, mostly in the highlands. Five types of passionfruit are grown: *suga prut*, purple passionfruit, banana passionfruit, lowland yellow passionfruit and granadilla. The fruit is eaten fresh. All five species were introduced after 1870. *Suga prut* (highland yellow passionfruit) is the most commonly grown. It is grown in the highlands over an altitudinal range of 1350–2350 m. It was a minor fruit until the mid 1970s, but its popularity has increased rapidly since then because the flesh is sweet and sweet fruits are valued by highlanders. Production is non-seasonal. Fruit is commonly sold in highland and some lowland markets.

Purple passionfruit was a village cash crop in the highlands from 1952 to 1974. Around 400–700 tonnes of fruit was purchased each year in Goroka and Mount Hagen and pulp was extracted in a factory in Goroka and exported to Australia. The exports collapsed in 1974 and production declined so that purple passionfruit is now a minor fruit. Purple passionfruit is grown from 800 m to 2300 m altitude. Production is markedly seasonal with fruit available in January–April. Some fruit is sold in highland markets.

Banana passionfruit is a wild species that grows at high altitudes. It fruits from 1850 m to 2800 m altitude. Fruit is gathered for consumption or sale in highland and some lowland markets. Production seems to be non-seasonal.
Lowland yellow passionfruit is a minor fruit that is grown from sea level to 850 m altitude. Fruit is occasionally sold in lowland fresh food markets. Fruiting is non-seasonal.

Granadilla produces a large fruit, typically 15–25 cm long. It is a minor fruit in the lowlands and grows from sea level to 1000 m. Fruiting is non-seasonal. Small quantities of fruit are sold in some lowland markets.

**Sources**


3.4 Nuts

More than 40 plant species that have an edible nut are grown in PNG.¹ Many nuts are grown in small quantities in a limited number of locations. Thirteen species are grown in sufficient quantity to be classified as ‘important’, all of which are indigenous (Tables 3.4.1, A3.4.1).² Ten of these ‘important’ species, which are grown by more than 8% of the rural population, are described below.³ A number of nut crops have been introduced since 1870 and three of these – macadamia, cashew and pecan – are grown, but all are very minor foods.

Five of the species discussed here are considered as having significant potential for commercial development for both the domestic and export market. These are galip, planted karuka, okari, pao and sea almond.

¹ See French (1986) for a comprehensive listing of edible nuts in PNG. In this volume Tables 2, 3 and 4 list 22 nut species according to their likely period of domestication or introduction into PNG.

² The data are from the Mapping Agricultural Systems of PNG Project (MASP; see Section 1.15). Figures are the number of rural villagers living in agricultural systems where each nut species was classed as important only (in contrast to the classification of staple crops, for which three categories are used – see Table 3.1.1). Because the number of plants per household is small and the plants are dispersed, relative importance is not easy to assess in the field and the figures are subject to large errors. Nevertheless, the ranking of the relative importance of the species is likely to be fairly accurate.

³ Coconut is considered under staples (Section 3.1) and peanut is included with vegetables (Section 3.2), although both could be classed as a nut.

Three of these are sold as processed nuts in modern packaging in Vanuatu. In the medium to long term, the indigenous edible nuts could be worth many hundreds of millions of kina to the PNG economy (see Section 5.3).

Breadfruit is grown by more than half the rural population (Table 3.4.1). The flesh and seed (nut) are eaten after being cooked, commonly in a stone oven, but there are numerous ways of cooking and preparing breadfruit.⁴ The tree is grown in all lowland environments in PNG up to 1250 m altitude and it is one of the most common food-bearing trees in the lowlands. Both the flesh and nut are eaten on the smaller islands off the north coast of New Guinea, the Bismarck Archipelago, the Solomon chain, and throughout Milne Bay Province. In contrast, only the nut is eaten on the mainland of New Guinea, with some exceptions, such as the mainland of Milne Bay Province and some coastal locations in Central Province. Types of breadfruit with few or no seeds have been introduced into PNG from Polynesia over the past century, but these remain uncommon.

Breadfruit does not produce fruit in a regular manner in most of PNG and the production period varies from year to year. The exception is in Milne Bay Province at 8–12° south where the producing period commences in October or November.

⁴ Other uses from the tree include medicine, timber, fuel wood, canoe construction, clothing, rope, wrapping and adhesive.
Production is likely to be seasonal at locations south of about 8° latitude, but is irregular at most locations in PNG that are nearer the equator. Such a pattern results from the changes in daylength during the year with increasing distance from the equator.

Breadfruit is an ancient crop in PNG and was probably domesticated in New Guinea. Even today, people select the best trees from which to collect seed for replanting. Plants are sometimes propagated from root shoots so as to maintain high-yielding trees. Poor-yielding trees are cut down to prevent them cross-fertilising high-yielding trees. Nuts are commonly sold in markets in Momase Region and fruit in markets on islands. Breadfruit is probably now a less important food than before the widespread adoption of sweet potato, cassava and Chinese taro in the lowlands.

**Planted karuka** (*Pandanus julianettii*), and a wild species (*P. brosimos*), are the most important of a number of pandanus species that produce edible nuts in PNG, all of which grow above 1000 m. Planted karuka is grown by almost half the rural population. It grows in an altitudinal range of 1800–2600 m (Figure 1.13.3), confined mainly to a band in the central and fringe highlands and the Huon Peninsula (Figure 3.4.1).

Kernels (nuts) of karuka pandanus are an important seasonal dietary item for those living at high altitudes in the New Guinea highlands. The kernel is eaten raw or cooked by roasting it in an open fire, baking in hot ashes or steaming in a stone oven. The nuts can be preserved by drying and smoking above a house fire. For longer storage, the kernels are extracted and stored in baskets hung in house rafters. Smoke from the house fires imparts a characteristic flavour to the nuts. When the nuts are in season, entire households and their domestic pigs migrate from villages to high-altitude bush camps for weeks to harvest and eat the nuts. When sweet potato is scarce because of frost damage or other causes, villagers depend on karuka if it is in season. The nuts are highly nutritious and provide both protein and oil, the two components that tend to be deficient in highlanders’ diets.

Production is irregular in the western part of the highlands, where rainfall seasonality is slight or absent. In the eastern part of the highlands, where rainfall is seasonally distributed, production is more seasonal, but there is still large year-to-year variation in the harvest size. In any year the producing period also varies between locations. The nuts are most likely to mature during January–March, but nuts may mature during any month of the year. After periods of soil moisture stress or drought, the producing periods coincide at most locations. The biggest harvests tend to follow major droughts.

Planted karuka is endemic to New Guinea and was domesticated there, probably from the wild species (*P. brosimos*). Surveys indicate that a significant proportion of village trees are immature, which suggests that people are making new plantings. Karuka nuts are commonly sold in highland markets, either cooked or uncooked.

**Wild karuka** (*Pandanus brosimos*) is eaten by about a third of the rural population. The kernel (nut) of wild karuka is an important food for villagers living at high altitudes in New Guinea, although it is not as important as planted karuka. Kernels are eaten both cooked and raw. This species is widespread in high-altitude locations (2400–3100 m) in the central and fringe highlands and the Huon Peninsula. Although

<table>
<thead>
<tr>
<th>Edible nut</th>
<th>Population</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breadfruit</strong></td>
<td>2,335,541</td>
<td>56</td>
</tr>
<tr>
<td>Karuka, planted</td>
<td>1,998,454</td>
<td>48</td>
</tr>
<tr>
<td>Karuka, wild</td>
<td>1,343,205</td>
<td>32</td>
</tr>
<tr>
<td>Galip (<em>Canarium spp.</em>)</td>
<td>1,314,173</td>
<td>31</td>
</tr>
<tr>
<td>Polynesian chestnut (<em>aiia</em>)</td>
<td>636,749</td>
<td>15</td>
</tr>
<tr>
<td>Sea almond (<em>tais</em>)</td>
<td>545,993</td>
<td>13</td>
</tr>
<tr>
<td>Pao (<em>Barringtonia procera</em>)</td>
<td>531,634</td>
<td>13</td>
</tr>
<tr>
<td>Okari (<em>Terminalia kaembbachii</em>)</td>
<td>501,609</td>
<td>12</td>
</tr>
<tr>
<td>Okari (<em>Terminalia impediens</em>)</td>
<td>352,130</td>
<td>8</td>
</tr>
<tr>
<td>Sis (<em>solomon</em>)</td>
<td>323,675</td>
<td>8</td>
</tr>
<tr>
<td>Castanopsis</td>
<td>301,214</td>
<td>7</td>
</tr>
<tr>
<td>Dausia</td>
<td>90,063</td>
<td>2</td>
</tr>
<tr>
<td>Tulip</td>
<td>68,619</td>
<td>2</td>
</tr>
</tbody>
</table>

Sources: NSO (2002), MASP
its range overlaps with planted *karuka*, wild *karuka* grows above 2800 m, the altitudinal limit of settlement and food gardens (see Section 1.10). When fruit matures, villagers migrate to high altitudes to harvest the fruit and extract the nuts.

Nuts are produced in an unpredictable manner. They are most likely to mature in January–February, but may mature in any month. The producing period may coincide with that of planted *karuka* in nearby locations at lower altitudes, but not always. Wild *karuka* is endemic to New Guinea and is not found elsewhere. Nuts have not been recorded in the main highland markets, but it is possible that they are sold in some high-altitude locations.

*Galip* (*Canarium* spp.) is grown by almost a third of the rural population. A number of species bear edible nuts in PNG, with *Canarium indicum* being the most important. The kernel of *galip* is generally eaten raw, and occasionally roasted. Trees are grown from protected self-sown seedlings or planted seedlings. It is estimated that there are one million edible *Canarium* trees in PNG, with kernel production of 7200 tonnes per year. *Galip* grows from sea level to 700 m altitude and is widely grown in forested locations below 500 m altitude along the north coast and inland areas of the New Guinea mainland and in the Islands Region (Figure 3.4.2).

Nuts are produced seasonally with the producing period typically about three months long. Latitude has a strong influence on the start of the harvesting season. Nuts usually mature from April–June onwards at 4–6° south, with the harvest commencing progressively later at locations further from the equator.

*Canarium indicum* is the oldest domesticated nut species in PNG. It has been identified in the archaeological record as early as 14 000 years ago, several thousand years before the start of arable agriculture in New Guinea (see History of agriculture). The distribution of this species in the archaeological record suggests that domesticated varieties were being moved between islands thousands of years ago. It is a direct link to an earlier era of hunting and gathering in New Guinea’s past.
There are indications that consumption is declining. For example, puddings made from *galip* and taro in some locations such as Bougainville Province were once common but are rarely seen now. Nuts are traded in some locations, for example, from Boisa Island to villages near the mouth of the Ramu River in Madang Province (in exchange for sago); on Vokeo Island north-east of Wewak, East Sepik Province; and Siassi Islands in Morobe Province. Again, there are indications that this trade has diminished in recent decades (see Box 5.3).

Potential for commercialisation of *galip* nut is considerable and the potential international market for *galip* nut is large. One unsuccessful attempt to commercialise *galip* was made in the Kandrian area of West New Britain Province. This was done as part of the AusAID-funded Kandrian Gloucester Integrated Development Project in the 1990s and the operation failed as soon as donor support ceased.

**Polynesian chestnut (aila)** is grown by about a sixth of the rural population. It grows from sea level to 400 m altitude on the mainland and island provinces. It is most important in Milne Bay Province, where it is available seasonally when garden food is scarce, and also in the Islands Region. The seed of Polynesian chestnut is cooked prior to consumption by baking the entire fruit or boiling or roasting the nut.

Production in PNG is non-seasonal at locations close to the equator, but fruit is not available in all months. In Milne Bay Province (8–12° south), fruit ripens seasonally over 2–3 months, especially in November–February. Polynesian chestnut has been eaten in PNG for a long time. It seems to have become a less important food since the widespread adoption of sweet potato and cassava over the past 60 years. The decline in importance of the nut as a food is a Pacific-wide phenomenon. Cooked nuts are sold occasionally in markets in the islands.

**Sea almond (talis)** is grown by 13% of the rural population, but this figure overestimates its importance as it is a very minor food in most locations where it grows. The small kernel is eaten raw or roasted, mostly by people who live near

![Distribution of galip as an important nut. Source: MASP.](image)
the seashore, particularly children. Sea almond is widely distributed along the coast of all lowland provinces up to 300 m altitude and is most common in Milne Bay Province and the Islands Region. It is sometimes planted in coastal and inland villages and has also been planted as a street tree in a number of PNG towns.

Sea almond fruits sporadically throughout the year near the equator but is seasonal at locations further from the equator, where fruit ripens sometime between November and May. In Milne Bay Province the producing period is reported by villagers as 2–3 months long, with fruiting most commonly around December–February.

Sea almond has a widespread natural distribution in near-coastal areas of the Indian Ocean, throughout coastal tropical Asia and the Pacific Ocean. It has been eaten in PNG for a long time. The fact that superior types exist, including soft-shelled types on Iwa Island in Milne Bay Province and on Mussau Island north of New Ireland, indicate that people have selected superior varieties over a long period. Nuts are not sold in PNG markets. The species has potential for commercialisation for sale within PNG and overseas. It is processed for sale in Vanuatu.

_Pao_ (Barringtonia procera) is grown by 13% of the rural population. The kernel is eaten either raw or roasted. _Pao_ is planted in coastal and inland locations up to an altitude of 500 m. It has a limited distribution within PNG, being confined mainly to the Islands Region (Figure 3.4.3). _Pao_ was probably introduced to PNG from Solomon Islands. It is increasing in importance and since about 1960 has been planted at other locations on New Britain and the New Guinea mainland, including coastal and island locations in Morobe, Madang, East Sepik, Sandaun and Milne Bay provinces.

_Pao_ fruits intermittently in a non-seasonal manner. It is an important edible nut in the Islands Region and is sold in markets there. Edible _Barringtonia_ species have been commercialised in Vanuatu, where there is high demand for the nuts. _Barringtonia procera_ in particular has considerable potential as a cash crop for both the domestic and export markets, given

Figure 3.4.3 Distribution of _pao_ as an important nut. _Source_: MASP.
the small area required per tree, a relatively short time to maturity and the possibility of growing it as a horticultural crop rather than relying on naturally occurring forest trees. Two related species, *B. novae-hiberniae* and *B. edulis*, bear edible nuts in PNG, but they are very minor foods.

**Okari** (*Terminalia kaernbachii*) is grown by about 12% of the rural population. The name *okari* is used in Motu (and now English) in the Southern Region for *T. kaernbachii*, but it has been adopted in Tok Pisin as the name for the related *T. impediens*. The former is a more important food and has significant commercial potential, whereas the latter is a minor food with limited commercial potential.

**Okari** (*T. kaernbachii*) nuts are eaten raw. Trees are preserved in garden land or planted. Villagers either harvest nuts from trees or, more commonly, collect the fallen fruit. **Okari** is mainly distributed in the Southern Region but also occurs in adjacent locations in Southern Highlands, Simbu and Morobe provinces; in Manus Province; and in West New Britain from the Aria River west to Cape Gloucester (Figure 3.4.4).

**Okari** was domesticated in New Guinea. Over the past 50 years the tree has been introduced to other locations in PNG, including East New Britain and New Ireland. It grows from sea level to 1100 m altitude. The species is uncommon near the ocean in its natural range in southern New Guinea, although it does bear near the ocean at, for example, Keravat on New Britain and Kavieng on New Ireland. It may be that the best production occurs where the diurnal temperature range (the difference in temperature between day and night) is greater.

The producing period is fairly constant from year to year and lasts for 2–4 months, although the size of the annual harvest is variable. There is a clear relationship between latitude and the start of the harvesting period, with the producing period commencing later at locations further south from the equator. This is presumably caused by differences in daylength, although it could also be related to seasonal temperature changes. Nuts mature from about March at 4° south and later at locations further south.

**Figure 3.4.4** Distribution of *okari* as an important nut. Source: MASP.
Okari nuts are eaten in the producing region and some are sold in local and regional markets, including in Port Moresby. Okari nut has considerable potential for sales within PNG and overseas. A local non-government organisation, Okari Ecoenterprises, attempted to commercialise okari nut on the Managalas Plateau in Oro Province in the early to mid 1990s. Nuts were collected from planted and self-sown trees and transported to Port Moresby where they were sold through Associated Distributors. The operation failed after a few years because of an irregular supply of nuts.

Okari *(Terminalia impediens)* is grown by about 8% of rural villagers, but this figure overemphasises its importance as it is a minor food where it is grown. The kernel is eaten raw. Trees are not planted, but are preserved when land is cleared for gardening. This species grows up to 1000 m altitude and is common in East Sepik, Sandaun and Madang provinces (Figure 3.4.4). *Terminalia impediens* was domesticated in New Guinea. Production is not expanding. The species is not sold in fresh food markets and probably has less commercial potential than the closely related *T. kaernbachii* because the nuts are smaller.

Sis *(solomon)* *(Pangium edule)* is grown by 8% of the rural population and is widely eaten in PNG, despite requiring extensive processing to remove a poison. The seed is eaten only after being washed in water, then roasted and fermented. *Pangium edule* is known by the common name *sis* in some locations in Momase Region and *solomon* in parts of New Britain. It is grown in most provinces, being most commonly eaten in Milne Bay. *Sis* grows from sea level to 1050 m altitude in both coastal and inland lowland locations. Production is seasonal, commonly starting around May or June and lasting 2–4 months. *Sis* is an ancient crop in PNG. It was probably a more important food before the widespread adoption of introduced foods including sweet potato, cassava and Chinese taro. It is occasionally sold in fresh food markets. Because of the extensive processing required to make the nut safe for human consumption, it is unlikely that this species has any commercial potential.

**Sources**


3.5 Stimulants

The term ‘stimulant’ here means a group of substances that people use to alter their perception, mood, consciousness or behaviour. The substances covered (tobacco, betel nut, marijuana, coffee, tea, locally brewed alcohol, kava and other psychoactive plants) are not all stimulants in a medical sense, but this name is less emotive than terms such as ‘narcotic’ or ‘drug’. The more precise term is ‘psychoactive drug’.1 These include drugs used as anaesthetics, painkillers, psychiatric medication and for recreation. Globally, the most common recreational psychoactive drugs are alcohol (in the form of beer, wine or spirits), nicotine (tobacco), caffeine (coffee, tea and many aerated soft drinks), betel nut and marijuana.

Six plant species are grown in sufficient quantity in PNG to be classified as ‘important’ stimulants (Tables 3.5.1, A3.5.1).2 Tobacco and betel nut are the most widely consumed. Because it is illegal to produce or sell marijuana, it was not possible to collect reliable data on its distribution. It is also illegal to sell locally produced alcohol without a licence, but consumption of tobacco, betel nut and kava is not illegal. There is negligible or no use of other recreational drugs such as amphetamines (speed), heroin, cocaine, ecstasy or LSD by Papua New Guineans in PNG.

Tobacco grows in most environments in PNG, from sea level to 2400 m (Figure 3.5.1). Most of the rural population live in locations where tobacco is commonly grown (Table 3.5.1). A large proportion of the adult male population, fewer women and many adolescent children, smoke tobacco. People use home-grown tobacco, and self-rolled and factory-manufactured cigarettes made from imported tobacco. Consumption of home-grown tobacco is probably much greater than that of manufactured cigarettes, but accurate data are not available. Locally grown tobacco is usually smoked as cigarettes rolled in newspaper, or rolled tobacco leaf. It is sometimes smoked in bamboo or wooden pipes and very occasionally eaten (for ritual purposes). It is uncommon on atolls and is not grown where most of the population are members of the Seventh-Day

---

1 A psychoactive drug is a chemical substance that acts primarily upon the central nervous system, where it alters brain function, resulting in temporary changes in perception, mood, consciousness or behaviour. These drugs may be used recreationally to purposefully alter one’s consciousness, for ritual or spiritual purposes, or as medication.

2 The data are from the Mapping Agricultural Systems of PNG Project (MASP; see Section 1.15). Figures are the number of rural villagers living in agricultural systems where each stimulant was classed as important only (in contrast to the classification of staple crops, for which three categories are used – see Table 3.1.1). Because the number of plants per household is small and the plants are dispersed, relative importance is not easy to assess in the field and the figures are subject to large errors. Nevertheless, the ranking of the relative importance of the species is likely to be fairly accurate. The term ‘narcotic’ was used in the MASP database for betel nut, tobacco and kava.
Adventist Church. Towards the top of its altitudinal range it is often grown under the eaves of houses, presumably to protect plants from the cold.

Production is non-seasonal in the highlands. Estimates of production are not available, but it is likely that production has kept pace with population growth in remote locations. It may not have done so where people have greater access to manufactured cigarettes and imported tobacco. Sales in local and distant markets are a significant source of cash income for some people (see Section 5.17).

Betel nut (*Areca catechu*) grows in most lowland environments from sea level to 1100 m (Figures 3.5.2, 1.13.3). It is grown by more than half the rural population. This figure understates the proportion of adults who consume betel nut because significant quantities are traded into the highlands, where it does not grow. Betel nut is usually consumed with the catkins,3 leaves or stems of the lowland betel pepper plant and less commonly with highland betel pepper (see below), together with slaked lime made from cooked and crushed seashells or coral. People sometimes chew betel nut on its own. It is an everyday substance and is commonly given as a small gift, but is also used in more formal situations, such as ceremonies.

Betel nut was domesticated in South-East Asia and introduced to PNG some thousands of years ago. Production has increased rapidly in recent decades, partly for local consumption, but especially for sale in urban centres and the highlands.

The supply is continuous throughout the year, but varies seasonally. In general the best supply occurs between April and August and the worst supply between September and December. There are some regional differences and the supply is less seasonal in Madang and more seasonal in Lae. The best supply in the Madang area occurs in January–March and this is the period of poorest supply in the Port Moresby area. A disease of unknown cause is destroying betel nut in the Markham Valley. It started to spread in about 2003 and the supply had almost ceased there by mid 2007.

Betel nut is a major cash crop in many lowland locations and significant quantities are transported to Port Moresby, Lae, other urban centres, mine sites and the highlands (Figures 5.1.1, 5.17.2). The 1996 Household Survey estimated production at 49 000 tonnes per year and consumption of betel nut, pepper and lime at 11 kg/person/year, with consumption levels similar in both urban and rural locations (Table A2.1.1).

**Lowland betel pepper** is grown by more than half the rural population. It is only consumed with betel nut or highland betel nut. The catkin, leaf and vine are used, with the catkin being the part most commonly used in PNG and the leaf and vine only used when the catkin is not available. Lowland betel pepper grows from sea level to 1000 m altitude. Its distribution is very similar to that of betel nut (Figure 3.5.2), although it does not grow to the altitude that betel nut does. Catkins sold in Kainantu market, which come from Karkar Island and the Markham Valley, are available throughout the year, but the supply varies seasonally with the best supply in January–March and the poorest in September–October.

Lowland betel pepper was introduced to PNG from South-East Asia thousands of years ago, almost certainly with betel nut. Production has increased in the lowlands in recent decades and in most locations has probably exceeded population growth as betel nut consumption has increased. In some locations where it has become a significant cash crop there has been a marked increase in production so that catkins can be sold in distant urban or highlands markets.

---

**Table 3.5.1** Rural population growing the most important stimulants

<table>
<thead>
<tr>
<th>Stimulant</th>
<th>Population</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco</td>
<td>4,134,099</td>
<td>99</td>
</tr>
<tr>
<td>Betel nut</td>
<td>2,172,390</td>
<td>52</td>
</tr>
<tr>
<td>Lowland betel pepper</td>
<td>2,149,154</td>
<td>51</td>
</tr>
<tr>
<td>Highland betel pepper</td>
<td>1,272,570</td>
<td>30</td>
</tr>
<tr>
<td>Highland betel nut</td>
<td>649,472</td>
<td>15</td>
</tr>
<tr>
<td>Kava</td>
<td>33,432</td>
<td>1</td>
</tr>
</tbody>
</table>

Sources: NSO (2002); MASP.
Figure 3.5.1 Distribution of tobacco as an important stimulant. Source: MASP.

Figure 3.5.2 Distribution of betel nut as an important stimulant. Source: MASP.
**Highland betel pepper** is grown by about a third of the rural population. The leaves, and occasionally the catkins, are consumed with betel nut or highland betel nut. Highland betel pepper is grown in mountainous areas over an altitudinal range of 1150–2300 m. It is widespread in Eastern Highlands, Simbu, and parts of Southern Highlands provinces, and the Menyamya area and Huon Peninsula of Morobe Province. Its distribution is similar to that of highland betel nut (Figure 3.5.3) and the two items are commonly sold together in highlands betel nut markets. The best supply of highland betel pepper leaves in Kainantu market occurs in September–November. This is the period of poorest supply of lowland betel pepper catkins and it is likely that leaves of the highland species are sold to make up the shortfall of the preferred lowland catkins.

**Highland betel nut** (*Areca macrocalyx*) is used in a similar way to betel nut, but is considered inferior as the fruit is smaller. About a sixth of the rural population live in locations where it is planted and consumed, two-thirds of whom live in Eastern Highlands and Morobe provinces. It is most commonly planted in Eastern Highlands Province, particularly in the Kainantu area, and in mountainous parts of Morobe Province in the Menyamya area and the Huon Peninsula (Figure 3.5.3). It grows over an altitudinal range of 1100–1950 m. In the Kainantu area nuts are available throughout the year, with the best supply in October–December. This pattern complements that for betel nut. It is likely that more highland betel nut is sold in highlands markets when betel nut from the lowlands is in short supply.

Highland betel nut is an indigenous species and was probably domesticated in New Guinea after the introduction of betel nut from South-East Asia. Consumption of highland betel nut may have declined over the past 20 years as the supply of betel nut from the lowlands has improved. Highland betel nut is commonly sold in Kainantu market and sometimes in other highlands markets. It is occasionally transported to lowlands markets, particularly Lae, when betel nut is scarce.

---

**Figure 3.5.3** Distribution of highland betel nut as an important stimulant. *Source: MASP.*
Marijuana is usually smoked as a cigarette. Both the flowering bud and leaves are used, with the former containing a higher concentration of the active ingredient (THC). Information on production and consumption is limited as production and sale of marijuana is illegal in PNG. Nevertheless, it is likely that a high proportion of young men in the main producing locations grow or consume the plant. Marijuana grows from sea level to about 2600 m in PNG, but is rarely grown in the lowlands. Most production occurs in the highlands from about 1400 m to 2200 m altitude in locations where rainfall varies seasonally. These are parts of Eastern Highlands, Simbu, Western Highlands and Central provinces. Marijuana is particularly common in the driest part of the highlands. Plants grown in seasonally dry highland locations are said to have a higher concentration of the active ingredient than those grown in coastal areas.

Marijuana was probably introduced into PNG in the mid to late 1960s by young expatriates. By the late 1970s it was being used by highlanders. Production and consumption has expanded since then. By the early 1980s it was readily available in Port Moresby and other lowland centres. By the early 1990s expatriate field workers in Eastern Highlands and Simbu provinces were regularly offered marijuana in rural areas; reports of sightings in village plantings became more common; social workers in the highlands commented on the negative impact of heavy use on young men in some highland locations; and some young highland village men spoke openly of how much they used. By 2007, marijuana cigarettes were being offered for sale openly or barely concealed in Goroka, Kundiawa and Mount Hagen markets. It seems that significant quantities of marijuana are grown in at least four provinces; that many young men use it and some use large enough quantities to have a detrimental effect on their wellbeing; and that it is readily available in urban centres. As a result, marijuana is an important cash crop for some villagers (see Section 5.17). It is unlikely that marijuana is imported into PNG but it is probable that some is exported from PNG to Australia where it is known as 'New Guinea Gold' among some users. Marijuana is implicated in reports of weapons trading from Australia to PNG across Torres Strait.

Coffee, tea and soft drinks. Coffee, tea and many aerated soft drinks contain caffeine, which is a psychoactive substance, although they are so common in most societies worldwide that they are not considered as drugs. Although coffee and tea are produced in PNG for the export market (see Sections 5.4 and 5.12), consumption levels are low. The 1996 PNG Household Survey recorded combined consumption of tea, coffee and Milo (a manufactured chocolate drink) of only 1 kg/person/year in urban areas and a few hundred grams per person per year in rural areas (Table A2.1.1). People consume more soft drink, particularly in urban areas, where consumption in 1996 was 12 kg/person/year and 3 kg/person/year in rural areas. Most coffee consumed is imported ‘instant’ powder. A very small quantity of locally roasted Arabica coffee is consumed, particularly by expatriates and in up-market restaurants. Some locally produced tea is sold on the domestic market and very small quantities are imported. Aerated soft drinks are manufactured in PNG from locally grown sugar and imported flavours.

Locally brewed alcohol. With the exception of coconut ‘toddy’ on some atolls, alcohol was unknown in PNG until introduced by Europeans in the late nineteenth century. Consumption by Papua New Guineans was prohibited until the early 1960s. Alcohol is now legally able to be consumed in PNG, with beer being the most common alcoholic drink. Consumption levels are low by global standards, with

---

4 According to the 2007 World Drug Report, the annual incidence of marijuana abuse in PNG (29.5%) among the population aged 15–64 is the highest of 138 countries surveyed. This can be compared with Australia (13.3%), the Philippines (4.2%), Fiji (0.2%) or Singapore (0.004%). The PNG figure is unlikely to be accurate, but nevertheless indicates a relatively high usage.

5 For example, police prosecuted an expatriate in Arawa on Bougainville Island in early 1970 for possession of marijuana. The prosecution failed because the police could not recognise the product. The author was subsequently requested to grow marijuana in a greenhouse at the Lowlands Agricultural Experiment Station at Keravat from 1970 to 1972 so that PNG police officers could recognise the crop. By the late 1970s, marijuana smoke could be smelt in some public locations in Kainantu that were frequented mainly by highlanders.
beer consumption recorded as 4 kg/person/year in 1996, and use higher in urban than in rural locations. Beer is brewed in Lae and Port Moresby from imported ingredients. Some spirit drinks are made and sold in PNG, based on ethanol (alcohol) manufactured at Ramu Agri-Industries Ltd and imported flavours. Other alcoholic beverages, including wine and spirits, are imported in small quantities.

An alcoholic drink (toddy) is made from the sap collected from the fruit stalk of coconut palms on Mortlock, Tasman and Nuguria islands in Bougainville Province. This appears to be a pre-European custom. The fermented sap produces a refreshing drink with a low alcohol content of about 2–3%. There are reports that coconut toddy was made in the lower Fly River area of Western Province, where it is possible the technique was introduced by Polynesian missionaries in the 1890s.

In a number of locations young men make an alcoholic drink known as ‘jungle juice’, ‘JJ’ or ‘Yawa’, by fermenting fruit, such as banana or pineapple, with yeast and sugar. This custom was possibly first introduced to the Gazelle Peninsula in East New Britain Province by Japanese troops during the 1940s. The Yawa banana variety is commonly used for this purpose because of its high sugar content. Increasingly, the fermented drink is distilled to produce a potent spirit known as hom bru.

During the civil war on Bougainville in the 1990s the practice was widespread and distilled spirit is now sold at roadside stalls there. It is also sold in some (and perhaps many) betel nut markets in the highlands. If not done correctly the distillation process can result in toxic products and reports of blindness and death among hom bru users occur from time to time. The spirit has a high alcohol content and consumption is associated with irrational and sometimes violent behaviour.

Kava is consumed as a beverage made from the chewed, pounded or grated root of a shrub that is related to betel pepper and black pepper. Chewing is the most common method of preparation. Once the kava root has been chewed and mixed with water, it is strained into a bowl or coconut cups and drunk. It is used in a very limited number of locations in PNG and by less than 1% of the rural population.

Kava was domesticated in Vanuatu and introduced from there to some locations in PNG. It was a pre-European crop in the Madang area and possibly in Manus Province. The area of greatest kava consumption in PNG was Manus Province, in particular Lou, Baluan, Pam, Rambutyo and the Fedarb islands. By the 1990s it was used only on Baluan. It was reportedly used in coastal areas north of Madang, the Rai Coast, some inland areas near the Ramu River and on Karkar and Bagabag islands. It is now used only in a limited number of villages in Madang Province.

Kava was also consumed in parts of Western Province on the Great Papuan Plateau near Nomad, near Balimo and in the region from Daru to the Papua (west New Guinea) border.

Consumption has declined in recent decades. Some research has been conducted on kava by NARI scientists interested in developing the crop for the export market, but there is no commercial production.

Other psychoactive plants. There are numerous reports of the use of other plants, mushrooms and fungi for their psychoactive effect. Most are indigenous to PNG but some are more recent introductions. They are used during various rituals and to induce visions or dreams. Some have been documented as having hallucinogenic properties. More than 60 species are reported to be used including mushrooms, fungi, and the fruit, leaves, sap, rhizomes, roots, bark and nuts of various plants. Some plants that have edible parts, including ginger, pandanus nut and castanopsis nut, are also reported to be used as psychoactive substances. A Datura species that has been used for this purpose has resulted in unintentional poisoning on a number of occasions. There is no reliable information on current usage of other psychoactive plants in PNG. However, it is likely that these plants were used in limited amounts in the past, certainly much less commonly than betel nut and tobacco are now used. It is also likely that their use has declined in recent decades in more accessible parts of PNG.

---

6 The spirit drink is not displayed openly in these stalls, but is signalled by the presence of bottles of Coca Cola, which is consumed with hom bru.

7 See Thomas (2000, 2003) for a comprehensive review of the psychoactive flora of PNG.
Sources


3.6 Intensification of agriculture

Intensification of agriculture occurs when production from an agricultural system is increased, but the area of land in use remains constant. The cause of agricultural intensification is most commonly attributed to the need to produce more food to meet the demands of a growing population, but this is an oversimplification.

The best-known theory of intensification is that of Ester Boserup. In 1965 she argued that the highly influential argument of Thomas Malthus – that population will always outrun food supply, leading to a reduction in food per person, and ultimately to famine and war – was wrong. Rather, said Boserup, as population increases, people will intensify their agriculture by permanently improving land quality (by draining or terracing, for example), changing agricultural techniques, adopting new crops, and working harder, to produce more food.

Boserup's ideas were applied to PNG agricultural systems by Harold Brookfield in the 1970s. Unable to find a good association between population density (the numbers of people per unit area) and the intensity of agricultural systems, Brookfield argued that the production of food in PNG was not solely for consumption by people, but was also used in displays and exchanges, in compensations for death and injury, as sacrifices to ancestral spirits, and in marriages. So food production had a social purpose as well as a nutritional one, which had to be taken into account when agricultural intensity was examined. Large exchanges of pigs and pig meat, some of which was wasted, or the production of yams of extraordinary length for rituals and exchanges, were two examples of Brookfield's 'social production'.

In shifting cultivation systems, land use can be intensified just by using the land more frequently in the absence of any other changes. That is, fallow periods can be reduced and cultivation periods extended (see Section 3.8). However, if fallow periods are reduced and cultivation periods extended to the point at which soil fertility is not restored by the fallow, food production will begin to decline and other symptoms of land degradation will appear. The intellectual and social processes that people go through when they become aware of declining crop yields and environmental degradation are not well understood. But it is assumed that these things trigger a response in the form of changes in the agricultural system that restore crop yields and food production to acceptable levels.

When people adopt new agricultural techniques they are 'innovating'. The sections that follow (Sections 3.7 to 3.11) describe the most important innovations used to intensify agriculture in PNG. They are mostly concerned with the maintenance of soil fertility when long fallow times are reduced or cultivation times are extended. The associations between agricultural intensity and fallowing, planting trees in the fallow, using leguminous crops in rotations with food crops, constructing wooden barriers or terraces, tilling the soil, constructing mounds and beds, and incorporating green manure in the soil (composting) are briefly outlined in Section 3.7. These practices
are then examined in detail in Sections 3.8 to 3.11. Lastly, a number of other practices that are not directly associated with agricultural intensification are described in Section 3.12.

Significant changes in social, economic and political organisation, work patterns, land tenure, and gender relations have been observed to occur in association with agricultural intensification. They are not discussed in detail here.

Sources


If crops are planted continuously on the same area, their production declines with every planting, until they produce very little food. This is illustrated in Figure 3.7.1, which shows some results from a long-term trial conducted at Keravat in East New Britain Province. The figure shows yield decline of sweet potato and taro where sweet potato, taro and peanut were grown in a rotation. Three things cause a decline in crop yields:

- Growing crops draw nutrients from the soil (nitrogen, phosphorus and potassium in particular, as well as a number of trace elements) and their harvest removes these nutrients from the soil.
- Soil that is exposed for cultivation loses nutrients when they are leached by rainfall or when soil is physically removed by erosion.
- Pests and diseases that attack crops build up over time to a level where they significantly reduce crop yields.

If agriculture is to be sustainable over the long term, crop production must be maintained at satisfactory levels. In order to achieve this, losses of soil and nutrients must be kept to a minimum. Soil nutrients that are lost during cultivation have to be replaced, physical characteristics of the soil that are altered during cultivation need to be restored or improved, and pests and diseases reduced to acceptable levels.

In PNG a wide variety of techniques are used to slow the loss of soil and nutrients during cultivation and to restore them between times of cultivation. These techniques are:

- Fallowing – long and short fallows.
- Planting trees in the fallow.
- Using leguminous crops in rotations with food crops.
- Constructing wooden barriers or terraces to slow the loss of soil by erosion.
- Tilling the soil and constructing mounds and beds.
- Incorporating green manure in the soil (composting).

The relationship between the use of these techniques and land use intensity, by agricultural system, is shown in Table 3.7.1 (see also Section 1.2). A number of techniques show a clear association with land use intensity; short fallows and composting are found in more than 60% of the highest-intensity systems and are not present in any of the lowest-intensity systems. However, this association is not perfect. It appears that people do not use these techniques, even if they know about them, until crop production falls to an unacceptable level. Many techniques that are used at the highest levels of intensity are also found in systems across the whole range of land use intensities. For example, the use of short fallows, clearly associated with the highest-intensity systems, also occurs in systems with medium and low intensity.
Table 3.7.1 The proportion of systems using selected agricultural techniques, by land use intensity class

<table>
<thead>
<tr>
<th>Systems in the intensity class (%)</th>
<th>Land use intensity class (R-value)</th>
<th>Very low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>81–100</td>
<td></td>
<td></td>
<td></td>
<td>Short fallows</td>
<td>Short fallows</td>
<td></td>
</tr>
<tr>
<td>61–100</td>
<td></td>
<td></td>
<td></td>
<td>Long beds</td>
<td>Composting</td>
<td></td>
</tr>
<tr>
<td>41–60</td>
<td></td>
<td>Small mounds</td>
<td></td>
<td>Small mounds</td>
<td>Legume rotations</td>
<td>Large mounds</td>
</tr>
<tr>
<td>21–40</td>
<td></td>
<td>Fences</td>
<td>Short fallows</td>
<td>Composting</td>
<td>Large mounds</td>
<td>Legume rotations</td>
</tr>
<tr>
<td>6–20</td>
<td></td>
<td>Small mounds</td>
<td>Medium-sized mounds</td>
<td>Medium-sized mounds</td>
<td>Legume rotations</td>
<td>Long beds</td>
</tr>
<tr>
<td>1–5</td>
<td></td>
<td>Long beds</td>
<td>Composting</td>
<td>Soil retention</td>
<td>Planted tree fallows</td>
<td>Small mounds</td>
</tr>
<tr>
<td>Not present</td>
<td></td>
<td>Large mounds</td>
<td>Legume rotations</td>
<td>Planted tree fallows</td>
<td>Square beds</td>
<td>Soil retention</td>
</tr>
</tbody>
</table>

Note: Only ‘very significant use’ is presented in the table. During field surveys to define and describe agricultural systems, a qualitative judgement was made on whether the use of a technique was present and whether its use was ‘not significant’, ‘significant’ or ‘very significant’.

Source: MASP.
Composting occurs in all land use intensity classes except the very low intensity class. Small mounds are used in some systems at all levels of land use intensity. In contrast, tree planting in fallows occurs only in the low and very low intensity classes.

The sections that follow (Sections 3.8 to 3.11) describe these techniques in more detail.

**Figure 3.7.1** Effect of ten years of continuous planting on sweet potato and taro yields at Keravat, East New Britain Province, 1954–1964. **Note:** Data are from rotations 4 and 5 of the first ten years of a long-term rotation trial. Treatments were a continuous rotation of sweet potato, taro and peanut. **Source:** Bourke (1977).

**Sources**


3.8 Fallowing

A very effective and almost universal way of restoring soil fertility in PNG is to use a **fallow**. A fallow is a period when land is not planted with crops, but is left to ‘rest’, or is planted with a species that assists in restoring soil fertility, such as a leguminous crop (see Section 3.10). In PNG, depending on the need to produce crops, land may be left in fallow from eight weeks to more than 40 years. A distinction can be made between so-called **long fallows**, which last more than twelve months, and **short fallows**, which are less than twelve months and are typically between two and four months.

The importance of short falls is to restore soil fertility, reduce pests and diseases and, where green manuring (composting) is practised, to provide fallow vegetation that can be incorporated into the soil at the next planting (see Section 3.11). The effect of a 16-month fallow on sweet potato yields in an experiment at Aiyura in Eastern Highlands Province is illustrated in Figure 3.8.1. The solid trend line shows yields falling prior to the fallow and the broken line shows the trend of yields after the fallow. The 16-month fallow restored yields almost to the level they were at eight plantings earlier. Short falls are commonly used in highlands agricultural systems.

When land is fallowed, naturally occurring plants colonise the previously cultivated area. These plant communities are known as the **fallow vegetation** (see page 237). If the fallow period is long enough and if sources of seed are present, fallow vegetation may progress to a tall tree cover. Tree roots penetrate deep into the subsoil and draw up nutrients to the leaves and branches. Soils become more friable as root systems develop and litter decomposes. The fallow vegetation protects the soil surface from rainfall and sunshine. Pests and diseases that live on particular food crop plants are significantly reduced because their target plants are no longer available to them. When the fallow is cleared most of the vegetation is not removed from the site. Leaf litter and woody material is either burned on site or decomposes, and this provides nutrients to the soil.

**Shifting cultivation and fallowing**

Shifting cultivation is the basis for most food production in PNG. The exceptions occur where food is derived from tree crops such as sago, coconut or breadfruit and from some sweet potato-based systems in the highlands where land is rarely fallowed. The majority of agricultural systems in the lowlands are shifting cultivation systems that use only long falls to maintain soil fertility. Other techniques, such as green manuring (composting) and planted tree falls, are more common in the highlands, but these techniques are still used within shifting cultivation systems. A lot of variation exists but, in general, land under fallow vegetation that is believed to be ready for cultivation again is cleared by slashing, and usually burning, the fallow vegetation and then planting food crops.
Although shifting cultivation is commonly associated with burning, almost 20% of PNG’s shifting cultivators do not burn slashed fallow vegetation during the preparation of plots for cultivation. Most of the systems where burning is not important are found in high rainfall areas or where sago is a main food source (Figure 3.8.2). Burning is also unimportant in agricultural systems where the cropping phase is long and soil fertility is maintained by green manuring.

After planting and harvesting crops, the cleared area is returned to fallow. Crops may be planted from one to many times, with 1–3 plantings typical in the lowlands. The cropping phase tends to be 2–5 plantings in the highlands but is even more extended in some highlands locations, particularly where green manuring is practised. The ratio of the time land is cultivated to the time it is left in fallow is one important measure of land use intensity (see Section 1.2).

Just under half of all rural people in PNG use agricultural systems where fallows are between 5 and 15 years long, and 34% use fallows that are longer than 15 years. Of the 11% of people who use fallow periods between 1 and 4 years long, most are located in Southern Highlands and Eastern Highlands provinces (Figures 3.8.3, 3.8.4, Table A3.8.1).

Villagers do not use long fallows in only nine of the 291 agricultural systems identified by the MASP project (see Section 1.15). Agricultural systems where a long fallow is not used have particular characteristics that distinguish them from all other systems: most are highlands systems; they are located between 1600 m and 2800 m in altitude; the lowlands systems all occur on small islands; population densities are high; land use intensity is very high; short fallsows are used in all such systems; soils are tilled; in the highlands, mounding and green manuring (composting) are used (see Section 3.11); sweet potato is the most important crop produced; pigs are often tethered in gardens; and burning of fallow vegetation is uncommon. In Enga Province 67% of the rural population do not use long fallows.
When land that has been cultivated is fallowed, a number of vegetation communities follow, or succeed, one another on the site. Hence they are called *fallow successions*. The most common pattern of succession is weeds and grasses first, followed by fast-growing shrubs and bushes, softwood trees, and finally hardwood trees. It may take 30 years to reach a secondary forest succession, with two or three layers of vegetation under a tree cover. Tall secondary forest may appear to be similar to undisturbed forest that has never been cultivated, but the species composition is much less diverse than in undisturbed forest. The rate at which fallow successions proceed depends on the soil fertility of the site, rainfall, sources of seed and whether the succession is disrupted, by a fire for example, or clearing. If fallows are cleared again for cultivation too soon, the fallow successions will not have had time to proceed beyond a certain stage and the replenishment of soil nutrients will not have been completed. Over time, soil fertility will steadily decline, fallow vegetation will not proceed past scrub or tall grass, relatively quick tree successions can disappear, and short grasses or tall grasses can become the dominant fallow vegetation.

Most of the land that is used for agriculture in PNG is cleared from tall woody regrowth that is more than 15 years old. This is particularly marked in Sandaun and Gulf provinces. More than 1.5 million people (37% of the rural population) clear tall woody regrowth fallows for cultivation (Figures 3.8.5, 3.8.6, Table A3.8.2). In the highlands provinces, where fallow periods are often shorter, short and tall grasses and low woody plants dominate fallow vegetation. A further 1.5 million people clear tall grass or grass and woody regrowth fallows.

1 'Tall woody regrowth' is the technical term for tall secondary forest.
2 Common tall grass fallow species are *Saccharum* and *Miscanthus*. Common short grass fallow species include *Imperata*, *Themeda* and *Ischaemum*. Scrub, or low woody regrowth species include *Parasponia*, *Dodonaea*, *Ficus*, *Macaranga*, *Kleinhovia*, *Melanolepis*, *Pipturus* and *Premna*.

---

**Figure 3.8.2** The use of burning to clear fallow vegetation. Source: MASP.
Figure 3.8.3  Length of fallow period. Source: MASP.
In Western Highlands, Simbu, Enga and Southern Highlands provinces, tall grass is the most common vegetation cleared from new garden sites, sometimes with woody regrowth. An important minority of around 10% of the rural population use short grass fallows, particularly in Eastern Highlands Province where 41% of the population use this fallow type.

The influence of rainfall on fallow vegetation is illustrated by the difference between Eastern Highlands, where a distinct dry season is experienced (see Section 1.5) and the four other highlands provinces. In the lowlands provinces, short grasses and savanna are important fallow vegetation only in the coastal areas of Western and Central, where rainfall seasonality is strong.

Although annual rainfall and rainfall seasonality are important influences on fallow vegetation, grass fallow complexes are associated with higher population densities and with fallow periods of less than five years.

**Sources**


Figure 3.8.5 Fallow vegetation cleared for cultivation. Source: MASP.


---

**Figure 3.8.6** Rural population clearing different fallow vegetation, by province. *Note:* Agricultural systems with ‘fallow not defined’ occur in swamps at the mouth of the Sepik River and on some atolls (see Table A3.8.2).

Sources: NSO (2002), MASP.
In PNG agricultural systems, two main methods are used to reduce the rate at which soil is lost from a garden site during cultivation. Both techniques have been developed by villagers. Given the widely dispersed use of these practices, it is likely that they were developed independently in a number of locations. The techniques are:

- Construction of physical barriers across the slope to prevent soil loss.
- Creation of benches across the slope to slow run-off and possibly to retain water.

### Soil retention

In many parts of PNG, barriers are constructed across the slope to slow or prevent the movement of soil downslope and out of the garden site. The barriers are constructed from wood but, over a number of years, stakes used sometimes sprout and form living, permanent barriers. This is particularly the case where *Cordyline* or *Piper* is used to make the barrier. In the Chimbu Valley for example, carbon dating of soils retained behind a barrier of live *Cordyline* suggest that it was first constructed over 200 years ago.

The size and design of the barriers vary from a simple pole laid along the contour, with stakes hammered into the soil on the downslope side to hold it in place, to a low fence constructed by weaving thin poles in and out of 50 cm tall stakes. In other cases, a 1.5–3.0 m high barrier made from tree branches is held up by substantial props on the downslope side. The distance between the barriers is also highly variable.

Where they are used with shifting cultivation systems, the barriers are often reconstructed in the same places after a long fallow and the soil that builds up behind the barrier becomes the beginning of a terrace. Steep, grass-covered hills south and west of Marawaka in Eastern Highlands Province have numerous ridge lines running along the contour. It is possible these lines are caused by the construction of soil retention barriers during previous cultivations.

Soil retention barriers are most important in agricultural systems in northern Simbu Province, on the Huon Peninsula in Morobe Province, east of Maprik in East Sepik Province, west of the Baiyer Valley in Western Highlands Province, in the headwaters of the Watut, Lakekamu and Waria rivers south of Wau in Morobe Province and in the D’Entrecasteaux Islands and mainland of Milne Bay Province (Figures 3.9.1, 3.9.2, Table A3.9.1).

Vetiver grass has been promoted in Simbu Province as a possible means of soil erosion control. The grass was introduced in the 1980s but was poorly managed and was not widely adopted. In the late 1990s CARE Australia began an extension program using vetiver grass planted behind existing wooden soil retention barriers and also trialled it in association with *Leucaena* trees. It will be some years before the outcomes of this program can be assessed, but there appears to be only limited adoption by villagers about ten years after the program was initiated.
Figure 3.9.1: The use of soil retention barriers. Source: MASP.

Figure 3.9.2: Rural population using soil retention barriers, by province. Sources: NSO (2002); MASP.
Another method of retaining soil on steep slopes is benching. Benching involves cutting a narrow bench into a slope along the contour. Benching is not common in PNG and true terracing is not used anywhere. Large areas of hillsides have been benched inland of Rabaraba in mainland Milne Bay Province (Figures 3.9.1, 3.9.2, Table A3.9.1). The benches are about 70 cm wide and 100 cm high. Men construct the benches by working together in a line moving from the bottom of the slope to the top. Wooden digging sticks were previously used but have been replaced by metal spades. The first bench is formed and spoil from the next bench is brought down on top of the first to form a low ridge along the top of the first bench. In this way, the whole slope is benched and ridged. Taro is planted into the ridge of spoil.

Although it seems likely that ground water seeps out of the low wall at the back of the bench, and collects behind the ridges, the practice is described mainly in terms of soil retention. Villagers say that unless this technique is used, severe soil loss will result if substantial rain falls on slopes that have been prepared for taro cultivation. Benches are also used on Goodenough and Wagifa islands in Milne Bay. On the Sogeri Plateau, Central Province, migrants from Kabwum in Morobe Province create small fences along the contour using *Piper aduncum* sticks and move spoil from the slope behind the fences to create a bench and a narrow terrace.

In the Pindiu to Ogeranang area of the Huon Peninsula, large fences 2–3 metres high are constructed from *Piper aduncum* stems. The fences help prevent soil erosion. Soil is moved from higher up the slope down to behind the fence. This creates a small terrace, with the soil deeper just upslope from the fence. Crops that require more fertile sites, such as banana and leafy green vegetables, are planted in the deeper soil with sweet potato planted elsewhere.

**Sources**


3.10 Tree planting and legume rotations

As intensification of agriculture increases in PNG and cultivation times are extended, methods other than fallowing must be used to maintain soil fertility or to slow the rate at which nutrients are lost from the soil. Two important techniques that villagers use to maintain or improve soil fertility are planting particular trees in fallow vegetation and planting legumes between or prior to planting root crops, particularly sweet potato. These practices provide other benefits, for example, timber for fencing and firewood.

Nitrogen in the form of ammonium is critical to plant and animal growth and life. Although the use of trees and legume rotations in PNG agricultural systems is poorly understood, it is assumed that these plants ‘fix’ nitrogen, that is, they absorb nitrogen from the atmosphere and convert it to a form that can be used by other plants. It is actually bacteria, which live in small growths or nodules on the roots of leguminous plants, that ‘fix’ nitrogen and allow the ammonium produced to be absorbed by the plant. Nitrogen is also fixed by certain other plants, including casuarina trees. The nitrogen only becomes available to other plants if the leguminous plant, or part of it, dies and decomposes in the soil.

1 A legume is a plant belonging to the family Leguminosae (peas, beans and pulses). Most legume species contain certain bacteria in their roots which enable them to convert nitrogen from the atmosphere and store it in plant tissue as ammonium, a form of nitrogen that the plant can use.

Tree planting in fallows

During a long fallow, it is usual for plant species to reoccupy the previously cultivated area without human assistance (see Section 3.8). However, in a number of places in PNG, people deliberately cultivate particular trees in fallow gardens in order to speed up the establishment of a tree cover and, frequently, to introduce species into the fallow that will put nutrients back into the soil.

The tree most commonly planted into fallows in PNG is *Casuarina oligodon* (yar). Other tree species planted in fallows in PNG are *Albizia* spp., *Parasponia rigida*, *Piper aduncum* and *Schleinitzia novo-guineensis*.

*Casuarina oligodon* seedlings are planted into fallows in the highlands, mainly between 1400 m and 2100 m in altitude, on sloping land, in hills or mountains, in areas where the annual rainfall is between 2000 mm and 3000 mm and the fallow vegetation is grass. Casuarina occurs naturally along water courses and in disturbed forest areas, such as landslides. Seedlings are transplanted from these sites and from mature stands of trees. Typically men collect seedlings and plant them in sweet potato gardens towards the end of the cropping phase. The seedlings grow during the fallow phase and are mature 8–12 years later.
Planting casuarina trees into fallows is most important in central Simbu Province, in adjacent locations in Eastern Highlands Province, in the Simbai and Kaironk areas in Madang Province, and in the Oksapmin area of Sandaun Province (Figures 3.10.1, 3.10.2, Table A3.10.1). Elsewhere, casuarina is planted around the edges of fields, around houses and in small plantations, but not in fallows.

Villagers say that casuarina trees improve soil conditions. It has not been established scientifically how the tree fixes atmospheric nitrogen, but soil under casuarina trees has been shown to be higher in nitrogen and carbon than the same soils under grasses, food crops or coffee. It has also been shown that nitrogen and carbon levels under casuarina trees increase over time. Soils under casuarina are ready for cultivation again in around 8–12 years. When a fallow that has been planted in casuarina is re-cultivated, the trees are either cut down (the roots are left in the soil to decompose) and used for fencing, ringbarked and eventually used for firewood, or severely pollarded (all but the topmost branches are cut off) to let light into the garden but to keep the tree alive during the cultivation of crops. These casuarinas rapidly form a tree fallow again when cultivation is completed. The pollarded trees grow during the cropping phase and provide seedlings so that the system becomes self-perpetuating.

Casuarina is particularly important in mixed crop gardens where crops are planted that demand higher soil fertility than sweet potato; around villages where the trees provide shade and timber and are also aesthetically important;² and as shade in coffee gardens. It is not known for how long people have been planting casuarina trees into gardens to improve soil fertility. It is likely the practice has increased in importance in the last 150 years and that it is still spreading. It is known that casuarina planting has increased in importance in Simbu Province since the 1950s and has been adopted at Oksapmin since about 1920 and at Okapa in Eastern Highlands Province since about 1960.

² People praise the look of the casuarina tree, its association with settlement and ‘home’, and the sound that the wind makes blowing through the leaves.
Another practice associated with planted casuarina trees is the burning of dried branches on the soil surface and the planting of leafy green vegetables or tobacco plants in the ashes. The fire probably releases nitrogen from the topsoil into the atmosphere. However, fires also kill large numbers of soil microfauna that release nitrogen as they decompose, which becomes available to plants.

As well as improving soils, casuarina trees are an important source of wood for firewood, house building and fencing. A 1980 study in Enga Province estimated that 370,000 m³ of casuarina wood per year was used for firewood (including that used in urban areas), 93,000 m³ for fences and 26,000 m³ for house building. This wood was valued at between K2.4 and K3.7 million in 1980 (K15–23 million in 2005 values). One mature casuarina tree was estimated to provide one cubic metre of wood. The study noted that all of this wood was produced by villagers planting trees.

It is reported from the Kaironk and Jimi valleys in Madang Province that, where casuarina plantings do not thrive, *Dodonaea viscosa* is planted in gardens from seed and seedlings.

*Albizia* spp. is a fast-growing leguminous tree of the subfamily Mimosoideae. It occurs in fallows in a number of locations around PNG, including East Sepik, Morobe, Madang and the highlands provinces. In places it is transplanted into food crop gardens. *Albizia* is used as shade and presumably provides nitrogen in semi-permanent mixed coffee–banana–Chinese taro gardens in the Erap and Wau areas of Morobe Province.

*Parasponia rigida* is not a leguminous plant, but rhizobia bacteria are found in its root nodules. So although *Parasponia* probably fixes nitrogen, the mechanism of how it is stored in the plant and released to the soil and to other plants is not understood. *Parasponia* is protected from fires and cutting during garden clearing in Enga Province, Southern Highlands Province and in the Kaironk area in Madang Province. It also occurs naturally in lowland fallows across PNG.

![Figure 3.10.2 Rural population planting trees in fallows, by province.](image-url)
**Piper aduncum** was introduced to PNG during the 1920s and is spreading in many places, with and without the encouragement of people. On the Sogeri Plateau inland from Port Moresby migrants from the Huon Peninsula in Morobe Province use *P. aduncum* stakes to create soil retention barriers in new sweet potato gardens in grasslands (see Section 3.9). The stakes sprout and after the garden is fallowed *Piper* forms a tree cover that prevents the grass from regrowing.

**Schleinitzia novo-guineensis** is a leguminous tree, also of the subfamily Mimosoideae, that is found in fallows on a number of small islands in Milne Bay Province. On some islands it is transplanted from natural stands into gardens.

Research is needed to understand why villagers favour these trees and under what conditions the various species perform best. There is much potential for tree planting practices to be spread to other parts of PNG. In some places villagers are experimenting with planting trees. For example, on Pinipel Island in Bougainville Province, some villagers are evaluating the usefulness of *Gliricidia* species to improve sweet potato yields.

### Legume rotations

In a number of sweet potato-based agricultural systems, mainly in the highlands, sweet potato plantings are alternated with the planting of leguminous plants. Before the introduction of peanut the most common rotation was sweet potato and winged bean. It is not known how widespread the use of a winged bean rotation was. Following the introduction of peanut between the 1930s and 1950s, a peanut–sweet potato rotation was adopted in parts of the highlands.

Legume rotations are most important in central Eastern Highlands Province and in the Wahgi and Nebilyer valleys in Western Highlands Province.
They have also become important in parts of the Gazelle Peninsula where a sweet potato–peanut rotation is practised, mainly in grassland gardens. Peanut rotations are also used on the Sogeri Plateau in Central Province and in the Ramu and Markham valleys (Figures 3.10.3, 3.10.4, Table A3.10.2).

The rotation of sweet potato with leguminous crops such as peanut or winged bean has two important effects. First, it increases soil nitrogen levels and, second, it reduces the number of sweet potato pests and diseases occurring in the garden soil. Both effects increase yields of sweet potato. Peanut is a widespread supplementary food crop and is also a common locally marketed cash crop. Winged bean is a minor supplementary food in the highlands and is sold in local markets (see Section 3.2).

**Figure 3.10.4** Rural population planting legumes (peanut and winged bean) in rotations with root crops, by province. Sources: NSO (2002); MASP.

**Sources**


3.10 Tree planting and legume rotations


3.11 Tillage, mounds, beds and green manuring

In many PNG agricultural systems, soil is formed into mounds or beds for the cultivation of crops. The main effects of mounding and bedding are to raise crops above the water table, to improve drainage, to increase the depth of topsoil and to thoroughly till the soil. These techniques also allow the application of green manure (‘compost’) to the soil where this is practised.

Mounds, which are usually roughly circular in shape, may be distinguished on the basis of their dimensions into:

- Small mounds (10–40 cm high and 40–100 cm in diameter).
- Medium-sized mounds (40–70 cm high and 100–250 cm in diameter).
- Large mounds (more than 70 cm high and more than 250 cm in diameter).

Beds can be classified by their shape:

- Square beds.
- Long (or rectangular) beds.

The use of mounds and beds forms reasonably discrete geographical patterns in PNG. The distribution of mounds and beds is influenced by topography, slope, soil type, staple crop, culture and history.

### Tillage

Tillage affects the physical, chemical and biological properties of the soil. Tillage influences soil particle size, soil temperature, water infiltration and water retention. Tillage allows air into the soil and so increases the rate of organic matter decomposition, which makes nutrients available to plants. Biological activities of earthworms, insects, bacteria and many other small organisms in the soil are vital to soil productivity.

In PNG, tillage is commonly associated with mounding and bedding. However, there are a number of places in PNG where soil is tilled in the absence of mounds and beds. In these cases, tillage is usually associated with the use of grass fallows (see Section 3.8). For example, grass fallows are tilled in the western Schrader Range along the border between Madang and Western Highlands provinces, and around Wopasali in the south-east of Southern Highlands Province. Hillside gardens are completely dug over to remove cane grass roots in the Tauri River Valley, north and east of Menyamya, Morobe Province. Steep, grass fallow hill slopes are tilled during the building of benches in inland Milne Bay Province from Agaun east towards the Rabaraba coast (see Section 3.9).
Small mounds are used to a varying extent by almost two-thirds of rural people in PNG, mainly to raise crops above a wet soil and to increase the depth of topsoil. With the spread of sweet potato, small mounds have become increasingly widespread because sweet potato yields are reduced by saturated soils.

Small mounds are important or very important in northern Simbu and Eastern Highlands provinces, where they are used by more than 95% of the provincial populations; in Bougainville Province (83%); and in Oro, Central and Milne Bay provinces (more than 75%) (Figures 3.11.1, 3.11.7, Table A3.11.1). Small mounds are also sometimes used to plant crops other than sweet potato, for example, yam (notably in Milne Bay Province), cassava (in Central Province) and green vegetables (in Gulf Province). Small mounds are not used or are a minor practice in Gulf, Southern Highlands, Enga, East Sepik and Sandaun provinces.

Medium-sized mounds are used in food gardens in the western part of the highlands. They may or may not be constructed over heaps of green manure (composted). Composting is discussed in more detail on page 255. Medium-sized mounds are an important or very important technique for two-thirds of the rural population in Southern Highlands Province and almost half the rural population in Enga Province (Figures 3.11.2, 3.11.7, Table A3.11.2).

Whether or not green manure is incorporated into the mounds, they are constructed in a similar way. Land is cleared from a long fallow of tall grasses and shrubs by removing all vegetation and roots and breaking the soil into a rough tilth. An initial crop of sweet potato is commonly planted on small mounds to further till the soil before medium-sized mounds are created. The garden is then planted and harvested many times, with a short fallow of up to eight months between plantings. The mounds are reconstructed at the beginning of each planting cycle.
After a harvest and a short 6–8 week fallow, land is prepared for planting again by breaking down the previous mounds and rebuilding them. Patterns of mound reconstruction include incorporating one-third of the three nearest into a new mound, or using one-quarter of the four nearest mounds to make a new mound. If the first technique is used, the mounds will form a regular triangular pattern across a garden, while the latter technique will create a regular square pattern of mounds. If the mounds are to be composted, the green manure is placed on the soil surface between the old mounds and the new mounds are formed on top of the green material.

### Large mounds

Large mounds are used by about 5% of the rural population. They are important in parts of Enga Province at Laiagam, the Lai Valley and Kompiam, and in parts of Western Highlands Province at Tambul and north-west of Mount Hagen town (Figures 3.11.3, 3.11.7, Table A3.11.3). Large mounds are used on soils derived from volcanic ash and are always composted. They are initially constructed in the same way as medium-sized mounds. However, after a harvest the mound is broken open by forming a depression in the centre, so that fallow large mounds look like small bomb craters. During the short fallow, weeds, sweet potato vines and grasses are thrown into the depression where they partially decompose. When the land is prepared for planting, more green material may be added and the mound is reformed by filling in the depression with soil from the outside of the mound. Thus large mounds are a relatively stable feature of the landscape and are not moved during the cultivation cycle, as medium-sized mounds are. Considerably more green manure is placed in large mounds than in medium-sized mounds.

### Square beds

Square beds are constructed by digging a grid of shallow drains at regular intervals across the garden site and throwing the spoil from the drains onto the

---

Figure 3.11.2 The use of medium-sized mounds in food production systems. Source: MASP.
surface between the drains. Grasses, weeds and other vegetation are usually left to dry and decompose on the surface and are buried by the spoil from the drains. Additional green material may be added, in which case the beds are composted. After the harvest and a short fallow, the beds are reconstructed by digging a grid of new drains through the middle of the previous beds, filling in the old drains and throwing the spoil onto the surface of what are the new beds. Square beds are usually found on flat or gently sloping land. They form a characteristic ‘chequerboard’ pattern observable from the air or on air photographs.

Square beds are most important in Western Highlands Province (where they are commonly used by 66% of the rural population) and in adjacent locations in Simbu Province (Figures 3.11.4, 3.11.7, Table A3.11.4). In the western part of Western Highlands Province, square beds give way to large mounds (Figure 3.11.3). Square beds are also important in some locations in Southern Highlands Province. The technique is used in the southern part of Western Province, where large areas of fallow or abandoned beds can be observed beneath secondary forest and savanna. Here beds are sometimes used to remove water from very poorly drained land and to lift crops above the high water table.

**Long beds**

Long beds, which are found on steeper slopes than square beds, are constructed in a similar fashion to square beds, but with much less regularity. Whereas square beds appear to be primarily a means for lowering the water table, long beds facilitate the passage of surface water across a sloping garden with a minimum loss of topsoil as the water flows between the beds. Both types of beds also result in a deeper topsoil and rooting zone. Long beds in particular are often observed sitting on brown or red clay subsoils.

Long beds are most important in the northern part of Eastern Highlands Province, where they are used by two-thirds of the rural population; in the central part of Southern Highlands Province; and in Western Highland Province. Square beds are also important in some locations in Southern Highlands Province. The technique is used in the southern part of Western Province, where large areas of fallow or abandoned beds can be observed beneath secondary forest and savanna. Here beds are sometimes used to remove water from very poorly drained land and to lift crops above the high water table.
Province around Balimo. Long beds are also used in a limited number of locations in Central Province and the Menyamya area of Morobe Province (Figures 3.11.5, 3.11.7, Table A3.11.5).

It will be apparent from Figures 3.11.4 and 3.11.5 that square beds and long beds sometimes occur in the same areas. In these locations, square beds give way to long beds as the slope gradient increases.

**Green manuring (composting)**

In some parts of the highlands, plant material is buried beneath the soil before sweet potato is planted. This is strictly speaking a form of green manuring, but in PNG it has become known as ‘composting’. Composting is practised mainly in Southern Highlands Province (using medium-sized mounds and beds); Enga Province (using medium-sized and large mounds); and the western end of Western Highlands Province (using large mounds). The use of composting is notably absent from the eastern part of Western Highlands, Simbu and Eastern Highlands provinces (Figures 3.11.6, 3.11.7, Table A3.11.6). The technique was developed by villagers and not introduced by outsiders. It is possible that composting was adopted in the main valleys of Enga Province about 150–200 years ago and subsequently adopted by other villagers in adjoining locations.

Composting is closely associated with mounding or bedding almost everywhere. It is restricted to areas between 1100 m and 2800 m in altitude; where mean minimum and maximum temperatures are 8–16°C and 18–27°C, respectively; and annual rainfall ranges from 2200 mm to 5000 mm. Composting is most common where rainfall is between 2200 mm and 3000 mm. The soils on which composting is most common are derived from volcanic ash. Volcanic ash soils are well structured and friable but have low levels of available phosphate and other essential minerals.

The amount of green plant material placed in mounds varies considerably. Below 1800 m altitude about 5 tonnes/hectare is applied, whereas above 1800 m up to 30 tonnes/hectare can be applied.
3.11 Tillage, mounds, beds and green manuring

Figure 3.11.5  The use of long beds in food production systems. Source: MASP.

Figure 3.11.6  The use of green manure (compost) in food production systems. Source: MASP.
Figure 3.11.7 Rural population using mounding, bedding and green manuring techniques in food production systems, by province. Sources: NSO (2002); MASP.
A study in the Lai Valley in Enga Province found the green manure applied was made up of sweet potato vines (63%), weeds (20%), highland pitpit leaves (10%), banana leaves (4%) and sugar cane leaves (3%). In Enga, women sometimes cut grass from nearby fallows and carry it to the garden and place it in mounds.

Composting is almost exclusively associated with sweet potato production. More than 20 agronomic trials have investigated the effect of composting on sweet potato yields. Composting increased sweet potato yields in all the trials but the response varied considerably. Investigations in Southern Highlands Province suggested that compost increased the availability of potassium to the sweet potato plants (other research has indicated that low levels of potassium limit sweet potato yields in the PNG highlands). Compost also increases top growth in sweet potato, increases soil temperature by up to 6 °C (which reduces the time to harvest because time to maturity is temperature-dependent in sweet potato), and reduces the incidence of fungal black rot in tubers.

One researcher suggested that composting protects sweet potato from frosts at high altitudes, but this is unlikely. The greatest benefits of composting are probably increased crop yield, reduced time to harvest and reduced incidence of rot.

The advantages of green manuring for the maintenance of soil fertility have been recognised by villagers in a number of locations outside the highlands. At Teptep in the Finisterre Mountains on the border of Morobe and Madang provinces, composted ridges constructed along the contour are used to grow sweet potato on volcanic ash soils at altitudes over 2000 m. The ridges are about 1.5 m wide, 0.6 m high, 20–30 m long and are constructed along the contour about 1.5 m apart. A short fallow follows each harvest. At the end of the fallow, grasses, weeds and sweet potato vines are placed between the ridges and new ridges are formed by moving half of the adjacent ridges into the space between the ridges to cover the green manure.

At Menyamya (Morobe Province, at 1500 m altitude) grasses and weeds are buried in long beds. Around Aseki (Morobe and Gulf provinces, at 1400–1900 m altitude) vegetation slashed during garden clearing is heaped over low wooden hurdles and banana and taro are planted along the edges of the heap. At Wagau in the Snake River Valley (Morobe Province, at 600–1100 m altitude) weeds, grasses and leaf litter are incorporated into medium-sized mounds, which are planted with single yam seed tubers. Near Bogia (Madang Province, 15 m altitude) weeds and grasses are dug into garden beds on drained alluvial flats. Around Dreikikir (East Sepik Province, 300 m altitude) the dry leaves of *Pometia pinnata* trees cut down during the harvesting of ton fruit are placed beneath yam seed tubers in holes in the garden. This practice has been adopted at nearby Seim, Sandaun Province.

**Sources**


---

1. It was argued that planting sweet potato on mounds raised the succulent parts of plants above freezing air flowing over the soil surface. However, observations of frost damage suggest the freezing air is usually deeper than the average height of most mounds. It has been shown that composting raises the soil temperature inside the mound, but this will not prevent succulent vines exposed to freezing air on the surface from being damaged.
3.11 Tillage, mounds, beds and green manuring


3.12 Other agricultural techniques

The most important innovations used by villagers in food production systems are described in Sections 3.7 to 3.11. A number of other agricultural techniques used in PNG deserve attention because they may become more important in the future, or because they demonstrate novel solutions to particular agricultural problems. The techniques described in this section are:

- Use of drains.
- Use of mixed crop gardens.
- Use of house gardens.
- The practice of placing pigs in gardens between crop plantings.
- Supporting crops with stakes.
- Cutting down fallow trees onto growing crops.
- Use of fences and other methods of creating barriers around fields or divisions between fields.
- Irrigation.
- Growing yam tubers in deep holes.
- Use of animal manure and inorganic fertiliser.
- Use of silt from floods to increase soil fertility.

**Drains**

Removing excess water from gardens is an important part of making crop production possible in saturated soils and increasing production in poorly drained soils. Drains have been a feature of PNG agriculture from its beginnings; the archaeological record of what is almost certainly agriculture at Kuk in Western Highlands Province, dated to 9000 years ago, is based on different phases in the draining of Kuk swamp (see History of agriculture). Around 63% of land used for agriculture in PNG is on mountains and hills (see Section 1.10), where steep slopes make drains unnecessary. Drainage has become more important since the introduction and widespread adoption of sweet potato as a staple crop from around 300 years ago.1

The use of drains to remove excess water is widespread in highland food production systems and the discussion that follows refers to this practice. Drains are also widely used in coffee, oil palm and cocoa plots. Drains are a very important part of agricultural systems in the northern part of PNG.

---

1 Archaeological research by Chris Ballard has shown that agriculture began on the swamp edges at Haepugwa, near Tari in Southern Highlands Province, over 2000 years ago but that the swamp centre was probably not drained until around 300 years ago. Drains were being constructed at Mogoropugua near Koroba before 1670 AD.
Eastern Highlands Province (Figure 3.12.1), where shallow drains are dug directly down the slope, in combination with the construction of long beds (see Section 3.11). In the Wahgi Valley, from western Simbu and through Western Highlands Province, drains are associated with the use of square beds. In the Lai and Nembi valleys in Southern Highlands Province, shallow, downslope drains similar to those used in Eastern Highlands Province are dug in conjunction with long beds. Drained swamps are a feature of agriculture in a number of locations in Southern Highlands and Enga provinces. Drains of impressive dimensions (up to 5 m deep) make it possible to cultivate sweet potato in the Kandep, Koroba, Kopiago, Tari and upper Mendi swamps. Outside the highlands, drains are important in the swampy southern part of Western Province and on a small area of floodplain near Maprik in East Sepik Province, where large ditches help remove floodwaters from gardens.

**Mixed crop gardens**

In all five highlands provinces, where land use intensity is high (see Section 1.2), smaller gardens of mixed species are planted (Figure 3.12.2). Mixed crop gardens are separated from the larger sweet potato gardens and their management is different. Mixed crop gardens contain up to 15 food crop species and sweet potato is usually excluded; they are smaller in area than the larger sweet potato fields that often enclose them; they are planted for shorter periods of up to twelve months; usually only one planting is made before a long fallow; they may be planted beneath pollarded casuarina trees (see Section 3.10); and the sites chosen are often less well

\[\text{Figure 3.12.1} \quad \text{The use of drains in food production systems. Source: MASP.} \]
drained than those used for sweet potato gardens. Mixed crop gardens are most often observed between 1500 m and 2000 m above sea level.

**House gardens**

House gardens (also known as ‘door yard’ or ‘kitchen’ gardens) are small areas that are cultivated with a number of food species, next to dwelling houses. House gardens are used all over PNG, but are almost universal in the highlands, southern Western Province, the western mountainous areas of Central Province, and parts of Milne Bay and New Ireland provinces (Figure 3.12.3).

House gardens are typically planted with a number of leafy green vegetables, sugar cane and pumpkin (pumpkin leaves are a commonly consumed green vegetable; see Section 3.2). They are maintained for long periods of time by the application of household rubbish: food scraps and peelings, ash from the house fire and sweepings from the house compound.

**The placing of pigs in gardens between crop plantings**

In restricted parts of PNG, pigs are tethered in gardens after the final harvest and prior to the next planting of sweet potato. This practice represents an intensification of pig management and has a number of benefits. It has been shown at Tari in Southern Highlands Province that pigs tethered in harvested sweet potato gardens gained weight significantly faster than pigs tethered in fallow grassland (probably because of a higher consumption of earthworms than of leftover sweet potato tubers).

---

3 Pigs in PNG are tethered by a rope, using a slip knot around the pig’s front leg.

---

**Figure 3.12.2** The use of mixed crop gardens in food production systems. Source: MASP.
In addition, the pigs break up beds and mounds and till the soil. Presumably, their dung and urine also contribute to soil fertility.

The placing of pigs in gardens between crop plantings is almost universal among the Goilala people of Central Province, and is widely observed in the highlands provinces except Eastern Highlands (Figure 3.12.4).

### Stakes

The use of stakes to support plants is widespread in PNG agricultural systems, but it becomes significant only where yams are an important crop (Figure 3.12.5). Other crops that are associated with a form of staking are bananas, where large bunches may be propped up or tied to stakes to prevent them breaking the main stem of the banana plant, and sugar cane, which is frequently staked to hold the canes off the ground.

In the Maprik area of East Sepik Province, lesser yam, greater yam and some other less important yam species are staked with stout 2–3 m long sticks. Yams are also trained up vines collected in the forest and tied to dead trees left standing in the garden. In this way, yams may climb up to five metres above the ground. Growers explain how the yam vine grows towards the sun, captures nutrients from the sun, and then, as the vine dries, drains those nutrients into the tubers beneath the ground. Yam staking is also important in southern Western Province, and parts of Central, Milne Bay, Morobe and Madang provinces. However, the staking of yams is not a universal practice. For example, lesser yam grown by Wosera people on the Amogu River floodplains is not staked, but the vines are arranged on the ground to give them maximum exposure to sunlight. Staking has been shown to increase yields of lesser yam.

![Figure 3.12.3 The use of house gardens in food production systems. Source: MASP.](image)
Figure 3.12.4 The practice of tethering pigs in food production systems. Source: MASP.

Figure 3.12.5 The use of stakes in food production systems. Source: MASP.
In a number of areas in PNG, the undergrowth in forest fallows is cleared and food crops are planted beneath standing trees. When the new food plants are established, around 8 to 10 weeks after planting, the trees are cut down on top of them. The areas where this is a typical practice have an average annual rainfall of over 4000 mm; the altitude ranges from near sea level to 1400 m; the soil is relatively infertile; and population density is low. There are two regions where this practice is common. One is on the lower slopes of Mount Bosavi, on the border between Western and Southern Highlands provinces. The other is in the north-eastern end of Gulf Province and nearby locations in Morobe Province (Figure 3.12.6).

Felling large trees onto the developing food plants results in much less damage than might be expected. Immediately after the felling, food plants disappear beneath a mass of twisted branches and tree trunks. However, the high rainfall, humidity and temperatures at this altitude result in the mass of leaves and small branches quickly decomposing and presumably contributing significant amounts of nutrients to the growing food plants. Within a year the trunks of large trees have all but disappeared. This technique reduces exposure of the soil to the very high rainfall and reduces the amount of weeding required. The gardens are planted only once before being fallowed again for up to 20 years.

A similar technique is employed north of Telefomin in Sandaun Province, but most of the trees are not felled. This is another area of very high rainfall (see Figure 1.5.1). The undergrowth beneath tall secondary forest is cleared and planted in taro. As the taro matures, more and more trees are killed by ringbarking or, if they are on the edge of a garden, felled outwards, to allow more light into the garden. This process is extended progressively across a garden site in a strip, exposing the soil to the heavy rainfall for only a short period. An associated technique in this area is the felling of all the trees on a garden site some years before it will be planted.
in taro. The felled forest decomposes rapidly and provides the soil with additional nutrients. A low secondary forest quickly colonises the site again but, when the site is planted in taro a few years later, the size of the trees that have to be thinned is much reduced.

### Fencing and other enclosures

Fences and other barriers around garden sites are used throughout PNG (Figure 3.12.7), mainly to keep out domestic and feral pigs and to a lesser extent smaller wild animals such as bandicoots. Fences also create a symbolic barrier that people must cross to enter a garden, which may deter theft of food, for example. In addition to fences, gardens may be surrounded by ditches and earth banks, and stone walls. Fences are commonly constructed from material that becomes available during the clearing of the garden site: cane grass and wood, bound together with split cane.

In the highlands in particular, fences are an integral part of the management of land and domestic pigs. In intensive highlands land use systems, cultivation periods are long, and so fences must last for a long time. They are commonly constructed from split casuarina wood palings, sharpened at each end. The fence is built by pushing one end into the ground and binding the tops together with cane. When the bottom end decays, the palings can be pulled out, reversed and pushed in again. In many parts of the highlands, individual fields are not fenced. Instead, a large area of many gardens, including land in a short fallow, is separated from land in a long fallow by a long perimeter fence. Pigs are allowed to forage in the fallow land and races are constructed to allow them to travel between the fallow land and housing areas without having to enter garden land. A study in Enga in 1980 estimated that 105 000 m$^3$ of timber per year, mostly casuarina, was used to make fences in the province. Old fences were also an important source of firewood. In the Tari area, deep ditches are constructed around gardens. Pigs and people

---

**Figure 3.12.7** The use of fences and other barriers in food production systems. Source: MASP.
travel along the ditches between homesteads and to foraging areas, without having to enter garden areas.

In many lowlands locations fences are less important than they were 50 years ago, following the introduction of shotguns and the subsequent reduction in the numbers of feral pigs. In the past, traps for feral pigs were commonly integrated into the garden fence. Fences were constructed every time land was cleared from a long fallow and were maintained only for as long as the land was cultivated, from between one and three years.

### Irrigation

Irrigation is not common in PNG, a not surprising situation in view of the very high rainfall received in many parts of the country. Irrigation systems existed where strong seasonal soil water deficits occur (see Section 1.5). But in a number of these places the importance of irrigation systems has decreased following the adoption of drought-tolerant sweet potato and cassava, and a decrease in the importance of taro, which requires more water to produce well.

Irrigation systems existed in the Kaironk Valley in Madang Province, in the Lamari Valley of Eastern Highlands Province, near Kabwum in Morobe Province and on the coast from Cape Vogel to East Cape in Milne Bay Province. At Kabwum irrigated plots were created on narrow terraces beside streams by heaping sods and cane grass roots against wooden barriers. This formed a series of small flooded enclosures in which taro was planted, with corn and other green vegetables. In the Lamari Valley, grassland and forest taro gardens were irrigated with water brought to gardens by bamboo pipes. Pipelines traversed several hundred metres. Use of irrigation had declined by the early 1990s, but in the Lamari Valley during the 1997 drought, water was again led to gardens using bamboo pipes. Two systems of irrigation were described in 1947 in the Wampit Valley, near Mumeng in Morobe Province, both associated with taro production. One involved damming a stream, diverting water into a ditch on the contour and letting water out of the ditch into furrows in a garden below the ditch; the second involved the use of bamboo pipes to bring water into gardens. These systems were not being used by 1992.

The only area where large-scale irrigation systems remain in use in PNG is on the coast near Rabaraba, in Milne Bay Province. Here streams are dammed at the top of large, gently sloping fans and water is led into ditches along the contour, from where it is diverted into gardens below the ditches. A shifting cultivation system producing a mix of staple food crops, including taro, banana, sugar cane, cassava and sweet potato, is maintained in this way. When fallow land is brought into cultivation, water is led through shallow ditches to the new garden. This system is threatened by flash flooding, which destroys the dams and water intakes. The floods are blamed on the clearing of forests in the headwaters of these streams.

### Deep holing

In the Maprik area in East Sepik Province and the Wantoat area in Morobe Province, greater yam is planted at the top of deep holes in order to grow tubers to an extraordinary length. In both locations, holes up to 2 m deep and 0.5 m in diameter are dug and refilled with a fine tilth of soil. The seed yam is planted in a small mound on top of the hole and the tuber grows down into the softer soil in the form of a single long tuber. Yams planted without this treatment will produce shorter and possibly forked tubers, depending on the hardness or stoniness of the soil. In both places the yam vines are supported on tall trellises, often made of bamboo.

At Wantoat, the holes are dug around the base of large, circular heaps of stones that have been cleared from the surrounding fields. When a field is cleared after a long fallow of 15–20 years, a search is made for the holes using a long steel rod (previously a long sharpened stick was used). The holes are then re-excavated, refilled with soil and the yams planted. At Maprik, the holes are dug on steep slopes. When the soil is replaced in the hole, a stick is inserted first and then withdrawn when the hole is full, to leave a small empty column down the centre of the hole. The seed yam is planted in a mound, which is supported
by a low wooden wall to prevent soil from falling
downslope. During the later part of the yam’s growth,
inspection tunnels are dug horizontally into the side
of the hole to monitor the tuber’s progress and to
assess the potential of the tuber in the competitive
displays and exchanges that follow.

**Use of fertilisers**

The manual addition of animal manure to cultivated
areas is unusual in PNG. Occasionally, chicken
manure from a chicken-raising project is added
to small plots of leafy green vegetables or other
food crops. Other materials used occasionally as
fertiliser are the skins and pulp from coffee berries
left over from processing, ash from wood fires, and
pig manure.

The application of inorganic (manufactured)
fertiliser on food crops is even less common than
the use of organic material. When purchased
fertiliser is used on food crops, it is almost always
in conjunction with growing vegetables for sale
(see Section 5.19).

**Use of silt from floods to improve
soil fertility**

In some low-lying areas, particularly along the Sepik
and Ramu rivers, garden land is regularly inundated
by floodwaters. These waters deposit a thin layer of
fresh silt on the garden surface, which helps improve
soil fertility. Another area where this is important is
south of Wanigela, Oro Province, on the alluvial flats
immediately inland of the coastal mangroves. On
the Sepik River, the planting and harvesting of crops,
and to some extent the crops used, are governed by
the annual rise and fall of the river. For example,
greater yam is common in food gardens on the
floodplains, whereas lesser yam is rarely planted. This
is because lesser yam takes longer to grow and its
tubers are not mature before the annual flood covers
the garden land.

**Sources**

transformations in the Southern Highlands of
Papua New Guinea. *Agricultural Transformation and
Intensification. Asia Pacific Viewpoint Special Issue*
42(2/3):287–304.

systems in Papua New Guinea. *Agricultural
Transformation and Intensification. Asia Pacific

Boyd, D.J. (2005). Beyond the Ipomoean Revolution:
sweet potato on the ‘fringe’ of the Papua New
Guinea highlands. In Ballard, C., Brown, P., Bourke,
R.M. and Harwood, T. (eds). *The Sweet Potato in
Oceania: A Reappraisal.* Ethnology Monographs 19
/Oceania Monograph 56. Oceania Publications,
University of Sydney and Ethnology, Department of
Anthropology, University of Pittsburgh, Sydney and

Carrad, B. (1982). The economy. In Carrad, B., Lea,
for Development. Volume 3 of Enga Yaaka Lasemana.*
Department of Geography, University of New

agriculture in Papua–New Guinea. In Hipsley, E.H.
Nutrition Survey Expedition 1947.* A.H. Pettifer,

relationships: outlining the technical system of Long
Yam cultivation and display among the Abelam
of Nyamikum village (East Sepik Province, Papua
New Guinea). PhD thesis. University of East Anglia,
Norwich.

Gorecki, P.P. (1979). Irrigated taro fields in the
highlands. *Oral History (Papua New Guinea)*
7(7):116–120.

*A Literature Review and Bibliography.* ACIAR
Monograph No. 108. Australian Centre for
International Agricultural Research, Canberra.
3.12 Other agricultural techniques


