The Decline of Taro and Taro Irrigation in Papua New Guinea

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Irrigated Taro (Colocasia esculenta) *in the Indo-Pacific*
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Taro is a very ancient food crop in Papua New Guinea (PNG) and was utilized in the highlands as early as 10,000 years ago. It was the most important food crop in PNG until about 300 years ago when it was displaced in the highlands (above 1200 m altitude) by the recently introduced sweet potato. In the lowlands, it remained an important food crop until the early 1940s. Since then taro production has been greatly reduced by a combination of taro blight, taro beetle and declining soil fertility. It is now the most important staple food crop in a limited number of remote inland locations. Taro provides only 4% of the food energy from the staple food crops, compared with 63% from sweet potato. In the 20th century, irrigation of taro was recorded as a generally minor practice at about 15 locations. There are indications that there was significant irrigation of taro in the seasonally dry Eastern Highlands prior to the adoption of sweet potato there. By the mid 1990s, taro irrigation was recorded as a significant practice at one location only. The glory days of taro and taro irrigation in PNG are now over.

1. Introduction

The mid-2011 population of Papua New Guinea (PNG) is estimated as 7.0 million. Most (81%) of the population are rural villagers who produce most of their own food, mainly from food 'gardens', but also from planted tree crops, self-sown trees, fishing and hunting. The balance of the population live in urban locations (13%) or in rural non-village locations (6%) such as high schools, mining or logging camps. A little over half (57%) of the rural village population live in the lowlands (sea level to 1200 m altitude), while the remaining 43% live in the highlands (1200–2800 m altitude) (Allen and Bourke 2009: Table 1.1.1).

Over the six-year period 1990 to 1995, a national level survey known as Mapping Agricultural Systems of PNG (MASP) was conducted of village agriculture (Allen *et al.* 1995; Bourke *et al.* 1998). The MASP surveys produced, amongst other things, data on distribution of staple food crops (Fig. 1). These surveys, combined with data from the 2000 national census, mean crop yields, food intake and other data, allow estimates to be made of the number of people growing the staple food crops and crop production (Tables 1 and 2). Using historical data, as well as a previous 1961 survey of village agriculture, the author has estimated the contribution to food energy of the most important staple food crops at six different periods (Fig. 2).

Table 1 Rural population growing staple food crops in 2000

Crop	Most important food		An important food		Grown for food	
	Population	%	Population	%	Population	%
Sweet potato	2,785,005	66	633,791	15	4,142,532	99
Banana	385,748	9	1,341,922	32	4,035,383	96
Taro (*Colocasia*)	265,094	6	1,026,171	25	3,991,472	95
Greater yam (*Dioscorea alata*)	–	–	167,122	4	2,508,298	60
Cassava	42,847	1	515,140	12	2,318,528	55
Chinese taro (*Xanthosoma*)	129,061	3	779,783	19	2,244,173	54
Coconut	1,662	<1	1,488,561	36	1,535,066	37
Sago	459,831	11	145,703	4	1,372,004	33
Lesser yam (*D. esculenta*)	271,968	7	237,093	6	1,369,959	33
Irish potato	–	–	120,881	3	668,769	16
Giant taro (*Alocasia*)	–	–	–	–	315,154	8
Queensland arrowroot (*Canna*)	–	–	–	–	184,334	4
Elephant yam (*Amorphophallus*)	–	–	–	–	139,707	3
Swamp taro (*Cyrtosperma*)	680	<1	3,466	<1	31,598	<1
Aerial yam (*D. bulbifera*)	–	–	–	–	21,538	<1
Yam (*D. nummularia*)	–	–	–	–	7,391	<1
Yam (*D. pentaphylla*)	–	–	–	–	3,436	<1

Percentages represent the proportion of total rural population (4,192,561 in 2000) growing 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. Source: Mapping Agricultural Systems of PNG database; Bourke and Allen (2009: Table 3.1.1)

Table 2 Estimated production of 18 staple food crops in Papua New Guinea in 2000

Crop	Weight (tonnes)	Weight (%)	Energy (kJ × 109)	Energy (%)
Sweet potato[a)]	2,871,851	63.57	11,422.68	62.77
Banana	436,496	9.66	1,260.98	6.93
Cassava	271,894	6.02	1,115.61	6.13
Taro (*Colocasia*)	229,088	5.07	748.14	4.11
Chinese taro (*Xanthosoma*)	226,536	5.01	739.81	4.07
Lesser yam (*Dioscorea esculenta*)	180,370	3.99	656.99	3.61
Coconut	100,929	2.23	633.88	3.48
Greater yam (*D. alata*)	91,358	2.02	294.54	1.62
Sago	82,962	1.84	1,240.00	6.81
Irish potato	18,759	0.42	55.77	0.31
Giant taro (*Alocasia*)	2,389	0.05	7.79	0.04
Queensland arrowroot (*Canna*)	1,431	0.03	4.69	0.03
Elephant yam (*Amorphophallus*)	1,217	0.03	3.98	0.02
Swamp taro (*Cyrtosperma*)	823	0.02	2.68	0.01
Yam (*D. nummularia*)	478	0.01	1.55	0.01
Aerial yam (*D. bulbifera*)	467	0.01	1.51	0.01
Rice	407	0.01	5.82	0.03
Yam (*D. pentaphylla*)	37	0.00	0.13	0.00
Total	4,517,492	100.00	18,196.54	100.00

[a)] Estimated sweet potato production includes that fed to pigs in the highlands. Source: Bourke and Vlassak (2004)

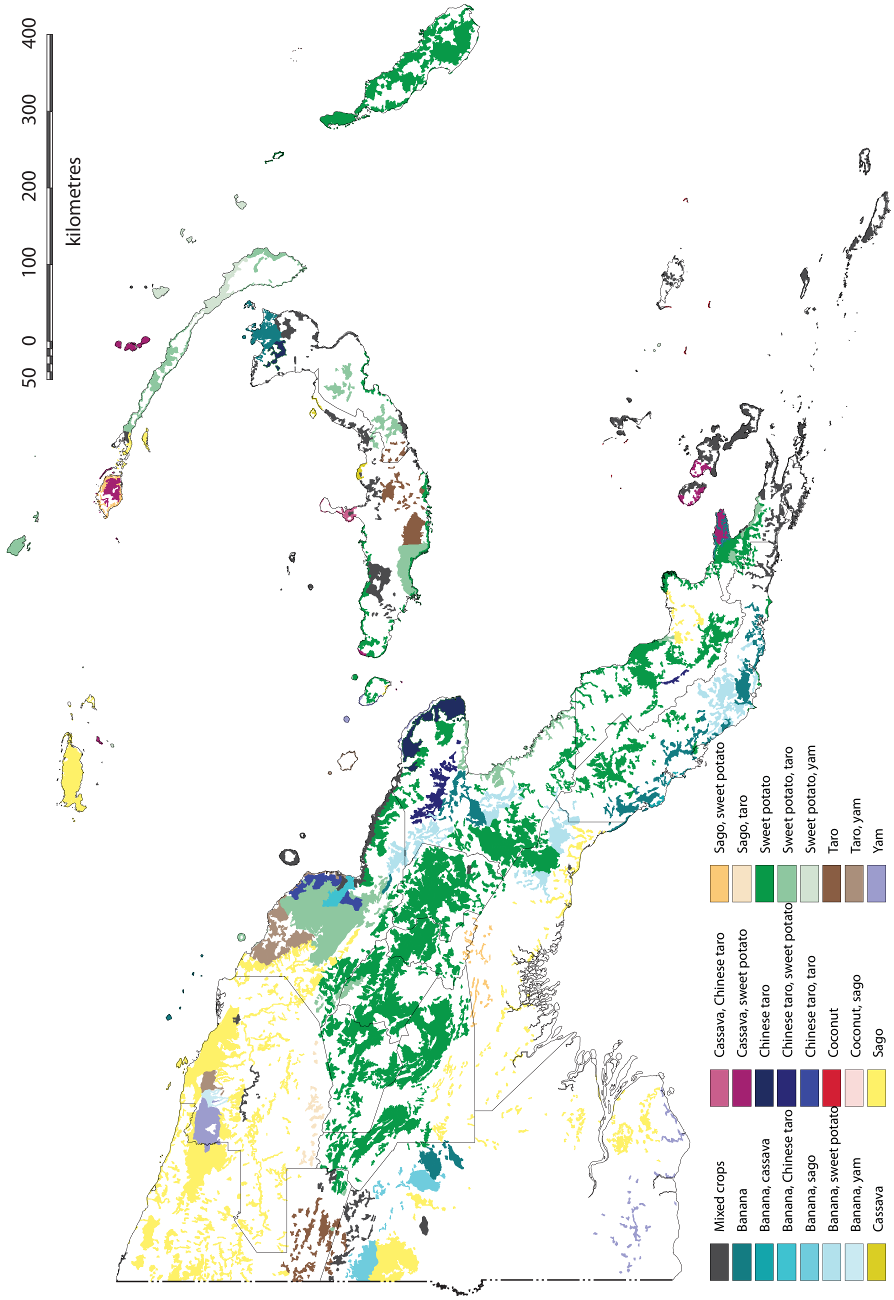

Figure 1 Distribution of the most important food crops in Papua New Guinea. Source: Mapping Agricultural Systems of PNG database (Allen *et al.* 1995; Bourke *et al.* 1998). Originally published in Bourke and Allen (2009: 198).

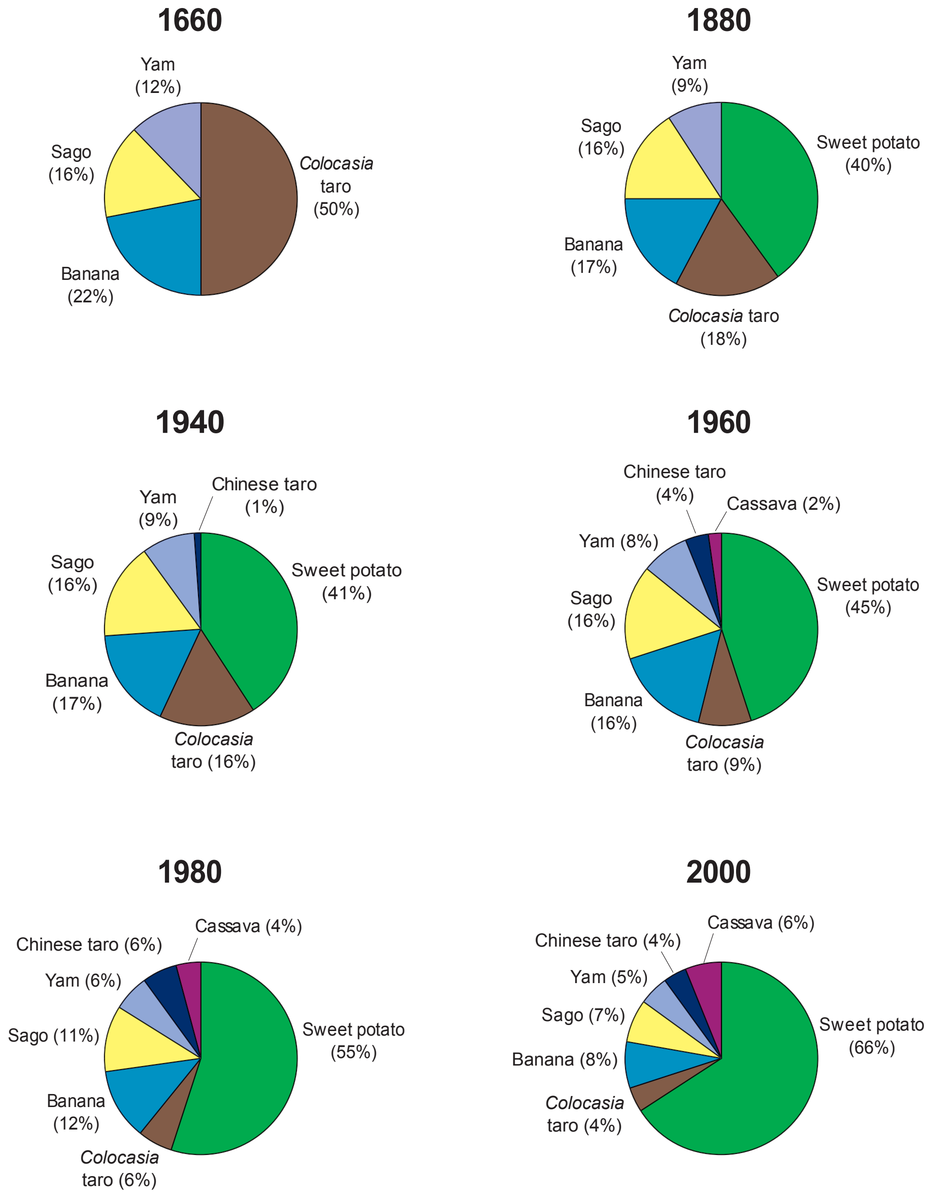

Figure 2 Estimated contribution to food energy of staple food crops at six different periods, 1660 to 2000 AD. Note: The year 1660 is arbitrary and was chosen to represent the period prior to the Long Islands volcanic eruptions and the subsequent adoption of sweet potato by about 1700 AD. The year 1880 represents the decade when written descriptions of village agriculture were first made in coastal areas, but before the pre-European patterns were altered. The year 1940 indicates the pattern immediately prior to the replacement of taro by sweet potato in Bougainville and elsewhere. Sources: 1660, 1880, 1940, 1980: author's reconstruction based on historical information (Bourke 2009); 1960: Walters (1963); 2000: Bourke and Vlassak (2004). Originally published in Bourke and Allen (2009: 199).

2. Taro in Papua New Guinea

Taro (*Colocasia esculenta*) is a very ancient crop in New Guinea and adjacent islands. Starch granules on stone tools at a cave site on Buka Island in the Autonomous Region of Bougainville have tentatively been identified as being from taro, within a stratigraphic unit radiocarbon dated to between 20,100 and 28,700 years before the present (BP) (Loy *et al.* 1992). Archaeological research over the past 40 years at Kuk swamp near Mt Hagen in the Western Highlands of PNG has shown that agriculture arose independently in New Guinea, with some cultivation as early as 10,200–9,900 years BP (Denham *et al.* 2003). Taro was utilized in the early Holocene at this site, that is, about 10,000 years ago.

Until about 300 years ago, taro was the most important food crop in PNG. It is crudely estimated that, prior to the widespread adoption of sweet potato in the highlands about 300 years ago, taro provided half of the food energy from the staple foods, with the balance coming from banana, sago and yam (Fig. 2). This proportion had declined to 9% by the early 1960s when the first national census of subsistence food production was conducted (Walters 1963) and to 4% by 2000 (Bourke and Vlassak 2004).

The decline in taro production has occurred in two periods: the first was about 300 years ago and the second has been over the past 70 years (1941–2011). Oral history and archaeological excavations suggest that taro was the most important food crop in most areas in the highlands, supplemented by some banana (*Musa* cvs) and yam (mainly greater yam, *Disocorea alata*) until about 300 years ago (e.g., Ballard 1995; Bayliss-Smith *et al.* 2005; Wiessner and Tumu 1998). Sweet potato was introduced into the highlands by about 1700 AD and began to replace taro as the most important food in most highland locations, probably within several generations, but at different rates in different regions.

When the first published records were made by European observers from 1871 onwards in the lowlands, and from 1919 in the highlands, taro was the most important food crop in many lowland locations, but a minor food in most highland locations. It is crudely estimated that in 1880 (a notional year), taro contributed 18% of food energy from the staple food crops (Fig. 2). A number of new food crops were introduced into the PNG lowlands from the early 1800s onwards, including 'Chinese' taro (*Xanthosoma sagittifolium*, a South American domesticate), cassava (*Manihot esculenta*), sweet potato and maize (*Zea mays*). The new food crops were incorporated into existing agricultural systems in the lowlands to a minor degree, particularly sweet potato, but the overall impact was small.

Then 70 years ago in about 1941, taro blight caused by the fungus *Phytopthora colocasiae* arrived in PNG and devastated taro production in some lowland locations. The disease was first introduced to Bougainville Island, part of PNG but geographically at the northeast end of the Solomon Island chain (Packard 1975). By the mid-1940s, taro had been almost completely replaced by sweet potato as the staple food on Bougainville and Buka Islands. The same occurred in the rest of the Solomon chain (now Solomon Islands) by about 1950. Taro blight spread to New Ireland and part of New Britain during the 1950s where, with other factors, it resulted in a decline of taro production. It came to Manus Island in the Admiralty Group in 1975 and destroyed most taro production within months (Rooney 1982). The disease caused widespread damage to taro production and its replacement by sweet potato in the late 1970s and early 1980s in a number of other locations, including the coastal strip southeast from Lae to Popondetta, and in inland lowland locations near the Indonesian border in Sandaun Province. The disease has caused the greatest damage in coastal locations where rainfall is high (above 2500 mm per year) and is well distributed throughout the year with no regular dry months. The impact has been less above about 300 m altitude and the disease is generally absent at altitudes above 1300 m (Bourke 2010: Table 6).

However taro blight was not the only reason for taro production to decline in PNG. High yields are obtained where soil fertility is high and, in lowland PNG, this is generally associated with fallows of tall woody regrowth of 10 or more years duration. Rapid population growth (2.7% per year from 1980 to 2000) is placing pressure on land resources. Villagers have reduced fallow periods and extended the cropping period before land is fallowed. This has led to a reduction in soil fertility. In most of the PNG lowlands, people have responded to the lower soil fertility by switching from taro and other crops which depend on higher soil fertility, to those which yield reasonably well, even as soil fertility has been reduced. The most important replacement food crop has been sweet potato, but *Xanthosoma*, cassava and triploid banana cultivars have also displaced taro.

Other factors responsible for the decline of taro include a build-up of virus diseases and taro beetle (*Papuana* spp.) infestation, high labour inputs relative to output, low availability of planting material, a decline in spiritual values associated with the crop and the availability of alternative easier-to-grow food staples (Bourke 1982).

The outcome of these changes are that, by 2000, taro was still widely grown, with 95% of the rural population growing some taro. However, it was the most important food crop for only 6% of the rural population, and an important food crop for a further 25% of the rural population (Table 1). Production in 2000 was estimated as about 230,000 tonnes per year, which provided only 4% of the food energy from the staple foods (Table 2).

2.1 Irrigation of taro in PNG

Over the period 1900 to 1990, irrigation of taro was recorded by outside observers in about 15 locations (Spriggs 1990: Table 1, Fig. 1). At most of these places, this was a minor component of the overall agricultural system. Soil moisture storage depletion was classed as moderate and irregular or as low and infrequent at most locations. The exception was in the Rabaraba area on the New Guinea north coast in Milne Bay province (Kahn 1984, 1986). There irrigation taro was an important component of the agricultural system. Drought is common in this area and soil moisture depletion is classed as 'severe and regular' with soil moisture below one third field capacity for more than 50% of each dry season (Spriggs 1990). In the highlands, the most important technique of true irrigation was simple flooding where water is led to the upper edge of the food garden and then circulates down. In the lowlands, the Rabaraba systems in Milne Bay Province utilize canal-fed island beds. Elsewhere in the lowlands there are occasional reports of pondfield irrigation as well as simple flooding (Spriggs 1990).

A sequence of terraces in the Arona Valley in the seasonally dry Eastern Highlands were originally identified as artificial and associated with prehistoric gardening designed to control water on the slopes (Sullivan *et al.* 1986). The authors of this preliminary study suggested that the terraces may have been associated with the cultivation of taro prior to the introduction of sweet potato several hundred years ago. Later investigations suggested that the terraces were natural features, but they could still have played a role in water retention enabling taro cultivation to be maintained despite the early deforestation of this landscape (Golson and Gardner 1990: 410). Given the marked annual dry season at this location and the water-loving nature of taro, it is probable that the extensive terraced landscape were used to grow taro prior to the widespread adoption of sweet potato about 300 years ago but do not represent a case of true irrigation.

Field visits were made to almost all rural locations in PNG over the period 1990–1995, as part of the Mapping Agricultural Systems of PNG project (Allen *et al.* 1995; Bourke *et al.* 1998). True irrigation was recorded at only two locations during six years of fieldwork. In the Kabwum area on the north side of the Huon Peninsula at 1200–1400 m in Morobe Province, very minor taro irrigated pondfields were observed (Bourke *et al.* 2002a: 59–61). In the Lamari Valley and nearby areas in Eastern Highlands, where irrigated taro had been reported from the time of first contact with outsiders in 1947 until 1980, no irrigation was observed or reported in 1990 (Bourke *et al.* 2002b: 79–81).

The only location where true irrigation remained important was in the Rabaraba area between Rabaraba government station and Topura village in Milne Bay Province (Hide *et al.* 2002: 37–39). This area is seasonally dry and experiences severe soil moisture depletion in most years. A weir has been constructed across a river to raise the water level so that it flows via a ditch to island bed taro plots. The population in this area in mid-2011 is estimated as about 4000 people, so the number of people irrigating taro today is a tiny fraction of the 5.7 million rural villagers involved in subsistence food production.

In 1997, much of PNG was impacted by a major drought, arguably the most severe in 130 years of recorded history. By the end of 1997, almost 40% of the rural population was suffering from severe food shortages (Allen and Bourke 2001). The irrigated taro system in the Rabaraba area continued to function. From the air, the irrigated taro plots and the irrigation channel stood out as bright green in an otherwise parched and burnt landscape. In the Lamari Valley in the Eastern Highlands, the defunct system of bringing water to taro plots via bamboo pipes and distributing it by simple flooding was briefly revived so that people could maintain their taro plots during the drought. It is presumed to have fallen into disuse after the drought ended in early 1998.

3. Discussion

Taro has made an enormous contribution to food supply for Papua New Guineans over the past 10,000 years. It was the most important food crop in PNG until in about 1700 AD. Oral history and archaeological research indicate that taro was displaced in the highlands by sweet potato about 300 years ago. In the lowlands, it has declined in importance over the past 70 years as a result of disease, taro beetle, declining soil fertility and changing social values. Taro is now the most important single food only in a limited number of remote locations in the Telefomin area in the highlands near the Indonesian border and at some locations in the inland Kandrian area of New Britain (Fig. 1). In these remote inland locations, taro blight is unlikely to devastate production because of the cooler temperatures.

At a national level, taro is still widely grown, but is the most important food for only 6% of the rural population (Table 1), and provides just 4% of the food energy from the staple foods (Table 2, Fig. 2). In contrast, the figures for sweet potato are 63% and 66% respectively. Taro is unlikely to regain its place as a major staple food in PNG. Its future may be as a high value crop grown for the domestic urban markets where people have the cash income to pay for a luxury food.

Given the demise of taro in PNG, irrigation is seen as having little potential to expand. Indeed the main issue for the now dominant staple food sweet potato is excessive soil moisture rather than inadequate soil moisture. Sweet potato is particularly vulnerable to excessive soil moisture, particularly at the tuber initiation stage. Villagers manage this issue by widespread mounding and drainage, as well as planting on sloping land. In a limited number of locations which experience a regular and severe soil moisture deficit, there may be limited potential for irrigating sweet potato, cassava, taro and other food crops. But the glory days of both taro and irrigation in PNG are now past.

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