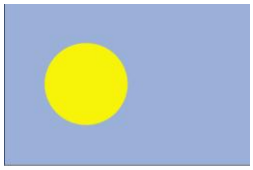
A technical assessment of the current agricultural conditions of Angaur Island Palau: with recommendations for the sustainable use of the island's natural resources



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Federal Ministry
for Economic Cooperation
and Development

A technical assessment of the current agricultural conditions of Angaur Island Palau: with recommendations for the sustainable use of the island's natural resources

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Contents

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Acronyms

CCCPIR	Coping with Climate Change in the Pacific Island Region SPC/GIZ Program
CIPI	Conservation International Pacific Islands (CIPI)
CoPopChi	Palau National Committee on Population and Children
ENSO	El Niño–Southern Oscillation
HDI	Human Development Indicator
HIES	Household Income Expenditure Survey
IESL	National UNDP Informal Employment and Sustainable Livelihoods
NOAA	National Oceanic and Atmospheric Administration
PIC	Pacific Island Country
SPC	Secretariat of the Pacific Community
TTM	Taiwan Technical Mission
UNDP	United Nations Development Program
USDA	United States Department of Agriculture

Currency: The currency of the Republic of Palau is the US dollar.

Executive Summary

Angaur is a 8.4 sq. km island located (6°54' N, 134°09' E) in the southwestern Palau Islands. The island makes up one of the Republic of Palau's 16 states.

Angaur has suffered considerable land degradation due to past phosphate mining as well as military action during WWII. Land degradation problems in recent years have been compounded by El Niño–Southern Oscillation (ENSO) high tides exacerbated by a gradual increase in average sea level attributed to climate change.

Germany discovered phosphate deposits on Angaur in 1903 and open pit mining commenced in 1909. The island was continuously mined until 1955, apart from a brief interlude in 1914 and during World War II. There were three distinct periods of phosphate mining operations on Angaur:

- 1909-14 -German mining period (estimated 285,000 tonnes extracted)
- 1915-44- Japanese mining period (estimated 2.8 million tonnes extracted)
- 1946-55 -US supervision of continued Japanese mining period (estimated 400,000 tonnes extracted)

German mining operations were entirely based on manual labour to source the most readily available phosphate. From 1935, Angaur's phosphate production increased dramatically as part of Japan's national self-sufficiency policy. To facilitate this increased demand, power excavation equipment was introduced in 1938 to enabled mining to be conducted below sea level. Pumps were used to lower the water table in the phosphate areas to a depth of 2 m below sea level. War activities saw a substantial reduction in phosphate mining in 1943. Mining operations ceased completely in 1945. Phosphate mining recommenced in 1946, as a part of a program to rehabilitate Japan's domestic agriculture, and ceased in 1955.

The people of Angaur find themselves in a precarious position with respect to food security. They have relatively low incomes and have very limited capability to grow their own food. This is due to a combination of factors:

- Salt contamination of the last remaining taro patch means that the preferred staple taro can no longer be effectively grown.
- What little taro that is still grown (mainly now for customary purposes) is severely damaged by monkeys.
- It is not possible to grow dryland taro due to insufficient depth of soil resulting of past phosphate mining.
- Fruit, of any kind (including coconuts), are rarely available for harvest due to the predatory of feral monkeys seeking moisture and food.

The identified constraints to agriculture and food production on Angaur are:

- A large and aggressive feral monkey population
- Degradation of the islands' remaining taro patch through salt contamination
- Insufficient topsoil for upland root crop production
- A severe labour shortage
- Inadequate transportation links

The eradication of the monkey population, or at least substantially reducing it to a manageable level, is a necessary condition for any worthwhile food production on Angaur. The first step in removing this overwhelming and binding constraint to food security and agriculture on Angaur is an unambiguous national government priority to eradicate/substantially control the macaque monkey population. An appropriate project to implement this policy needs to be designed. It is expected that specialist technical assistance will be required, with adequate long term funding to achieve the desired objectives.

The saltation of the remaining taro patch has reached a level whereby the taro (*colocasia esculata)* can no longer be viably grown. Taro is traditionally the most important food for the people of Angaur.

Superficial observation suggests that the remaining taro swamp is permanently damaged and beyond repair. However, hydrological investigations beneath the taro patch are necessary to confirm if this is true, and if not, whether appropriate remedial measures can be taken. It is possible that the primary reason for the salt contamination is the extreme ENSO induced high tides that have been experienced over the last decade. This is exacerbated by a gradual increase in average sea level attributed to climate change. If this was the case, it might be feasible to drain the swamp and to trial fresh water flow systems into the swamp. Technical assistance to undertake the required hydrological investigation would be justified on food security grounds and on the cultural significance of the island's remaining taro patch. An investigation of Angaur's drinking water wells should also be a supplementary component of the hydrological investigation, with the view of taking remedial measures.

Dry land taro and sweet potato production were traditionally important on Angaur and significant volumes were grown in pockets were there was sufficient depth of top soil. The blanket removal of top soil for phosphate mining means that such areas no longer exist. It is recommended that a pilot reclamation, with sufficient top soil, of one of the smaller mining pits that has already been partially reclaimed during the post-World War II period, be undertaken. Any program to plant food crops has to be based on the assumption that the macaque monkey population is eradicated, or at the very least brought down to manageable levels.

A major constraint to food production is the management and labour resources to do the work required. Angaur's population is disproportionally skewed toward the very young and elderly. Any sustainable expansion of local food production would require some reverse migration of younger people back to the island. To reverse a long term trend of outmigration would require a concerted effort from the wider Angaur community and in particularly from the Angaur State Government. The improvement of the

quality of life on Angaur through the eradication of feral monkeys, the reestablishment of clean drinking water supply, and improved transportation links, would be important necessary steps in the process. However, the establishment of broader and attractive employment opportunities will be critical if young people are to be attracted back to the island. Such opportunities are unlikely to be found in agriculture, as perceived by young Palauans. It is in the area of eco-tourism and related industries that the most enticing opportunities are likely to be found.

Angaur's major advantages would seem to lie with the island's unique environment, together with its historical cultural heritage. This could be complemented by growing high value hardwood timber, that is suitable to Angaur's hash limestone environment. Two major natural resource utilisation opportunities have been identified for Angaur:

- High value, low impact eco-tourism development based on a unique natural environment and history.
- The development of low labour, input agroforestry built around hardwood timber

The physical environment is distinctive and aesthetically attractive, despite underlying ravages of resource degradation. This forested raised limestone island lies within a world renowned marine environment. Angaur's biodiversity, while substantially degraded, remains significant and unique. Even the macaque monkey, could be converted from a liability to a unique eco-tourism asset within a ' jungle;' environment, if their population could be substantially reduced. Given the island's isolation, these environmental assets on their own would unlikely be sufficient to attract a significant number of visitors to Angaur. However, the island offers a unique set of eco-tourism attractions when environmental assets are combined with Angaur's rich historical and cultural heritage. Perhaps Angaur's main tourism marketing asset is its World War II heritage. As the theatre of the fiercest battles of the Pacific campaign, the island, and its neighbour Peleliu, are in-situ museums of battle relics and shrines.

The present small number of tourist arrivals is not surprising considering:

- there are no scheduled flights to the island;
- trips by sea are dangerous in inclement weather;
- there is no suitable accommodation for tourists on the island; and,
- there seems to be little or no promotion of Angaur as a destination in Palau's tourism promotion campaigns.

All these limiting factors would need to be addressed before a sufficient number of high value tourists could be attracted to Angaur. Angaur's contaminated water would also need to be dealt with before significant tourist numbers could be accommodated. The realization of Angaur's eco-tourism potential would require substantial investment from visionaries who recognized the benefits that could be obtained. Technical assistance can help in the identification appropriate investors and in promoting Angaur as a high value, low impact eco-tourism tourism investment opportunity. It can also have a role in the promotion of the island as a unique visitor destination. It is expected that the greatest potential for tourism development on Angaur is at the top end of the market. Thus any investment promotion

would be targeted accordingly. The fact that Angaur already has a substantial airstrip already in place will make this promotion an easier task.

The arrival of 500 to a 1,000 visitors a year, spending an average of 3- 4 days on the island, could potentially transform the economic and social landscape of the island. Tourism could create the type of jobs that would attract young Angaurians back to the island and create the critical mass of population. In particular, tourism opportunities are likely to attract women back to Angaur and help address the severe gender imbalance. Tourism could also generate the demand for high value agricultural products to be consumed on the island and in the suitcases of tourists when they leave the island. It would also mean an improvement in transportation links that would allow the marketing of agricultural products.

Current labour supply on Angaur is only sufficient to undertake minor subsistence activities. In contrast, the growing of timber is a far less labour intensive activity, which is not adversely affected by the presence of feral monkeys. High value timber trees can be planted and initially maintained utilising supplementary labour resources provided by government departments.

The leading candidate high value tree is Dort (*Intsia bijuga)*. Dort, which is native to Palau, grows well in limestone rock that is porous and fractured allowing the roots to penetrate to find pockets of soil and organic matter. Thus the tree is well adapted to Angaur, Peleliu and the limestone rock islands.

Intsia is one of the most highly valued trees in the Pacific islands, both in terms of its traditional cultural importance and its value as commercial timber[1].

Globally, *Intsia* is seriously threatened due to its overexploitation. The scarcity of *Intsia* has steady driven up its prices in real terms. The major constraint to attracting private investment into planting *Intsia* is the long rotation of the tree. Rotations of 50-80 years are likely to be necessary to produce the solid wood sizes necessary for some of its principal uses. Thus the reality is that those who plant the tree are unlikely to harvest the tree. This does not mean that there are no significant benefits to the current generation. Shorter term benefits to the tree planter, the community and the wider environment might include:

- The psychological benefit of planting something that will benefit the ones children and grandchildren.
- Soil conservation and land regeneration.
- As a primary tree crop in an agro forestry system.
- Income generation for the planters of long rotation trees.

A detailed project feasibility/design activity will be required for the planting of *Intsia bijuga* as part of an agroforestry system. It is envisaged that technical inputs for this could be obtained from GIZ//SPC. Consideration would be given to prospects of security carbon credits from a forestry rehabilitation program. It is envisaged that the implication of the tree planting would come under the auspices of the Palau Forestry Division of the Bureau of Agriculture.

[1] Intsia bujiuga is know by the trade name “Merbau”

A list of potential activities to support Angaur's agricultural and natural resource rehabilitation have been identified. These are:

- Technical assistance for the eradication/control of feral macaque monkeys.
- Technical assistance for the adaptation of food production to the presence on monkeys.
- Adequate long term funding to achieve appropriate monkey eradication/control/adaptation objectives.
- Hydrological investigations beneath the taro patch to determine the cause of saltation and determine if appropriate remedial measures can be taken.
- Design and implement, if feasible, appropriate remedial measures for the rehabilitation of the taro swamp.
- Design and implement, if feasible, appropriate remedial measures for the rehabilitation of the potable water supply.
- Investigate the feasibility of a small scale pilot reclamation of an appropriate mining pit using top soil and compost assembled on Angaur. The objective would be to plant dry land root crops as part of an agroforestry system involving appropriate timber trees, spices and fruit trees.
- Technical assistance in identify appropriate investors and in promoting Angaur as a high value, low impact eco-tourism tourism investment opportunity.
- A detailed project feasibility/design activity for the planting of *Intsia bijuga* as part of an agroforestry system.
- Support for an applied research program on suitable management regimes for *Intsia bijuga* and other suitable high value timber species that are cultivated as part of an agroforestry system.

A technical assessment of the current agricultural conditions of Angaur Island Palau: with recommendations for the sustainable use of the island's natural resources

Background to the study

In 2010the government of Palau requested support from the government of Germany through the Permanent Mission of Germany to the UN to assess the agricultural conditions on the island of Angaur and to develop recommendations for measures to adapt to and mitigate climate change as well as for the sustainable use of natural resources.

This Mission was undertaken under the auspices of the SPC/GIZ Coping with Climate Change in the Pacific Island Region (CCCPIR) program based in Fiji. The study was undertaken by agricultural economist Dr Andrew McGregor, with assistance provided by Palau-based agriculturalist Mr Robert V. Bishop. Field work was conducted in Palau from April 5th-12th, 2011. The fieldwork comprised of two days on Angaur, and seven days of stakeholder consultation in the Koror and Babeldaob States.

Country Background

Key national geographic, economic and social indicators for Palau are present in table 1.

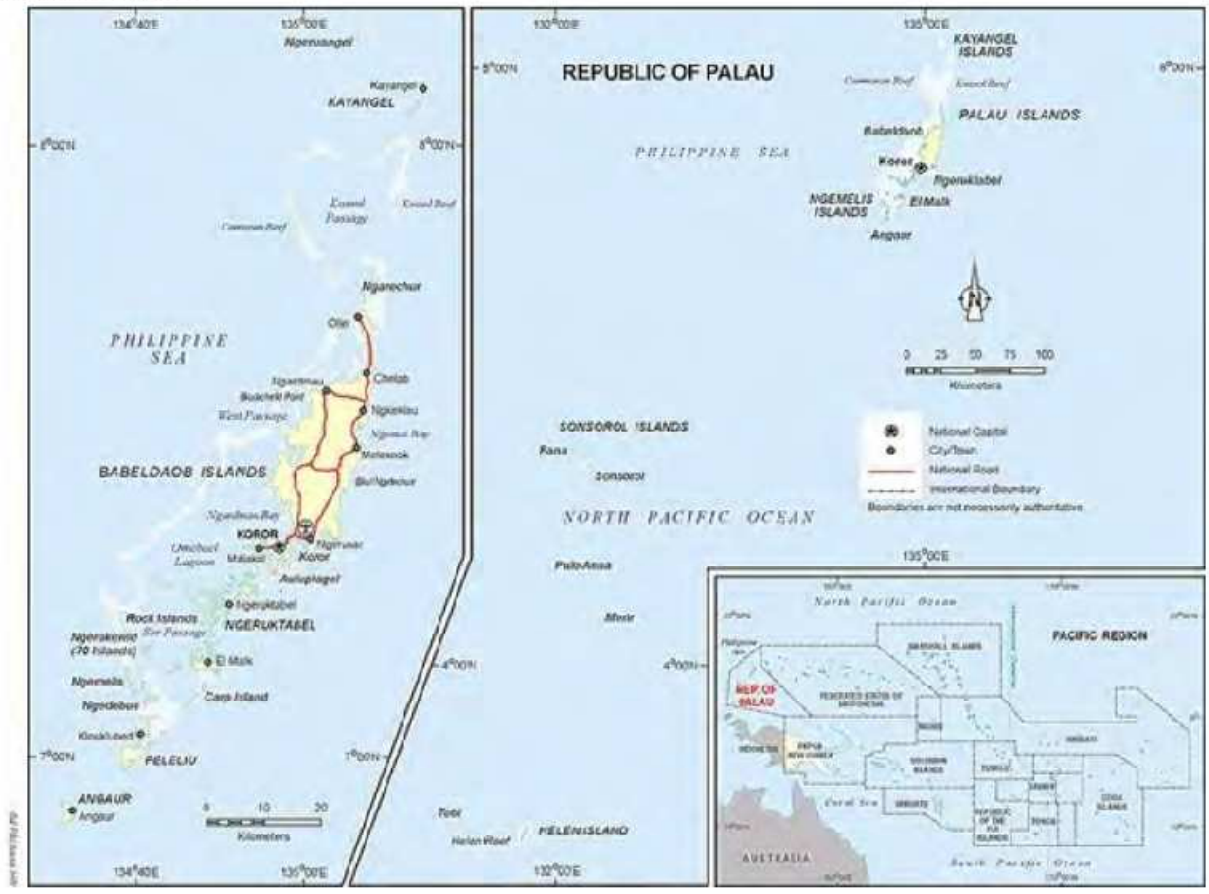
Table 1: Some key geographic demographic, economic and social indicators for the Republic of Palau

Land area	488 sq .kilometres
Total forest area	350 sq. Kilometres
Area classified as arable	14 percent
Exclusive economic zone	3,120,000 sq. kilometres
Population (2007 est.)	20,227
Population classified as Palauan	82percent
Population density (mid-2008 estimate)	41 persons per sq. kilometre
Annual intercensal population growth	0.6 percent
GDP (2007 est.)	USD 160 million
GDP per capita (2007 estimate)	USD 8,412
Urban population living below basic needs poverty-line (2006)	26.2 percent
Rural population living below basic needs poverty-line (2006)	28.9 percent
Agriculture as a percentage of GDP (2005)	1.1 percent
Fisheries as a percentage of GDP (2005)	2.0 percent
Tourism as a percentage of GDP (2005)	12.2 percent
Public administration as a percentage of GDP (2005)	22.9 percent
Total services as a percentage of GDP (2005)	61.7percent
Real GDP growth	5.5 percent
CPI annual growth	7.7 percent
Exports (2006/07 estimate)	USD 10.0 million
Imports (2006/07 estimate)	USD 91.2 million
Trade balance (2006/07 estimate)	USD minus 81.2 million
Tourist arrivals (2006)	86,275

Crude birth rate per 1,000 (2006)	12.0
Crude death rate per 1,000 (2006)	6.6
Total fertility	2.0 children per women
Infant mortality per 1,000	20.0
Male life expectancy at birth	67.8 years
Female life expectancy at birth	75.7 years
Urban population	64 per cent
Dependency ratio (15-64 years)	44
Medium age	33.7 years
Youth (15-24)	15.3 years
Male labour force participation rate (2005)	75
Female labour force participation rate (2005)	64
Access to main electricity	99 percent households
Access to public sewerage or a septic tank	85 percent households

Source: SPC Statistics and Demography Programme (and its Pacific Regional Information System PRISM www.spc.int/prism)

Map of Palau



Source: Government of Palau/SPC (2009)

The Palau group comprises around 340 islands with a total land area of 488 km^2. The four larger islands (Babeldaob, Arakabesan, Koror, and Malakal) are volcanic. The remainder are raised coral limestone islands (including Angaur), with the exception of the northern island of Kayangel and some of the

remote South West Islands, which are atolls. The archipelago lies between 6^0 50' and 8^0 15' North latitude and 133^0 50' and 134^0 45' East longitude. Palau lies in close proximity to South East Asia and Papua New Guinea (location map). The Philippines are only 800 km to the west and the Southwest islands are closer to Indonesia than they are to Koror.

Babeldaob (the Big Island) is by far the largest island with an area of almost 400 km^2. It also contains most of Palau's limited arable land. The islands have a remarkably diverse flora. Some 72% of the land mass remains under some sort of forest cover, with eight classes of forest delineated (mangrove forest, casuarina forest, swamp forest, upland forest, plantation forest, limestone forest, palm forest, and atoll forest). Even the raised limestone rock islands, such an Angaur are characterised by a rich vegetative cover.

Just south of commercial centre on the island of Koror are some 300 limestone islands known as the 'Rock Islands.' The largely uninhabited limestone uprises are world-renowned for their beaches, lagoons and marine lakes and as a diving destination. Further south (one hour's travel time by speedboat) are the raised coral islands of Peleliu and Angaur. A further 350 -550 km to the extreme south are located the sparsely populated and ethnically distinct Southwest Islands.

A barrier reef 125 km long and up to 60kmwide surrounds Koror, Babeldaob, the Rock Islands, and Peleliu. Angaur lies outside this barrier reef. The larger maritime Exclusive Economic Zone encompasses 422,530sq.km, and holds substantial deep-water marine resources.

It was not until 1891 that Palau formally came under foreign political domination. This lasted for just over a century. Successive colonial powers were Spain (1891-99), Germany (1899-1914), Japan (1914-45), and the United States (1945-94). Palau achieved independence in 1994 but maintains close political and economic ties with the United States through a Compact of Free Association. The Compact is a 50-year political, strategic and economic treaty under which Palau conducts its own domestic and foreign affairs while the United States maintains control of security and enjoys strategic access to land and sea areas.

Palau is a constitutional Republic, with a constitution modelled loosely on that of the United States. There is a national government with an elected president and 16 states administered by an elected governor and assembly.

Demographic considerations

In terms of population, Palau is one of the smallest countries in the world. Amongst Pacific Island Countries (PIC), only Nauru, Tuvalu, Wallis and Futuna, and Tokelau are smaller. At the time of the 2005 Census, Palau's population stood at 19,907, of which 82% were classified as Palauan. The 2005 population census revealed a sharp decline in population growth to only 0.8%, from well above 2% for the previous census period (table 2). At any one time, there is likely to be an additional 3,000 tourists in the country, with annual tourist arrivals of around 85,000 (Palau Office of Planning and Statistics).

Table 2: Palau population and growth rate: 1986 – 2005

Census Year	Population	Average annual growth rate (%)	Urban Population		Rural Population	
			Number	Percent	Number	Percent
1986	13,873	2.3	9,442	68.1	4,431	31.9
1990	15,122	2.2	10,501	69.4	4,621	30.6
1995	17,225	2.6	12,299	71.4	4,926	28.6
2000	19,129	2.1	13,303	69.5	5,826	30.5
2005	19,907	0.8	15,399	77.4	4,508	22.6

Source: SPC PRISM

Palau, unlike most PICs, is an urbanised country. At the time of the 2005 Census, 74% of the population lived in and around the civil and commercial centre of Koror. The overall density of the resident population was a relatively low 41 persons/km^2. However, for Koror the density was around 700 persons/ km^2. These demographic factors have important implications for the prospects and nature of agricultural development.

Terrestrial Resources

Soils

Most Palauan soils can be described as infertile, highly acidic, and erodible. In contrast, the soils of the limestone islands tend to be highly alkaline. Only approximately 14% of Palau's land (6,700 ha) is regarded as arable by virtue of soil type and slope (USDA, Soil Conservation Service). Cassava, the main planted staple, is sometimes planted on land not classified as arable. However, cassava is a heavy feeder, the continuous replanting of which degenerates soil to the point that it is of little or no cropping value and the cassava becomes bitter. Significant areas of land on the big island of Babeldaob, are in a degraded state, particularly areas that were mined for Bauxite during the Japanese colonial era. On Angaur, there has been considerable land degradation due to past phosphate mining as well as military action during WWII.

Bishop (2001) reports that the availability of arable land in Palau exceeds current needs and that there is considerable potential for expanded production of vegetables, fruits and staple crops without further clearing of forested land.

Forestry Resources

In 1994, it was estimated that primary forests (inclusive of mangroves) covered 75% of Palau. Mangrove areas comprise approximately 11% of Palau's land area.

These forests contain a rich diversity of terrestrial life including 1,258 species and varieties of plants of which 839 are indigenous and 104 are endemic (Bishop 2001). The species composition differs significantly between the volcanic islands in the north (Babeldaob, Arakabesang, Malakal, and Oreor) and the limestone islands in the south (Peleliu, Angaur and the Rock Islands). The volcanic islands support a number of landscape vegetation types, including strand vegetation, interior volcanic forest, riparian forest, and savannah and fernland on degraded soils (Donnegan ,2007). The southern, raised

limestone islands support evergreen, closed-canopy forest that is quite species rich and variable from island to island (Donnegan p.5, 2007).

Marine Resources

Palau is located on the north-eastern margin of the biologically rich 'Coral Triangle' that covers the tropical marine waters of the Philippines, Indonesia, Malaysia, Solomon Islands, Timor-Leste and northern Papua. With respect to marine species diversity, Palau is generally higher than other Pacific island areas and the most diverse area of Micronesia (Colin p. 25, 2009). Colin notes in particular that nearly all shallow water marine habitats are present in Palau. The Palau islands, within a relatively small area, probably have greater diversity of tropical marine habitats as any-comparably-sized area anywhere in the world (Colin p. 25, 2009). This makes Palau a particularly desirable destination for divers and snorkelers.

The economy: an impressive record but vulnerable

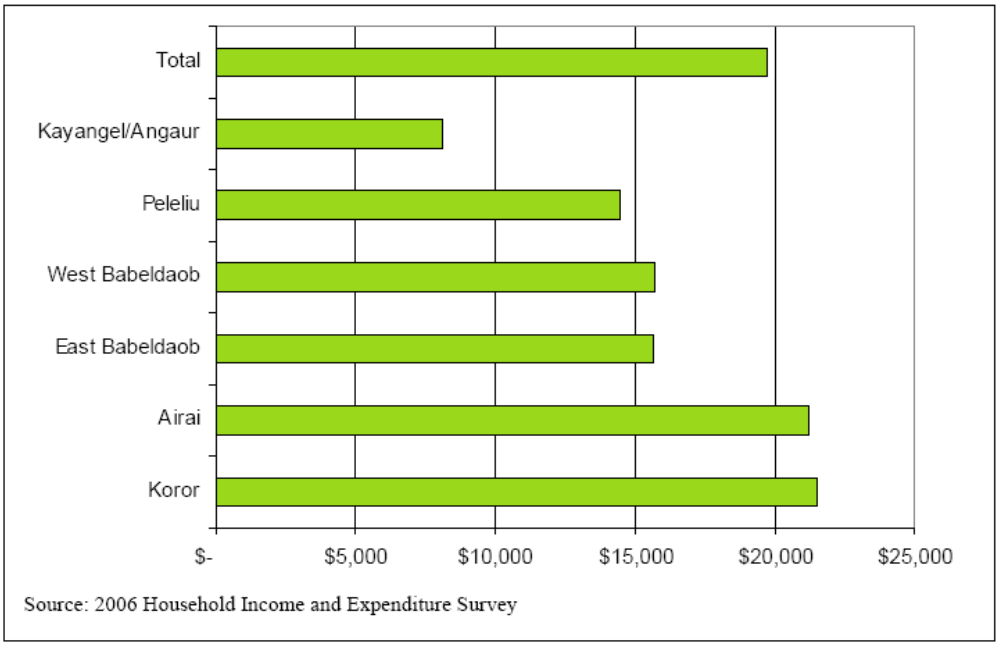
Palau is one of the world's smallest economies, with an estimated Gross Domestic Product (GDP) in 2007 of USD 160 million (SPC PRISM). Despite it remoteness and size, Palau enjoys a per capita GDP of approximately USD8,400, the highest of any independent Pacific island country. However, this figure is distorted by Palau's exceptionally high aid per capita. Palau also ranks the highest in terms of the UNDP's Human Development Index (HDI)[2]. Yet, due to Palau's unique relationship with the United States comparisons are often made with Guam and Hawaii. Palau's GDP per capita is less than a third of that of Guam and about a quarter of Hawaii (Bank of Hawaii p.15, 2000). In common with most Pacific island countries, there is a large income disparity between the centre and the outer island periphery. The 2006 Household Income and Expenditure Survey estimated the average household for income at $22,000 compared with $7,600 for Angaur/Kayangel (figure 1).

Over the past 35 years, Palau's economy has grown rapidly from a GDP estimated at USD14.5 million in 1975 to USD144 million in 2000, standing at USD 160 million in 2007. However, in recent years the Palau economy has contracted[3]. In recent decades there has been a significant shift in the composition of the economy away from primary production toward services. In 2005, agriculture and fisheries constituted 3.1% of GDP (down from 25% in 1990) while services constitute 62% of the economy (SPC PRISM). A small manufacturing industry accounts for less than .5% of GDP.

[2]The HDI from the 1999 UNDP Human Development Report Pacific Islands are: Palau .860Cook Islands .860; FSM .568; Fiji Islands .668; Kiribati .507; Marshall Islands HDI .568; Niue .677; Papua New Guinea .302; Samoa .598; Solomon Islands .370; Tonga .654; Tuvalu .590; and Vanuatu .408.

[3]Negative annual GDP growth rates were experienced in the years 2006 through 2009, at the rates of -3.7%, - 0.5%, -4.9%, -2.1% respectively (ADB 2010). Some recovery was experienced in 2010 with a positive growth rate of 2% recorded.

Figure 1: Average Household Income by Region, 2006



There is an inherent fragility in Palau's economy, which is heavily biased toward services and public sector infrastructure development and heavily dependent on tourism and foreign aid. All services, including public services and tourism, accounted for 62% of GDP in 2005. Public administration's contribution to GDP was 23%. Payments under the Compact of Free Association (the Compact) with the United States had enabled Palau to maintain a large public service and high levels of public sector investment.[4]

Tourism offers perhaps the best prospects for the development of the Palau economy. However, there are divergent views on the rate and direction of this development (Palau National Committee on Population and Children/United Nations CoPopChi 1997p.43).The 13% drop in tourist arrival numbers in 1998, due to the Asian economic crisis, shows the potential vulnerability of an economy heavily dependent on tourism. The recent Japan earthquake/tsunami caused a similar drop in Japanese tourist arrivals (32.4% of tourist arrivals in 2009). The multiplier impact of tourism is also likely to be quite low, with most visitors coming on package tours paid for in Taiwan, Korea and Japan. The economic impact of tourism could be greatly increased if greater linkages to agriculture could be achieved.

[4] The Compact is a 50 year political, strategic and economic treaty with the United States that commenced in 1994. Over the period 1994-2009, a total amount of USD630 million is to be paid (Bank of Hawaii 2000). Under the broad framework of an Economic Development Plan, Compact funds are designated for three general uses: 1) funding government operations to maintain a certain level of public service (employment) while the economy moves towards greater reliance on markets and the private sector, 2) building of a basic infrastructure such as roads, energy, transport, communication and water facilities with which Palau can develop an independently-functioning and eventually self-supporting economy, and 3) a trust fund (initially about USD70 million) that accumulates enough cash reserves in the first 15 years of the Compact to generate interest income that will replace the budgetary aid provided by the United States during that period (Bank of Hawaii p.6, 2000).

Palau, like many economies of comparable size and structure, has a large merchandise trade deficit. In 2006/07, total exports (mainly fish, some garments, and a small quantity of betel nut) totalled USD10 million, while imports were USD91.2 million. It is noticeable that this trade deficit has been widening. In 1994, total exports were USD12.6 million compared with imports of USD44.2 million. The difference has been more than made up by tourist receipts and until recently Compact payments and grants[5]. Thus, Palau, unlike a number of other PICs, has not as yet, had to face significant balance of payments problems.

Agriculture and food in Palau[6]

Traditional agriculture

Traditionally Palauan agriculture, as described by Bishop, featured an environmentally sustainable multi-story agroforestry system, in which tree crops provided a protective canopy, which supported the intensive production of 40-50 plant varieties (Bishop 2001,p. 14). Traditionally, every Palauan woman had a garden (or gardens). According to Bishop, female-produced agricultural products together with male and female harvested marine and forest products provided a self-sufficient food system with in-built security against natural and economic disasters, pest intrusion, and old age.

Contemporary self-sufficiency and informal agriculture

Today, remnants of the traditional system still remain although less than three percent of land is now under agro-forestry production. An additional 1% of land is estimated to be under non-traditional cultivation (e.g. without tree cover). Most mature rural women and many urban women produce some of their household's food needs through cultivation of a garden or gardens. Typically, women will have one or more taro gardens each and at least one dry land garden for cassava. The taro gardens most closely resemble the traditional agro-forestry system although contemporary gardens are less intensively cultivated than those of the past. Although traditional methods of composting and mulching are still used, imported agricultural chemicals are also in use. Most crops produced in this informal economy are used for family food and customary exchange. Only small volumes reach the market and still smaller volumes are reflected in official economic statistics. It is for this reason that agriculture's contribution is significantly under estimated. Estimation of the agricultural sector's contribution to GDP have been notoriously inaccurate in PIC national accounts and Palau is likely to be no exception. Problems particularly arise in measuring the subsistence component of GDP (see McGregor 1999). The under estimation of the value of subsistence in Palau was demonstrated for Palau with the (IESL) Project (UNDP 1997).

Subsistence crop production remains the predominant agricultural activity in Palau, with the main crops being taro, cassava, sweet potato, banana and coconut. Betel nut and betel pepper leaf are also

[5]Over the period 1994-2009, the Compact paid approximately USD 630 million to Palau for three general purposes: (1) budgetary support for government operations: (2) infrastructure development as a catalyst for economic development: and (3) establishment of a trust fund, the proceeds from which will provide budgetary support after Compact revenues ceased in 2010.

[6] This section draws heavily on Bishop (2001)

commodities of considerable importance. 'Backyard' chickens and pigs are also important. Under-representation of informal production greatly complicates analysis of agriculture productivity. Bishop reports a 1996 survey that placed the value of the informal sector (consisting primarily of agricultural products) at $5 million, or twice the value of agricultural products recorded in official economic statistics. A significant proportion of the population earns a livelihood from the informal sector. This same survey reports an estimated almost 3,000 people generate income from the informal sector (Palau Informal Employment and Sustainable Livelihood Project ,p. 2). Of this total, it was estimated that there were 665 persons involved in agricultural production and marketing, of which 86% were women.

Another survey estimated the betel nut trade (consisting of domestically produced nuts, leaves and lime) to be valued at USD 9.8 million(Pestelos 1997, p. 1). Betel nut plays a similar role in the economy of Palau as kava does in the economies of Vanuatu and Fiji. Similarly, excessive betel nut consumption has serious health and nutrition consequences. It is also understood that significant volumes of marijuana are grown. However, because the production and sale of marijuana is illegal in Palau no official information is available of this crop.

Commercial agriculture

The Japanese colonial government in Palau made considerable efforts to encourage commercial agricultural development. During the Japanese colonial period, Palau developed a significant commercial agriculture sector. During this period, the copra industry was developed and expanded, and the growing of cassava, rice, and oil palm introduced (Pacific Islands Year Book1999, p. 429). With the exception of subsistence cassava production, none of these industries remain today.

Bishop (2001) reports that agriculture and forestry sectors have not been accorded national priority in Palau since the Japanese occupation of the nation in the inter-war period. Consequently, agricultural and forestry development is beginning from a low base and is typified by limited technical and managerial skills, coupled with limited private or public investment in the sector. According to the tabulations of the 1994 Agricultural Census, there were only 16 full time farmers in Palau, who employed 48 workers (p.1). Those employed are almost entirely foreigners – sourced from the Philippines, Bangladesh, and China.

The commercial sub-sector largely focuses on market gardening of vegetables and some fruit crops. The main crops are cucurbits (particularly cucumbers), beans, and cabbage. These are the dominant supplier of the hotels and supermarkets. Conspicuously absent in Palau are municipal produce markets, which are at the hub of most commercial small holder agriculture in most Pacific island countries.

Agriculture in the Palau economy

Despite there being significantly more agricultural activity in Palau than is recorded by official statistics, agriculture is now a minor and a relative declining sector in the Palau economy.

Contribution to GDP

According to national account statistics, agriculture and fisheries contribution to GDP is a little less than 5%, with agriculture's contribution estimated at 1.1% in 2005. In 1983, agriculture's share of GDP was estimated at 9.8%.

Agricultural exports and food imports

Palau's agricultural exports are restricted to insignificant quantities of betel nut and cassava to Guam. It is of note that no betel nut is currently exported to Pohnpei, on account of the FSM quarantine authorities concern that it may be a host for Oriental fruit fly.

Palau has high and increasing levels of food imports. According to the Bureau of Revenue, Customs and Taxation, the value of food imports was USD11 million (about 20% of total imports) in 2006. Food imports constitute over 10% of GDP, compared with agricultures contribution of a little more than 1%. Ryan (2009) notes that food imports have grown by 133 % in the last decade, while the population has increased by 20% (p.1). The 2006 Household Income and Expenditure Survey (HIES) shows imported food constituting between 81% and 84% of total food consumption. A study by Judy Otto found that imported food constitutes more than 90% of the average household diet (Otto 2000). This makes Palau perhaps the least food secure Pacific island country (McGregor *et.al.* 2009)[7]. To date, Palau has been able to bridge the food import gap with foreign exchange earned through services (largely tourism) and aid transfers.

Public health and nutrition

Palau enjoys a high standard of health, demonstrated by low infant mortality (20 deaths per 1,000 live births) and high life expectancy (71.8 years) (SPC PRISM). These excellent indicators are the result of sanitation, education, and public health services standards, which have communicable diseases under control. However, the CoPopChi note Palau is at a transitional stage with respect to health. To quote:

> changing lifestyles and **dietary patterns** combined with alcohol, tobacco and betel nut use and abuse threaten to spawn an epidemic of non-communicable diseases which create new challenges for both public health and curative services (1999 p. 109).

The CoPopChi concluded that besides tobacco, the single greatest factor affecting the health of Palauans is diet and related obesity (1999). The prevailing dietary patterns, which contribute to overweight and associated ill heath were listed as:

- a general pattern of over-consumption relative to exercise;
- over-consumption of protein in general and low quality protein in particular (e.g. canned meats high in salts, fats and preservatives);
- low consumption of fruit and vegetables;
- high consumption of rice and declining consumption of more nutritious taro;
- a preference for imported processed food; and,
- low levels of nutritional awareness.

[7] Estimates of the proportion of Imported Food in Total Food Expenditure derived from HIES include:

- Solomon Islands, 35–44% (2006)
- Samoa, 56% (2002)
- Tonga 45% (2001)
- Federated States of Micronesia, 39% (2005)
- Kiribati, 36% (2006)

Palau's low overall consumption of fruit and fleshy vegetable can in large measure be attributed to damage caused by Oriental fruit fly(McGregor 2000). The Oriental fruit fly (*Bactrocera dorsalis*) is a relatively recent introduction to Palau, dating back only to the mid – 1990s. It is reported that prior to its arrival, fruit flies in Palau did little obvious damage (Allwood *et.al*. 1999). Now, most of Palau's fruit and fleshy vegetables are affected by fruit flies with varying degrees of severity. The consequences are particularly severe in terms of food security and nutrition. A study undertaken in 2000 that looked at the feasibility of eradicating Oriental fruit fly concluded that the presence of Oriental fruit fly has severely limited the agricultural development opportunities for Palau (McGregor 2000). The study also concluded that it would be technically and economically feasible to eradicate Oriental fruit fly on Palau. However, these recommendations were not acted upon.

Obesity, combined with high sugar and salt intake, results in increasing prevalence of chronic diet-related diseases – hypertension, diabetes, gout, renal disease and cardiovascular diseases. The Palau National Plan for Action in Nutrition points to the particularly dramatic increase in diabetes. The Plan further notes that specific micro-nutritional deficiency problems are now becoming apparent – notably nutritional anaemia amongst women of reproductive age and vitamin A deficiency amongst children[8].

Collectively, these lifestyle and diet related health problems significantly reduce the wellbeing of individuals and households. The adequate consumption of fruit and vegetables has a critical contribution to make in addressing health problems and reducing their cost to society.

The poverty situation

The analysis of the 2006 Palau Household Income and Expenditure Survey concluded:

> Poverty and hardship in Palau do not mean hunger or destitution, but, in a high-cost society which enjoys a comparatively high standard of living with good access to many basic services, those HH which are in the lower expenditure deciles, and where households might be classed as "working-poor", will be struggling to meet daily/weekly living expenses. The low level of home food production and the heavy reliance on imported food and other non-food "essentials" means that having a regular cash income is vital, although clearly not always sufficient to meet the cash costs (Palau Office of Planning and Statistics and UNDP Pacific Centre 2006).

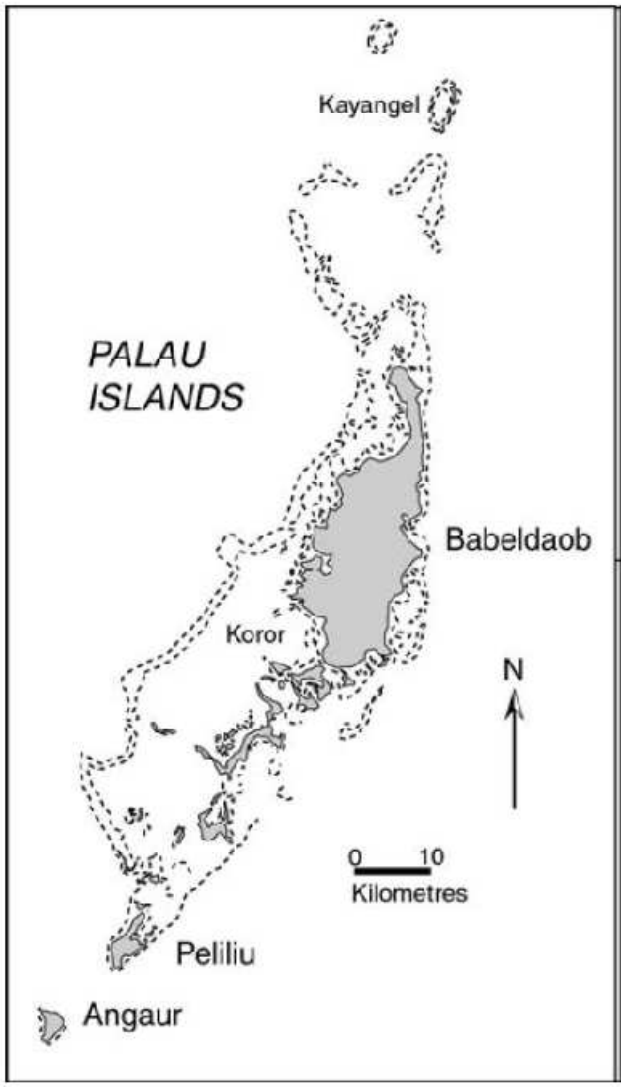
However, two situational analysis of household food security in Palau found some households were unable to purchase or otherwise obtain food sufficient for their needs at the end of the payday cycle (Bishop and Wichman 1995, and Rarick 1997)

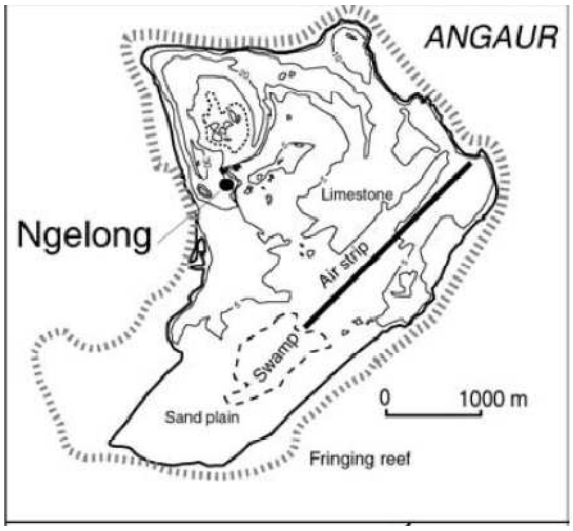
Outer island locations such as Angaur are particularly impoverished due to a lack of opportunities and the difficulties faced in providing for basic subsistence needs. Compounding this is disruptions in transportation needed to maintain a lifeline to the commercial center.

[8] The National Plan for Action in Nutrition notes: "while overt manifestation of vitamin A deficiency have not been recorded in Palau, some diet recall studies have indicated the probability of sub-clinical vitamin deficiency among children in Palau" (Palau Bureau of Public Health 2000 , p. 18).

Situation and resource assessment for Angaur

Plate 1:





source: Clark and Wright (2005)

Germany discovered phosphate deposits on Angaur in 1903 and open pit mining commenced some seven years later in1909. The island was continuously mined until 1955, apart from a brief interlude in 1914 and during World War II. It is estimated that approximately 3.5 million tonnes of high quality phosphate was extracted from Angaur (Wentworth 1955, p 680). Some 93 % of this phosphate was shipped to Japan for fertilizer and ammunitions manufacture (United States Department of Agriculture Natural Resources Conservation Service, Republic of Palau 2000, p. 15).

There were three distinct periods of phosphate mining operations on Angaur[9]:

- **1909-14** -German mining period (estimated 285,000 tonnes extracted)
- **1915-44**- Japanese mining period (estimated 2.8 million tonnes extracted)

[9]These estimates are derived from information provided in Wentworth 1955 and United States Department of Agriculture Natural Resources Conservation Service, Republic of Palau 2000

- **1946-55** -US supervision of continued Japanese mining period (estimated 400,000 tonnes extracted)

The initial mining was concentrated on the central part of the island then moved southwest and later north northwest[10]. During the Japanese mining from 1914 to 1945, the mining was conducted in all four of Angaur's villages at different times but mostly concentrated on the central part. The eastern side of the island was not mined except for the excavations done to the southeast side or near the south end of the airport runway on the ocean side of the island. These excavations were done during the American/Japanese period from 1947 to 1955.

German mining operations were entirely based on manual labour (Micronesian and subsequently Chinese workers) to source the most readily available phosphate. Investments were made in a rail system, conveying and drying systems and storage facilities. During the period of German mining, a total of 285,000 tonnes of phosphate were extracted (37,000 tonnes annually). In 1914, Japan occupied the Micronesian islands and acquired them as a mandate under the League of Nations in 1919.

The Japanese reinstituted mining operations on Angaur in November 1914. Over the period 1918-34, expanded manual labour based operations extracted an average of 60,000 tonnes of phosphate annually.

Plate 2: The remains of a phosphate storage facility from the German mining era

Plate 3: One of the lakes formed on Angaur as a result of mining below sea level

From 1935, Angaur's phosphate production increased dramatically as part of Japan's national self-sufficiency policy. To facilitate this increased demand, power excavation equipment was introduced in 1938 to enabled mining to be conducted below sea level (Wentworth 1955). With mechanisation, annual phosphate mining reached an estimated 100,000 tonnes. Pumps were used to lower the water table in the phosphate areas to a depth of 2 m below sea level. War activities saw a substantial reduction in phosphate mining in 1943, with only 25,000 tonnes exported in 1944. Mining operations ceased completely in 1945.

[10] The information presented in this paragraph was provided in personal communication by Ambassador Carlos H. Salii

Phosphate mining recommenced in 1946 as a part of a program to rehabilitate Japan's domestic agriculture. The mining was undertaken by the Phosphate Development Company (Tokyo) under the supervision of the US Administration. During the post War period, approximately 400,000 tonnes of phosphate was extracted.

A geological assessment team was appointed in 1951 jointly by the Headquarters of the Tokyo based Supreme for the Allied Powers and the Office of the High Commissioner for the Trust Territory of the Pacific Islands, to 'assess the damage to ground water and to agricultural land and if possible suggest methods of repairing some or all of the damage' (Wentworth *et.al.* 1955,p. 671). The assessment team's findings were grim: 'lakes had formed in these excavations and, despite an annual rainfall of 110 inches, contamination of fresh-water supplies and of agricultural land by salt water resulted from tidal pulsations through the fissured rock' (Wentworth *et.al.* 1955,p. 699).

During the US supervised post-War period, excavation of the water-filled phosphate pits continued with 'dragline' cranes and suction dredges. Remedial measures were undertaken aimed at reducing the level of salt water contamination. These are described in Wentworth *et.al* (1955) and the United States Department of Agriculture (2000). The latter report describes these measures taken and claims that they were largely successful. To quote:

> Many lakes and ponds created by early phosphate mining are scattered over the island of Angaur until the Trust Territory Administration become concern about the encroachment of saline water. Mining operation had remove phosphate deposits, which form protective seal over the highly permeable limestone (Van der Burg,1984). After1950,the Phosphate Mining Company was required to fill the lakes with limestone quarried outside the mining area and to backfill each excavation immediately after mining was completed (Van der Burg, 1984). Before the lakes had been filled the water was brackish showing tidal effects (US DOD, 1956). After the lakes were filled, chloride concentration of wells in the area dropped considerably (US DOD, 1956). The US government provided $4.3 million compensation for the phosphate mining to the people of Angaur in 1995 (p, 16).

What was clearly apparent from the visit to Angaur in April 2011 is that the lakes are not filled (plate 3), a number of wells are contaminated and the last remaining taro patch is no longer a viable production area because of salt contamination.

When mining ceased in 1955 the estimated reserves of phosphate remaining on Angaur was 500,000 tonnes, most in areas that had not been authorised for mining such as under the airfield and the remaining taro patch (USDA 2000 p, 16).

World War II

Japan occupied Angaur from 1914. During the war the Japanese civilian and military population grew to around 2,500 - while at the beginning of this period Palauan population was about 2,000 (USDA 2000 p, 14). At the commencement of the Japanese military occupation most of the most of the Palauan population were evacuated to Babeldaob. A few remained hidden in limestone caves in north of the island to be discovered by American soldiers.

The US Military invaded Palau in 1944 to secure approaches to the Philippines and New Guinea. The 81st Infantry landed on Angaur on 17th September 1944, supported by four cruisers (USDA 2000 p, 14). Organised resistance ceased after 3 days, although some 700 Japanese held out for more than a month in the caves and holes in the phosphate mining area in the north west of the island. There were high causalities inflicted on both sides during the Battle of Angaur.[11] Sixty five years on, remnants of this battle remain in the form of tanks and aircraft in the dense undergrowth and shrines to the war dead.

Plate 4: The wreckage of an aircraft from WWII

Plate 5: A shrine to the Japanese war dead on Angaur

The lasting physical legacy of the World War II is the 2,300 mx 100 m airstrip that was build immediately after the conquest of the island (plate 6). The airbase was used extensively in support of the Philippines campaign. The airstrip is no longer used but remains in good condition and represents an important asset for future tourism based development of the island.

Plate 6: Angaur WWII built airstrip

The fierce Battle of Angaur and subsequent building of military installations cleared the island of much of its vegetation. In 2000, the United States Department of Agriculture and the Natural Resources Conservation Service for the Republic of Palau conducted a detailed study to determine if wartime activities inflicted permanent environmental damage Angaur (USDA 2000). The conclusion of the USDA/Natural Resources Conservation Service report was that it had not. To quote the report:

> The World War II impacts to soil health parameters are generally not discernable except where permanent land use changes were made. Present soil fertility of Angaur shows that some of the soils were disturbed by war activities, including the pre-war and post war occupations of the island. The resulting conditions of some soils of Angaur after the war were fragmented, and in some cases, soil was displaced. However, in the fifty-five years since the war the

[11] The 81st Division suffered 264 dead and 1,355 wounded (USDA 2000). All the Japanese forces were eventually killed except for 59 taken prisoner.

vegetation has regenerated and the organic matter has collected to form small amounts of topsoil on most of the island.

Some of the vegetation on Angaur was destroyed or damaged during the American assault in 1944. At the conclusion of the war, the vegetation rapidly re-established through natural plant succession processes. Presently 97 percent of Angaur is in some form of vegetation cover. Forest biomass is relatively high indication that the soil quality was not permanently impaired by the temporary removal of vegetation except where topsoil was removed in construction activities (p,3).

However, unfortunately the comprehensive USDA report is silent on the consequences of phosphate mining on the availability of top soil for agricultural activities.

Post – WWII activities

From 1945-78 the U.S. Coast Guard operated a LORAN transmitting station on Angaur. The Coast Guard buildings remain in derelict condition

Environmental setting

Location and access

In good weather conditions, Angaur is 1 ½ hours by speed boat or 4-5 hours from Koror on the Angaur state owned 'roll-on-roll off' barge

Physical geography

Angaur was formed by tectonic uplifting, which exposed the coral reef deposits. The limestone forming the island was initially underwater as a coral reef that accumulated coral debris on its surface. The island now consists of a combination of a limestone platform and beach deposits from the reef.

Plate 7: The low elevation of the island seen from Red Beach

Most of Angaur is flat, with the majority of the island less than 10 m above sea level (plates 1 and 7). Limestone is characteristic of many of the low platform islands of Palau, such as Peleliu and Angaur and the mostly higher and steeper Rock Islands. The limestone is generally porous and has about 97% calcium carbonate (US DOD 1956). The features of the karst topography include pits and pinnacles, caves, depressions, and sinkholes resulting from the dissolution of the calcium carbonate.

Plate 8: Angaur's elevated north west coast

Plate 9: A large phosphate mining excavation hole

Plate 10: The swamp at the south eastern end of the island

Soils in areas of limestone are characteristically thin, generally less than 25 cm deep. The northwest portion of Angaur consists of limestone ridges that raise steeply from the coast to elevations above 20 m (plate 8). The highest point on the island is a limestone peak 50 m above sea level. The limestone topography contains the common features of pits, pinnacles, caves and sink holes. Superimposed on this terrain are large excavated holes, remnants of phosphate mining (plate 9). Some of the larger excavations, dug below sea level in the interior of the island are filled with water (plate 3). A large swamp of approximately 85 ha is located at the south eastern end of the island (plate 10). Located within the swamp is the islands' last remaining taro patch.

Soils

Over the post war period, Palau has been subject to numerous soil surveys through the services of the United States Department of Agriculture, Natural Resources Conservation Service (USDA 2009;USDA 2000;USDA 1983;Vessel *et al* 1958). The following discussion of Angaur soils draws on a number of these reports. The majority of soils on Angaur are derived predominately from coral limestone (known as *Peleliu* soils). The remainder of the soils are formed in coral sand (known *Ngedebus* soils) or formed from freshwater marsh vegetation overlying coral sand (*Ngerungor* soils). The USDA Soil Service list six separate soil-mapping units on Angaur:

Soil mapping unit	Name	Description	Slope (percent)
424	*Ngedebus*	sand	0 to 3
425	*Ngedebus* variant	cobbly loamy sands	2 to 6
427	*Ngerungor* variant	high in organic matter	0 to 1
432	*Peleliu*	rock outcrop complex	0 to 4
433	*Peleliu*	rock outcrop complex	6 to 20
434	Rock outcrop	*Peleliu* complex	80 to 150

The first four of these are classified as adequate for agriculture soils and are discussed briefly below.

Peleliu soil type

432 *Peleliu* and 433 *Peleliu* are the dominate soil types on Angaur, as they are on the island of Peleliu. According to the USDA, 71% or 574 ha of soil on Angaur are derived from limestone and are of the

Peleliu series type. These soils are very shallow (< 50 cm deep) and well drained, with approximately 75% of the soil surface covered by cobbles and stones. Soil depth on Angaur is usually no more than a few centimetres with much of the islands' topsoil removed during the phosphate mining period. Prior to phosphate mining there would have been areas of sufficient soil depth to grow dryland taro, which requires a minimum soil depth of 25 cm (Evans *et.al.* 2008 p, 30). In varying degrees, some organic matter has been replenished through the passage of time. In particular, pockets of high quality soil can be found in porous limestone fractures (plate 11). Small qualities of this soil is now bagged and sold to Koror home gardeners and flower growers, where it is highly prized. *Peleliu s*eries soils are alkaline, due to the very high content of calcium (Ca) with a pH ranging from 7.3 to 7.6. The high alkalinity affects plant nutrients, such as phosphorous, iron, manganese, zinc, copper and boron. USDA 2000 note that while phosphorus tailings from mining operations are a local source of P but due to the high pH, about a quarter to a third of the added phosphorus will not be available. Nitrogen and potassium are low in *Peleliu* series soils. The low available nutrient levels are significant limitations for plant growth on Angaur.

The free draining nature of *Peleliu s*eries soils are particularly favoured by relatively large trees such as casuarinas (*Casuarina equisetifolia* and *Intsia bijuga* locally know as dort or iron wood) (plate 12).

USDA 2000 lists the positive soil characteristics of *Peleliu* series soils as:

- most essential nutrients are present; and,
- moderate to high organic matter content.

The soil quality concerns for the *Peleliu* series are listed as:

- shallow soil depth, typically less than 25cm (*and considerably less where phosphate mining has occurred*);
- low water-holding capacity;
- excessive gravel and cobbles
- high calcium and pH
- difficult tillage due to rock outcrops.

Traditionally, Peleliu series soils have been used for subsistence agriculture,

Plate 11:Pockets of high quality soil found in porous limestone fractures

Plate 12: Casuarina the dominant tree species on *Peleliu* series soils

including root crops, coconuts, breadfruit and other fruit trees.

Ngerungor soil type

The Angaur swamp area located at the south eastern end of the island is situated on the *Ngerungor* soil type. Soil maps show a smaller area of *Ngerungor* soil in the north of the island. However, due to phosphate mining, taro is no longer grown in this area. USDA soil surveys refer to many depressional areas containing *Ngerungor* soil as having been in periodic cultivation. Such areas are no longer apparent. The water table for *Ngerungor* soil is located a few centimetres below the surface and thus these soils are usually flooded. Ngerungor soils are moderately deep(0.5 to 1 m), with high organic matter.

USDA 2000 lists the positive soil characteristics of Ngerungor soils to include:

- good depth (0.5 to 1 m);
- a pH (6.3 to 7.5)within the optimum range for the release of nutrients;
- most essential nutrients are available;
- water holding capacity is high; and,
- bulk density is low.

The soil quality concerns for Ngerungor soils are listed as:

- excessive wetness;
- potential for low potassium; and,
- potential to be inundated with brackish water (the is certainly now the case with the last remaining Angaur swamp).

Traditionally, *Ngerungor* soils that did not contain brackish water were used for wetland taro production on Angaur. Today, the one remaining *Ngerungor* soil swamp faces severe salt contamination, making taro (*colocasia esculata)* extremely difficult to grow. The probable cause of salt contamination is the tidal pulsations through rock fissured during underwater phosphate mining (figure 4), combined with extreme high tides induced by sustained period of frequent El Niño events (figure2).

Ngedebus soil type

The *Ngedebus* series consists of deep, somewhat excessively drained soils adjacent to coastal beaches. The soil surface is typically sand. USDA 2000 indicates that 20% of the soils on Angaur are of this type. With very low clay content limited amounts of plant nutrients can be retained. The agricultural uses of these coastal soils are largely confined to coconuts and breadfruit.

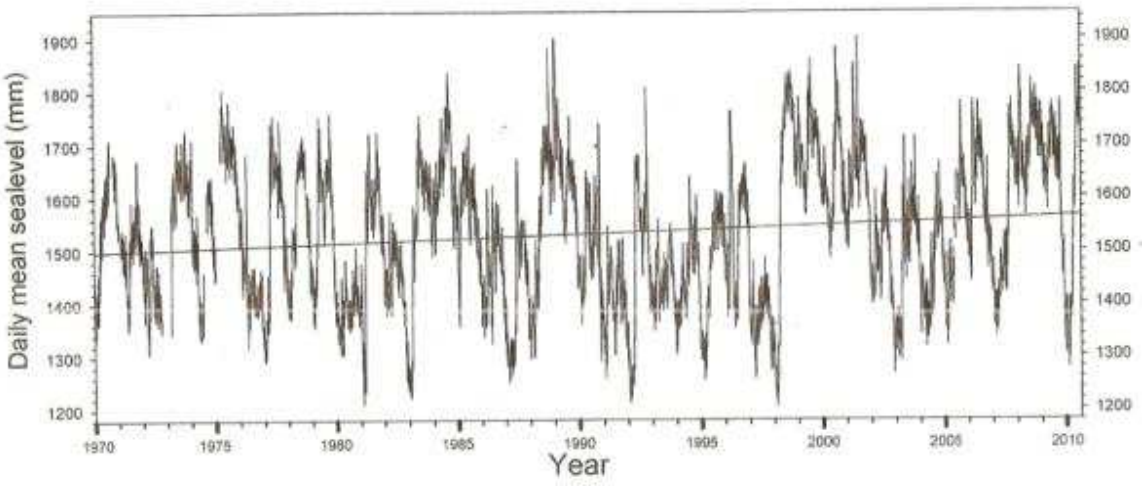
Climate[12]

Palau has a tropical moist climate. The maximum and minimum temperatures do not fluctuate markedly through the year (figure 3). However, rainfall is highly variable, with a distinct wet season (May to November) and dry season (December through April). Relative humidity averages about 90

[12] Climate data obtained from the National Oceanic and Atmospheric Administration (NOAA), Hawaii unless otherwise stated

percent at night and 75 to 80 percent during the day. The average annual rain fall for Angaur lies in the range of 3,300 mm to 3,500 mm, which is lower than Koror which lies in the range of 3,500 to 3,700 mm (annex 2). However, there is considerable annual variability in rainfall ranging from 3150 mm to 4400 mm. The marked wet and dry seasons affect the hydrological regimes of Angaur. The shallow soil profile and the topographical relief result in limited moisture storage capacities. The moisture content of the soil remains close to field capacity only during wet periods, rapidly falling below field capacity with moisture conditions at the wilting point during periods of drought (USDA 2010).

Figure 2: Palau's extreme tidal fluctuations illustrated by the daily mean sea level for Koror harbour *

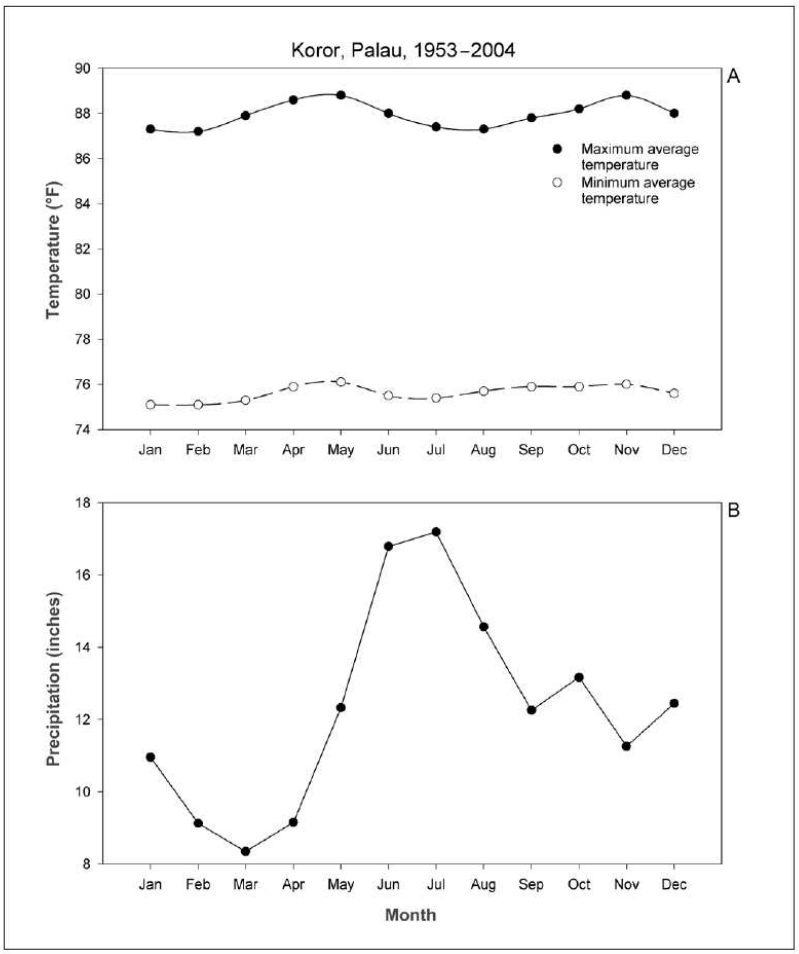


*Source: Hawaii Sea Level Center data – supplied by Patrick L. Colin Coral Reef Research Foundation, Koror Palau.

Palau's proximity to the equator means that it outside the normal typhoon zone, although severe typhoons do occur from time to time induced by the El Niño–Southern Oscillation (ENSO). ENSO is a naturally occurring global phenomenon that has existed for millennia (Grove 1998)[13]. Archaeological studies on Angaur refer to an extreme El Niño in the 16th Century (Clark and Wright 2005). El Niño event occurs every 3–8 years or so and are usually accompanied by periods of low rainfall (during the El Niño phase) followed by periods of high rainfall (during the La Niña phase) of the cycle.

[13] In the ENSO the temperature of the sea, the air pressure over the sea and the circulation of the air across the oceans move together, from one extreme to another.

Figure 3: Koror temperature and rainfall (1953-2004)*



Source: Donnegan et.al 2004

In recent years Angaur has been in drought phase of the ENSO cycle. For limestone islands such as Angaur, El Niño induced drought events can be particularly damaging due the low water holding capacity of the soil. These events are also associated with tidal extremes (figure 3). For atolls this can lead to the infiltration of salt water through the fresh water lens. In the case of Angaur salt water contamination appears to have been exasperated by fissures in the underlying limestone that occurred when phosphate mining was undertaken below sea level.

It is expected that future ENSO cycles are likely to continue to be a significant source in climate variability for Angaur and the region as a whole. These cycles are not directly related to a longer term climate warming trends and average sea level rise (Salinger *et.al.* 1996)[14]. However for a small

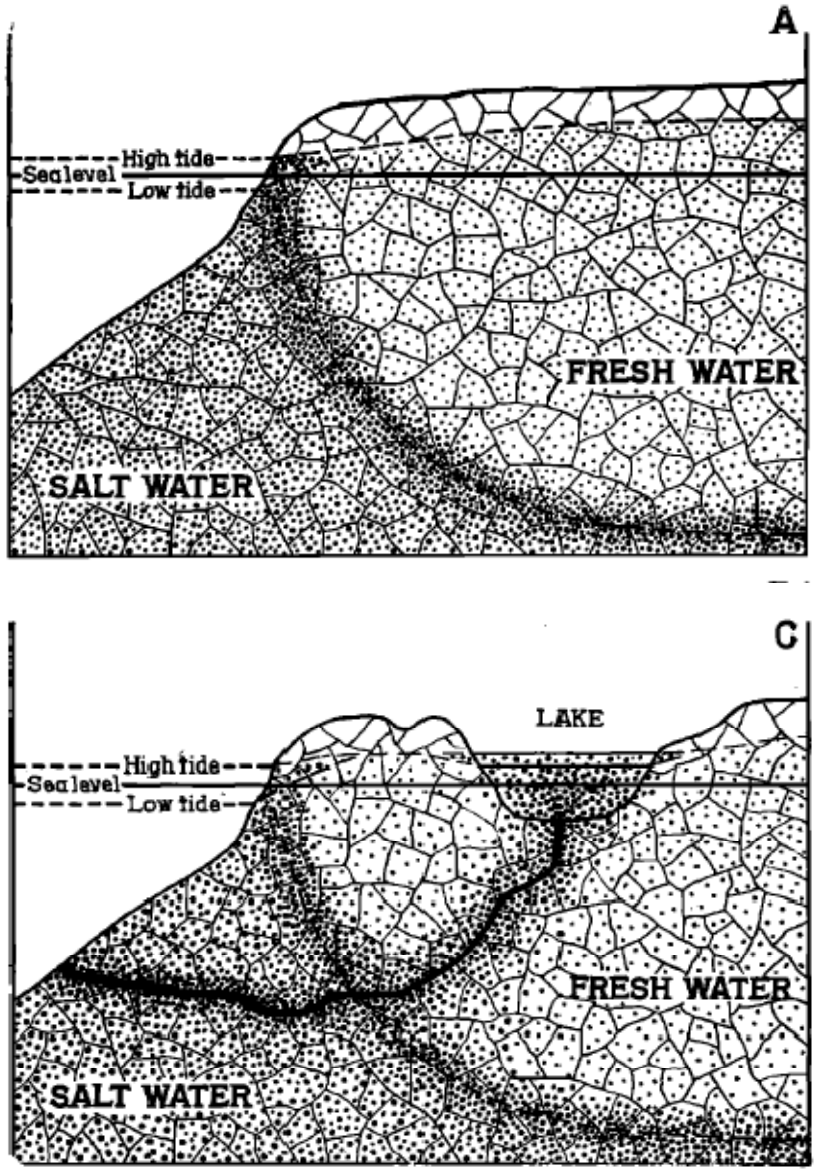
[14]Tidal data collected for Koror harbour since 1970 show and average rise in sea level of 1.5 mm/yr (data – supplied by Patrick L. Colin Coral Reef Research Foundation, Koror Palau).

limestone island with a damaged fresh water lens, sea level rise will only accentuate the problems created by future El Niño events.

Water

Angaur has no rivers with the whole island serving as a single watershed. Rainwater infiltrates limestone rock until it reaches denser salt water. A thin fresh water lens exists under the coral rabble and calcareous sand (figure 4). Thus potable water was can only be obtained from wells and rainwater catchment tanks.

Figure 4: Angaur's freshwater lens*



source: Wentworth *et.al.* 1954

Prior to World War II there were two wells operating in the phosphate drying area (Van der Burg, 1984).There were reported to be 9 wells in operation during the height of American military presence when 10,000 men stationed on the island. After phosphate mining ended in 1955 only two wells remained in operation (Van der Burg, 1984).

Mining operations below sea level damaged the protective seal over the highly permeable limestone (Wentworth *et.al*1954 and figure 4). Remedial measures taken by Phosphate Mining Company in the 1950s, on the instruction of the Trust Territory Administration, appear to have met with some initial success, with chloride concentration dropping considerably (Van der Burg 1984). However, with passage of time and with the pressure of tidal extremes these measures seem to have broken down. One of the remaining wells is foul smelling[15] and seldom used. The remaining swamp is no longer suitable for growing *colocasia* taro because of salt contamination. Thus availability of fresh water is a major constraint to any future development of Angaur.

Vegetation and timber resources

The harsh environment of Palau's limestone islands limits the plant species that can survive. Yet on Peleliu, Angaur, and the Rock Islands species-rich and structurally diverse forest forms exist. This is despite excessively drained coral limestone soils with an imbalance of plant nutrients and occasional severe drought (Donnegan *et.al* 2003)[16]. Casuarina*(Casuarina equisetifolia),*or locally known as *ngas*, casuarina, ironwood, Australian pine, has become the dominate tree species on Angaur. Surprisingly casuarina is not included in Donnegan *et.al.'s* survey of Palau's forest resources. Casuarina is classified as native/early Micronesian introduction has proven to be a successful coloniser of denuded areas, new surfaces and fresh sand flats (Kitalong 2008). This species has nitrogen-fixing bacterial root nodules and produces carpets of "needles" that exclude other plants.

Internationally casuarina is valued for its nitrogen-fixing qualities as well as for timber, fuel and charcoal. China has more than 1,000,000 hectares; India 800,000 hectares, and Vietnam 100,000 hectares, mainly in coastal areas where land degradation is worst (World AgroForestry Centre). The World AgroForestry Centre acclaims the role *C. equisetifolia* can play in land reclamation and as a soil improver[17]. This would certainly seem to be the case with Angaur. *Casuarina* forests now cover some 450 hectares or 20% of the coral islands of Palau).

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[15] Water quality report

[16] The tree species surveyed by Donnegan et.al. (2003) include *Intsia bijuga (*iron wood*, dort), Psychotria* spp., *Clerodendron inerme (butcherechar), Eugenia reinwardtiana(kesiil), Morinda latibracteata (ngel), Garcinia matudai (tilol), G. rumiyo* var *(tilol),clacicola, Rinorea* sp., *Cycas circinalis, Flacourtia rukam* var. *micronesica, Aidia cochinchinensis* (Ti plant*, kerumes), Meryta senfftiana, Polyscias grandifolia (bungaruau), Geniostoma sessile, Premna serratifolia (chosm), Cyrtandra todaiensis (mesechelangel), Guettarda speciosa (belau), Badusa palauensis, Psychotria hombroniana, Ixora casei(*ixora *kerdeu) ,* and *Tarenna sambucina.* Most of these tree species have an identified Palau name shown in parenthesis and derived from Mad 1999.

[17] Grows vigorously on barren, polluted sites and thrives in deep sandy soils andcolonizes sterile tin tailings. Root nodules containing the actinorhizal symbiont Frankia enable C. equisetifolia to fix atmospheric nitrogen. These root nodules can be prolific. Soil improver: C. equisetifolia possesses proteoid roots and forms associations with vesicular arbuscular mycorrhizae" (World Forestry Centre: Agroforesty Tree Data Base - *Casuarina equisetifolia*, 2011).

Surprisingly casuarina is classified as an invasive species of environmental concern to Angaur, due to the contribution of their shallow rooting system to beach erosion (Kitalong 2008). Space *et.al.* recommend that consideration be given to removing these trees from beaches in the Rock Islands and replacing them with alternative native strand (beach) shrubs and trees (Space *et.al.* 2003). These conclusions and recommendations appear to be at odds with the findings World Agroforestry Centre that sees erosion control as an important service provided by *C. equisetifolia* "Since it is salt tolerant and grows in sand, *C. equisetifolia* is used to control erosion along coastlines, estuaries, riverbanks and waterways. In Sarawak, Indonesia the species is protected because of its importance in controlling coastal erosion"(World Forestry Centre: Agroforesty Tree Data Base - Casuarina equisetifolia, 2011). Casuarina is an excellent fuel wood that is well suited for charcoal[18] and in Palau is regarded of only limited value as a timber[19]. Palau Bureau of Agriculture does not recommend the planting of casuarina.

Canfield 1980 describes much of the flora of Angaur as weedy introductions during the intense military activity of World War 2. These include such high undesirable species as lomoea, lantana and aesculina. A full list of invasive flora species considered to on environmental concern on Angaur are presented in annex 3. Food producing trees, forest trees, and other useful plants are found near dwellings and abandoned food gardens along costal roads. The most common food producing trees include:

Common name	**Scientific name**	**Palauan name**
coconuts	*Cocos nucifera*	***lious***
breadfruit	*Atrocarpus altilis*	***meduu***
mango	*Mangifera indica*	***iedel***
betel nut	*Areca catechu*	***buuch***
mountain apple	*Eugenia malaccensis*	***kidel***

Other fruit and nut trees present are:

Common name	**Scientific name**	**Palauan name**
avocado	*Persea americana*	**bata**
carambola	*Averrhoa carambola*	**kemin**
guava	*Psidium guajava*	**kaubang**
Indian mulberry	*Morinda citrifolia*	**ngel**
citrus	Citrus spp.	**meradel**
papaya	*Carica papaya*	**bobai**
Tahitian chestnut	*Inocarpus fagifer*	**keam**
Tropical almond	*Terminalia catappa*	**miich**

[18]The World Agroforestry Centre: Agroforestry Tree Data Base reports that *Casuarina equisetifolia* reports that this highly regarded wood ignites readily even when green, and ashes retain heat for long periods. It has been called 'the best firewood in the world' and also produces high quality charcoal. Calorific value of the wood is 5000 kcal/kg and that of the charcoal exceeds 7 000 kcal/kg.

[19]The World Agroforestry Centre: Agroforestry Tree Data Base reports that *Casuarina equisetifolia* reports shrinkage is moderate to very high, and in the latter case the wood is difficult to season due to severe warping and checking. Wood is hard to very hard and strong. The heartwood is highly resistant to pressure treatment, but sapwood is amenable to such treatment. Heartwood is also resistant to dry-wood termites. On sawn timber, the rays are prominent on radial faces. Uses include house posts, rafters, electric poles, tool handles, oars, wagon wheels and mine props.

Regrettably very little of the fruits is available for human consumption due to the predation by Angaur's large feral monkey population.

Wild life

A survey of forest birds in Palau conducted in 2005 showed that Angaur has the lowest bird population of any island in Palau (VanderWerf, E. 2007). This contrasts with the nearby limestone island of Peleliu that had the greatest diversity and number of birds. The difference is attributed the presence of the feral long tailed macaque monkeys (*Macaque fascicularis*) on Angaur. Angaur is the only location in the Pacific islands which has an established monkey population. The macaques were introduced to the island more than a century ago – with a variety of explanations given for their introduction. The monkey population now outnumber the humans by more than 5 to 1 (Newsome 2003). Past papers on the "Crab-eating Macaques" refer to coexistence with the humans (Poirier and Smith 1974). The monkey population was largely confined to the jungle in the southern interior of the island, where their preferred food - mountain apple - is in abundance. Monkeys only ventured away from this area in search of food and water when mountain apple were not fruiting[20]. This is no longer the case. In the absence of any controls or natural predators there has been an explosive growth in monkey population. The monkeys have devastated taro patches, gardens and food/craft trees/plants in search of food and water. The damage caused to the taro patches and food gardens is so severe these traditional cropping systems are no longer viable. The impact of monkeys on agriculture is discussed in some detail later in this report.

Plate 13: Feral macaque monkeys on Angaur: Source - Conservation International Pacific Islands (2011)

The socio economic situation

Demographic situation

According the 2005 Population Census, Angaur's population was 320, who lived in 86 households. This compares with a population of 193 at the time of the 1995 Census. This represents a 70% increase in population over the inter-census period, compared with a 4.1% increase for the Palau population as whole. However, the Angaur population appears to have fallen dramatically since the 2005 Census. The 2006 The Household Income Expenditure Survey (HIES) estimated the combined population of Angaur/Kayangel to be only 178 (Visia Alonz, 2007). A population count on 15th April 2011 put on-island population at 129, living in 40 households. On an average week-end the population will increase by a further 20 people and on special occasions the population can swell by 40 to 50 people(Per Comm. Resident Chairman of Angaur Legislature). Angaur has a total of approximately 400 registered voters, most of who live in Koror or Guam

[20] Official Angaur Historian Theodosia F. Blaides

Indications are that Angaur has become a less attractive place to live. The growing and increasingly emboldened monkey population has amplified the stress on daily life. Recent years have seen a particularly severe drought (including extreme high tides) during which period the island's water supply has become contaminated.

The Population Census shows a relatively disproportionally low number of people of working age living on Angaur (Palau 2005 Population Census Report, table 1). In 2005:

- 30.6% of Angaur's population was under the age of 18, compared with the national average 28.9%.
- 3.1% of the Angaur population were between 18 to 25 years , compared with national average of 8.9%.
- 8.8% of population was over 65, compared with the national average of 5.7%.

There are also significantly more men living on the island than women. The Census showed a male/ female ratio 122.

Income and employment

Information sources on income and employment are provided by the 2005 Population Census, the 2006 HIES and the various reports of the UNDP Informal Employment and Sustainable Livelihoods (IESL) Project. The fairly recent HIES should have been the main source of such data. However, it is unfortunate that the 2006 HIES pools the data from Angaur with the most northern state of Kayangel. These two states would appear to have little in common other than their small size and remoteness.

Wage employment

The 2005 Population Census showed a low level of wage employment on Angaur, with those that are employed being on the payroll by the national or state governments. For Angaur 51.4% of males over the age of 16 and 36% of females were in wage employment (Palau 2005 Population Census Report, table 2). The national average was 53.6% of males and 44.3% of females in wage employment. Of the males in wage employment on Angaur, 64.1% worked for the government (National, State, or Statutory Authorities). This compares with the national average of 34.7% working for government. At the time of the April 15th 2011 field visit there were 31 government employees on Angaur, 15 of which worked for the State Government, 12 for the National Government, and 4 for the power and electricity utilities.

Involvement in subsistence and informal sector activities

According to the 2005 Population Census there is very low involvement in subsistence activities on Angaur. The Census shows that only 7.2% the population were involved in some subsistence activities and none were involved solely in subsistence activities (table 4). This compares with a national average of 11.8% involvement in some subsistence activities and 2.3% of the population being involved solely in subsistence activities. Significantly a much larger percentage of the population on the nearby island of Peleliu is involved in subsistence activities. 35.8% of Peleliu's population had some involvement in subsistence activities and 6.1% are fully involved in subsistence activities.

In the 2005 Population Census only 9.4% of Angaur's population over 16 was reported to be employed in agriculture, forestry and fisheries (table 4). This represented a total of 14 people. Whereas, 40.6% of

Angaur's population over 16 years were classified as "operators, fabricators and laborers". On Peleliu 15.1% of the population over 16 was reported to be employed in "agriculture, forestry and fisheries" and 32.4% were classified as "operators, fabricators and laborers".

The data collected a decade earlier by the IESL Project showed a different situation (table 3). The IESL surveys indicate a high involvement in subsistence activities at that time. In 1996 a total of 232 people were reported to involved in agricultural production and marketing of which 182 were male. Only one State (Peleliu) had a higher participation rate in subsistence activities. The IESL Project reports that a total of 306 people were involved in whole of the informal sector on Angaur in 1996, of which 251 were males and 51 were female. Again only Peleliu had a greater percentage number of people involved in informal economic activity.

Income

The Angaur income statistics presented in the 2005 Population Census and compared with the national average are (Palau 2005 Population Census Report, table 5):

- Median household income $10,278 (national household median income $15,107).
- Per capita income $2,979 (national per capita income $5,097).

The relatively low income status of Angaur is confirmed in the findings of the 2006 HIES. The HEIS found that Angaur/Kayangel had the lowest average household income of any region in Palau, and was less than half of the national average (figure 1). Analysis of the data for the rural areas from the Palau Poverty Analysis 2006 shows that the States with the highest proportion of poor households were in Angaur, Kayangel, and in West Babeldaob (Holm 2011).

Despite the relatively low income of Angaur/Kayangel only a very small proportion of this income is attributed to subsistence (table 4). In 2006 only 2.6% of Angaur's total income was attributed to subsistence. UNDP 2008, using 2006 HIES data, estimates the national Basic Needs Poverty Line (BNPL) to around $13,000 for an average sized household ($244.67 week for an average sized household) (p,27). Using the same data set the average household income for Angaur is around $8,000, with the household growing very little of its own food. The real value of income earned in Angaur/Kayangel is also significantly lower than income earned in most other part of Palau due to the high cost of transport. The price of rice on Angaur was found to be some 20% higher than Koror. The combination of low income and a low level of subsistence make Angaur a particularly economically depressed and vulnerable location.

With these difficult circumstances and the lack of livelihood opportunities it hardly surprising that the isolated island of Angaur is reputed to have become a significant marijuana growing area for the Koror market and beyond.

Table 3: The estimated number of individuals in informal agricultural food production and marketing, and in the informal sector as a whole, by State, 1996

State	Agriculture			Whole Informal Sector		
	Male	Female	Total	Male	Female	Total
Aimeliik	1	54	55	23	72	95
Airai	0	99	99	5	123	128
Angaur	**182**	**50**	**232**	**251**	**55**	**306**
Hatohobei	20	20	40	38	50	88
Kayangel	2	37	39	15	62	77
Koror	0	51	51	29	64	93
Ngardmau	20	99	119	134	17	151
Ngeremlengui	3	30	33	18	31	49
Ngatpang	10	15	25	45	21	66
Ngaraard	15	135	150	50	159	209
Ngarchelong	8	46	54	144	27	171
Ngchesar	80	80	160	94	95	189
Ngiwal	38	88	126	69	101	170
Melekeok	55	87	142	55	109	164
Peleliu	175	331	506	589	357	946
Sonsorol	10	25	35	38	31	69
Total	619	1247	1866	1597	1374	2971

Source: Palau Informal Employment and Sustainable Livelihoods Project, 1999

Table 4: Angaur/Kayangel income by source, 2006

Source of income	$'000	Percentage of total
Wages and salaries	804	55.7%
Imputed rent	473	32.8%
Social Security	52	3.6%
Customs	51	3.5%
Business	2	0.1%
Home consumption	16	1.1%
Remittances	8	0.6%
Subsistence	**38**	**2.6%**
Total	**1444**	

Source: HIES 2006, table 9

Food security

Palau overall is a highly food insecure country with over 80% expenditure on food going to imported food. The island of Angaur is in an even more precarious position in terms of food security. Angaur people now have very limited capability to grow their own food due the following factors:

- Salt contamination of the remaining taro patch means that the preferred staple of *colocasia* wet land taro can no longer be effectively grown (plate 14).

Plate 14: The remnants of the once flourishing taro patch

- What little *colocasia* taro that is still grown (mainly now for customary purposes) is severely damaged by monkeys (plate 15).

Plate 15: Taro tops damaged by monkeys

- It is not possible to grow dryland taro, or other dryland root crops, due to insufficient depth of soil resulting of past phosphate mining.
- Fruit, of any kind (including coconuts), are rarely available for harvest due to the predatory of feral monkeys seeking moisture and food (plates 16 and 17).

Plate 16: Coconut trees with nuts remove by monkeys

Plate 17: Papaya trees destroyed by monkeys

It is due to this combination of factors that virtually all Angaur food is imported. The income to import this food is considerably lower than the national average and the cost of this food is higher than average.

Marine food resources are available. However, these are relatively more difficult to access because Angaur lines outside the protective barrier reef.

The 2006 HIES found that the average Angaur household spent 17.6% of their income on food, compared with 16.3% for the nation as a whole (HIES table 15). In the case of Angaur virtually all this expenditure is on imported food. However, given the discussion above this HIES percentage of income spent on food consumption appears to be surprisingly low.

Health and nutrition

Palau overall enjoys a high standard of health, demonstrated by low infant mortality and high life expectancy. These excellent indicators are the result of sanitation, education, and public health services standards which have communicable diseases under control. However, the Palau National Committee on Population and Children (CoPopChi) concluded that besides tobacco, the single greatest factor affecting the health of Palauans is diet and related obesity (p, 116). Amongst the factors identified by CoPopChi in the prevailing dietary patterns, which contribute to overweight and associated ill heath are:

- low consumption of fruit and vegetables;
- high consumption of rice and declining consumption of more nutritious taro; and,
- a preference for imported processed food.

Palau's low overall consumption of fruit and fleshy vegetable can be attributed to damage caused by Oriental fruit fly (*Bactrocera dorsalis*) (McGregor 2000)[21]. However, for Angaur the damage caused by an exotic fruit fly invasion pales to insignificance compared with the ravages caused by an exotic monkey.

In addition to the physical health consequences there are likely to be significant psychological and cultural health consequences of the current conditions of life on Angaur. These are consequences are summed up by the former team leader of Palau's IESL Project in his contribution to this report, to quote:

> In traditional times, Angaur was self-reliance in terms of food and other basic needs. Large community projects were executed. The quality of life was high. Its people were strong healthy and lean. Today, sadly, the opposite rules the day. Angaur is dangerously food insecure as it is heavily dependent on imports. Angaur is vulnerable in all its basic needs. Its people are sickly, malnourished and physically unfit. Today Angaur is peopled by mainly the elderly and very young. Most of Angaur residents fled their traditional homeland to elsewhere in search of better opportunities and to escape the depressing cycle of environmental, cultural and social degradation. The bank of social capital in Angaur has been ruptured. The village way of life is fissured. The quality of life has lessened.
>
> Why has this happened? There many reasons for this depopulation and marginalization. Four of the most prominent reasons are interlaced. These four reasons are changes in the weather, explosive growth in the destructive monkey population, fissures in the base rock and contamination of the water lens.
>
> Changes in weather have resulted in seawater intrusions, brackish water inundations, high water temperatures which 'cook' taro and 'drowning' of plants in the taro patch. The explosive growth in the destructive monkey population has wreck havoc on the demoralized people of Angaur. The monkeys have devastated taro patches, gardens and food/craft trees/plants in search of food and water. The damage cause by the monkeys to the taro patches and gardens are so severe the cropping systems are nonviable, unproductive, crippled and cannot recuperate. The monkeys have invaded the villages. The 'attacks' of the monkeys are continual and heavy resulting in some people in Angaur suffering from the effects of 'battle fatigue'. Deep excavations using powered equipment have caused fissures in the base rock resulting in stagnant foul smelling brackish waters contaminating the fresh water lens. The contamination of the water lens is further exasperated by the ENSO effect.

[21] The nutritional contribution of fruit to nutrition is often substantially underestimated in the Pacific island countries. The reason is that surveys based on household meals would normally show little or no fruit consumption (McGregor 1999). Most fruit is consumed as what might be loosely defined as "snacks". These "snacks" would include wild fruits foraged largely by children. This consumption is opportunist in nature and goes almost unnoticed. But it makes a significant contribution to the nutrition of this relatively low priority group when it comes to allocating food at meal times. The children of Angaur no longer have this opportunity, which brings with it serious health consequences.

Land ownership and settlement[22]

The German anthropologist Augustine Krämer recorded four villages (Ngermasech, Rois, Ngebeanged, Ngerabelau) in the early 1900s. Each of these villages was associated with its own taro patch. Since the commencement of phosphate mining Angaur population was concentrated in the west-central area of the island. This area is associated with villages of Rois and Ngermasech. Angaur people continue to identify themselves with a particular clan *(kebliil),* house *(blai)* and community even if they no longer live in a nucleated village and even if they live away from Angaur. The initial mining was concentrated on the central part of the island then moved southwest and later north northwest. During the Japanese mining from 1914 to 1945, the mining was conducted in all four villages at different times but mostly concentrated on the central part. The eastern side of the island was not mined except for the excavations done to the southeast side or near the south end of the airport runway on the ocean side of the island. These excavations were done during the American/Japanese period from 1947 to 1955.

The forced relocation of the populations from Ngerbelau, Ngebeanged, and Rois started in late 1936 during the Japanese era. The people from the villages of Ngerbelau, Ngebeangedand Rois were relocated to Ngermasech where they have remained since. When phosphate compensation was made starting in late 1949 by the U.S. Naval Administration, the chiefs of Angaur reduced the number of clans (kebliil) to 4 each in Ngerbelau, Ngebeanged and Rois and 6 in Ngermasech contrary to the traditional land holding structure where each village has 10 clans. As a result, Angaur has up to today a total of 18 clans.

The traditional titles for all 18 Angaur clans follow the matrilineal line. Only 6 clans signed the 1909 German deed, giving permission to mine their lands but the deed is referred to the entire island as being sold by these 6 clans. These six clans included all four clans from Ngerbelau and one each from Ngebeanged and Rois for a total of six. During the American mining period, only 12 clans from Ngerbelau, Ngebeanged and Rois were classified as land owning clans and signed contacts with to allow mining on their lands. The mining prior to World War II was simply disregarded even though this mining included parts of Ngermasech village.

Prior to the commencement of phosphate mining, each village lived separately and apart from each other. There were village wars as well as inter island wars. However, the last war between villages on Angaur was in 1903.

Role of women

In common with Palau generally land ownership on Angaur is matrilineal. Traditionally there was a clearly defined gender based division of labour. This was described by Mereoni Seniloli (2002):

> Men's roles are confined to fishing activities and they have a close relationship to the sea and its resources. They can illustrate the types of fish, types of baits and the fishing methods that are appropriate to catch the desired fish species.

[22] Information for this section has been supplied by Theodosia F. Blaides, Angaur Official Historian and by Ambassador Carlos Salii

> Women on the other hand are involved in in-shore coastal fishing and agriculture. They cut trees to make way for their vegetable and root crops gardens. They dig, cultivate the soil and plant seeds and seedlings. Angaur has poor saline soil so the women have learned to make compost manure that provides the medium for crops to grow. They take intricate care of their vegetable gardens visiting and making note of germination time to harvesting time of crops. They are also aware of pests, diseases and signs of nutritional disorder in the crops. Monkeys are a major pest on the island and women scare them by placing scarecrows in their plantations. Rats are another pest. Women mix grated coconut with leaves of a leguminous tree (glyricidia) to make a poisonous rat bait. To improve soil fertility women plant nitrogen-fixing trees. These trees are multi-purpose and can be used as firewood, insecticide, windbreaks and green manure. For iron deficiency problem in crops women mix rusted pieces of iron in water and spray the mixture on crops. Women know the seasons for crab and the species of crabs that are available for consumption (p, 46)

While gender based division of labour essentially remained in place on Angaur, the state of agricultural food product at a point of collapse. Three elderly women made occasional visits to their severely salt damaged taro patch. Vegetable gardens are restricted to micro planting in the closest proximity to the house, where there is some prospect of protecting the fruits of her labour from monkey theft. At the time of Seniloli's fieldwork in 1997, there were more than a dozen women actively involved in taro patch, vegetable gardening and fruit production (South Pacific Commission 1997).

The main income earning activity for women now seems to be the selling of pepper leaves (*kebui*). This is one of the few products that is not damaged by monkeys and is available year round in significant qualities. The pepper leaves grown on Angaur receive premium prices on Koror because of their superior quality.

The present Governor of Angaur, Maria Gates-Meltel, reflects the leading role women continue to play in Angaur society.

Physical infrastructure

The infrastructure situation for Angaur presents a very mixed picture. For a remote outer-island in a Pacific island country, Angaur is fortunate to have some outstanding physical infrastructure in the form of roads, airfields, telecommunications and electricity. All this infrastructure appears to be well maintained. In contrast in other infrastructure areas, such as marine access and water supply, Angaur is particularly poorly served.

Infrastructure positives

There is well maintained all-weather roading access to most parts of the island. Limestone rock provide an excellent road foundation. Concrete roads service west-central area of the island where the population is now concentrated (plate 18). The extent of Angaur roading network can be clearly seen from the Google Earth satellite photograph. Mains electricity distributed underground is available to all households (Plate 19).

Plate 18: Concrete road in the Angaur residential area

Plate 19: Electricity articulated underground to all Angaur residents

All island residents have access to international standard telecommunications.

The lasting physical legacy of the World War II is the 2,300mx 100 m airstrip that was built immediately after the conquest of the island (plate 6). The airbase was used extensively in support of the Philippines campaign. Despite a large airstrip that remains in good conditions there have been no air services to the island for a decade. However, the airstrip represents an important asset for future tourism based development of the island.

Infrastucture negatives

During World War II Angaur's fresh water lens was able to meet the potable water requirements of 10,000 American servicemen. Today much of the water system is severely contaminated and can't meet the basic needs of 130 inhabitants. This water supply situation is spelt out in a letter of March 11, 2011 to Angaur Governor from the Palau Environmental Quality Protection Board: Water Quality for Angaur State Water Supply System.

Angaur access to the outside world is dependent on its marine infrastructure. Transport is expensive and can be treacherous with the island located 11 km outside the barrier reef. The island does not have an all-weather harbour. The final enter into the small boat harbour can be particularly challenging even and it is not uncommon for speed boat to be turned back during adverse weather conditions (plate 20). The Angaur State Government has recently purchased a "roll on-roll off" barge that provides a weekly service. This barge represents a significant improvement in term of capacity, access and safety.

Plate 20: Leaving the Angaur boat harbour in good weather

Angaur's agriculture and food production

Traditional farming systems

Palauan agriculturalist Robert Bishop describes traditional food production systems as follows:

> Traditionally, Palauan agriculture featured an environmentally sustainable multi-story agroforestry system in which tree crops provided a protective canopy, which supported the intensive production of 40-50 plant varieties. The Palauan system was broadly similar to traditional agriculture systems elsewhere in Oceania. Traditionally, every Palauan woman had a garden (or gardens). Female-produced agricultural products together with male and female harvested marine and forest products provided a self-sufficient food system with in-built security against natural and economic disasters, pest intrusion, and old age (Bishop 2001, p. 15).

Angaur's traditional food production was a variant on this basic system. Taro was at the centre of Angaur cropping system. This was mainly *colocasia* taro (known locally as *kukau*) and giant swamp *cytosperma* taro (known locally as *prak*) grown in taro patch swamps. Angaur's designated historian, Theodosia Blailes, describes four traditional taro patches on Angaur, which were linked to Angaur's four traditional villages. The taro patches on Angaur were not irrigated systems, as was common in other parts of Palau. The Angaur taro patch was a permanent swamp. Theodosia Blailes also talks of dry land taro (known locally as *bisch*) production also being traditionally important on Angaur.

The current situation

In 1997, the Secretariat of the Pacific Community (SPC) undertook a participatory rural appraisal of Angaur. The report lists 18 women under the age of 55 involved in agricultural activities and 19 women over the age of 55 involved in farming activities. The report describes the farming activities as follows:

> Farms are located mainly on the west side of the island and central part of Angaur. They are near homesteads and a few near the forest. Women, who are the principal farmers in Palau, are prevented from farming new land near forests due to crop damage and theft by

> monkeys. Thus women tend to over-utilise the small plots of land near their homes. Some of them are unable to plant a second crop because of low soil fertility. Thus, monkey damage is one of the single-most causes of food insecurity on the island (SPC 1997, p.7).

The SPC assessment, despite the recognition of severe monkey damage, describes quite a diversified food production system on Angaur. The following garden crops were identified:

> Garden crops grown include bitter melon *(*marekoso), English cabbage, cassava, cucumber, ginger, kangkong taro, okra, hot pepper, pumpkin, sugar cane, sweet potato, dry land taro (*bisch*), wetland taro *(kukau*), giant taro (*prak*), tomato, wax gourd (*tongang)*, yam, sunset hibiscus (*ysaol*), etc. Tree crops namely avocado, banana, betel nut, breadfruit, citrus (lemon/lime), coconut, guava, mountain apple, papaya, soursop, star fruit, tropical almond, spondia (*titimel*) cucumber tree (*imekurs*), football fruit(*riamel*) etc. thrive well on Angaur. However these are vulnerable to greedy monkeys robbing the hard working women of the fruits of their labour on already infertile soil (SPC 1997, p. 7).

The SPC assessment, conducted some 14 years ago, describes an already food insecure situation. In the intervening years there has been a marked deterioration in this already poor situation. This is primarily due to two primary interrelated factors:

- the emboldened and desperate monkey population that has encroached into the household compounds in search of food and moisture and;
- severe salt contamination of the remaining taro patch.

The freshwater taro patch was an important source of moisture for the monkey population, particularly outside the mountain apple season that provides the primary source of moisture. With the salt contamination of the taro swamp, this source of moisture was no longer available. Out of desperation, the monkeys have turned to alternative plant moisture, which hitherto they had avoided.

According to Mrs Tamae Gabriel[23] there are now only three elderly women, including herself, involved in any form of taro production. In the past, Tamae would visit her taro patch on a daily basis to plant, weed and harvest taro. This is now reduced to occasional visits to salvage the remnants of the taro that remains (plate 21). She now mainly uses the small amount of *colocasia* taro for ceremonial exchange purposes.

Plate 21: Tamae Gabriel harvest taro from the Angaur taro patch

[23] Tamae Gabriel was a lead participant in the SPC 1997 Assessment. The SPC Assessment describes Tamae Gabriel as an Angaur Community Organiser, who was a survivor of World War II occupation.

Taro

Kukau (Colocasia esculata) taro was Angaur's main traditional crop and is the preferred staple. It was mainly grown in *Ngerungor* soil swamps, with some grown as dry land taro. Today, the one remaining *Ngerungor* soil swamp is severely salt contaminated. Tamae Gabriel accompanied the team on her taro harvesting trip . Small, scattered clumps of *kukau* were observed. The water was distinctly warm, saline and weed infested. The physical appearance of the patch is one of neglect and abandonment. Evidence of monkey damage to the taro tops is readily apparent. Four of the seven taro corms harvested by Tamae were suffering from an unidentified fungal rot that rendered them inedible (plate 22).

Plate 22: Rotting colocasia harvested from the taro patch

Plate 23: Giant wetland taro grown in Angaur taro patch

With the exception of small home garden plots utilising compost, upland growing of taro is no longer feasible, due to lack of sufficient top soil. *Prak* (*cytrosperma* giant taro) is a less preferred staple but is relatively salt tolerant and less subject to monkey damage. The relatively robustness of *prak* was apparent in the visit to Tamae Gabriel's taro patch (plate 23). Pockets of *prak* were also observed on the fringes of the taro swamp. These appeared to be in varying states of neglect and health.

Other root crops

Cassava and sweet potato, previously significant Angaur staples, are for the most part, no longer planted. The only planting that remains is on a micro scale next to the domestic home, where some degree of protection against pilferage can be provided. This is reflected with sweet potato grown in tire gardens next to the house of a local resident (plate 24).

Plate 24: Sweet potato grown in a tire garden to ensure it can be harvested

Planted vegetables and fruit

Without prospect of harvesting the fruits of their labour, it was apparent that households on Angaur no longer plant the fleshy vegetables or fruit trees (e.g. papaya, banana) that were described in the 1997 SPC Assessment. In addition, residents are seldom able to harvest the fruit from more permanent fruit trees such as mango, avocado, breadfruit, citrus, guava, mountain apple, papaya, soursop and star fruit. Most distressing of all for a small Pacific island community, is that Angaur locals seldom have access to coconuts. Under moisture stress, monkeys have turned to young coconuts as their major source of hydration.

Other crops

The destruction inflicted by the monkeys is largely confined to crops that offer hydration or the prospect of food. However, some root crops are often damaged for no apparent reason. Betel nut is damaged in the early formative stage of fruiting, but a crop can usually be harvested. High quality betel pepper leaf is not damaged and has become a major income source for Angaur households. Leafy vegetables are also of little or no interest to the monkeys. Marijuana apparently goes unscathed.

A summary of constraints to Angaur agriculture and food production

The identified constraints to agriculture and food production on Angaur are:

- A large and aggressive feral monkey population
- Degradation of the islands' remaining taro patch through salt contamination
- Insufficient topsoil for upland root crop production
- A severe labour shortage
- Inadequate transportation links

These constraints are discussed briefly below, followed by recommendations for their amelioration.

A large and aggressive feral monkey population

Conversations with Angaur residents begin and end with their daily trials and tribulations with monkeys. This problem has been documented for decades (Poirier and Smith 1974,SPC 1997, Matearikiet *et.al.* 1998, Newsome 2003, Conservation International 2011). The impression gained from the April 2011 field visit is that the problem has reached a crisis point. The eradication of the monkey population, or at least substantially reducing it to a manageable level, is a necessary condition for any worthwhile food production on Angaur.

Control measures recommended by Newsome (2003) centred on culling through the use of a certified designated marksman. This recommendation was not adopted despite apparently strong community support. Why it was not adopted is unclear, except that it was probably contrary to Palau's strict gun control laws. How successful such a measure, on its own, would have been, against such a highly intelligent and well adapted adversary, is debateable.

It has also been suggested, although not confirmed, that the killing of primates is in contravention of US Fish and Wild Life regulations and there are animal rights group concerns. Thus it is highly significant that Conservation International Pacific Islands (CIPI) in collaboration with Palau Conservation Society, is calling for 'strong and systematic action' to control the macaque monkey population on Angaur (Conservation International 2011). CIPI's major concern is the severe environmental consequences of this invasive species being established elsewhere in Palau. Particular reference is made to a Palau Bird Survey prepared for the US Fish & Wildlife Service and Palau Conservation Society (VanderWerf, E. 2007). The survey found that Angaur had the lowest bird population of any island in Palau, whereas the nearby limestone island of Peleliu had the greatest diversity and number of birds. This invasive species is not only a severe threat to food security and the environmental, there are also major public health concerns, most notably the Herpes virus (B-virus) spread from pet macaque monkeys (Ostrowski et.al 1998).

The population control and management of such a highly intelligent primate will be no easy task. This is witnessed by the fact that a long standing feral macaque population still exists in Hong Kong's Kowloon Hills (Wong and I-H. Ni 1999). A sustained multi-pronged approach will probably be required, the cost of which could be considerable. However, the benefits of a successful monkey control program extend far beyond Angaur's food security and environmental restoration. The establishment of macaque monkey populations beyond Angaur would be associated with substantial environmental, public health and food security costs.

The first step in removing this overwhelming binding constraint to food security and agriculture on Angaur is an unambiguous national government priority to eradicate the macaque monkey population. If eradication is found not to be technically or economically feasible then the policy needs to be to significantly reduce the population to a manageable level and then to maintain the population at that level[24]. With a eradication/control policy in place, an appropriate project to implement this policy needs to be designed. It is expected that specialist technical assistance will be required. GIZ could be a potential source of this technical assistance. Adequate long term funding to achieve the desired eradication/control objectives will be required.

Plate 25: Vegetables grown in plastic bags with a shade house

[24] It is of note that Palau is a signatory to the Convention on Biological Diversity. Target 9 of the Aichi Biodiversity Targets for this Convention states "invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment".

It may well be deemed that monkey eradication is not a realistic objective. If so, emphasis would then need to shift to reducing the Angaur monkey population to a manageable level. This would need to be accompanied by a supplementary project that focused on the adaptation of Angaur agriculture to the presence of macaque monkeys. Some of the crop protection and monkey decoy possibilities that could warrant investigation include:

- Intensive production high quality vegetables in monkey proof screen houses. Good results are being achieved in Fiji growing vegetables (tomatoes, capsicum, eggplant, cucumbers) contained in large plastic bags in shade houses (plate 25). The planting media used is high quality sterilized soil and compost. The Fiji experience has shown that it is possible to have a least one crop rotation with the planting bag. A recent investigation has shown that this production on a relatively small scale can be cost effective when compared with open production systems[25].Excellent quality planting media would be available on Angaur for such a vegetable growing operation.
- Solar powered electric fence repulsion systems for gardens.
- Motion detector light/siren repulsion systems.
- Repulse the monkeys through utilization of plants, local materials and easily made devices.
- Use of lithium chloride for plant aversion by the monkeys.
- Use of guard dogs, shepherd dogs, geese, guinea fowl and ducks to repulse the monkeys.
- Use of four smelling chemical beta mercapto ethanol for aversion training of monkeys.

Technical assistance will also be required to formulate and implement Angaur food production adaptations to the presence of monkeys.

The degradation of the remaining taro patch through salt contamination

The saltation of the remaining taro patch has reached a level whereby the kukau taro (*colocasia esculata)* can no longer be viably grown. Kukau taro is traditionally the most important food for the people of Angaur. Three elderly women still stoically eke out a few taro corms from the patch for customary exchange purposes. This is indeed a tragic situation, considering that according to Palau traditional legend, life and the Palau culture began in Angaur (per. comm. Bob Bishop). The Palauan proverb 'The taro patch is the mother of breath (life)'highlights that traditional Palauan culture is intricately intertwined with the taro patch.

In principle, the breeding of salt tolerant taro varieties could offer a longer term solution to the salinity problems faced by Angaur and other atoll and low lying locations throughout the Pacific islands. However, the realistic prospects of developing salt tolerant taro varieties within a reasonable time frame are not good (Lebot 2009). This contrasts to some progress that is being made in the development of salt tolerant sweet potato varieties (per. comm. Mary Taylor SPC)

Superficial observation suggests that the remaining taro swamp is permanently damaged and beyond repair. However, hydrological investigations beneath the taro patch are necessary to confirm if this is

[25] Per.com. Sant Kumar, Manager AusAID Disaster Mitigation Seedling Project.

true and, if not, whether appropriate remedial measures can be taken. It is possible that the primary reason for the salt contamination is the extreme ENSO induced high tides that have been experienced over the last decade. If this was the case, it might be feasible to drain the swamp and to trial fresh water flow systems into the swamp. It might also be possible to trial a deep ditch with high raised beds as a system of taro production, including the use of a cement containment box. This would essentially be an irrigated system of taro production, which is common in other parts of Palau. Technical assistance to undertake the required hydrological investigation would be justified on food security grounds and on the cultural significance of the island's remaining taro patch. An investigation of Angaur's drinking water wells should also be a supplementary component of the hydrological investigation, with the view of taking remedial measures.

Insufficient top soil for upland root crop production

According to the designated Angaur historian, Theodosia Blailes, dry land taro and sweet potato production were traditionally important on Angaur and significant volumes were grown in pockets were there was sufficient depth of top soil. A minimum of 25 cm of soil is required for dryland taro production (Evans 2008 p, 57). The blanket removal of top soil for phosphate mining means that such areas no longer exist. It is recommended that a pilot reclamation, with sufficient top soil, be undertaken one of the smaller mining pits that has already been partially reclaimed during the post-World War II period. The target should be have sufficient soil dept to plant dry land taro. The University of Hawaii report Taro: Mauka to Makai describes the requirements for planting small areas of taro with little soil, to quote:

> In contrast from the way a carrot grows- downwards- the taro corm grows upwards from the bottom of the hole in which it is planted. It is important to provide the taro plant with the opportunity to grow to its full potential by providing a planting depth or hole into which the corm can grow upwards at least 6 inches. Corms will only be as long as the depth of the hole they are planted in, plus whatever hilling you might do on the soil surface (Evans 2008 p, 57)

The scale of this pilot project should be sufficiently small that the necessary top soil could be assembled from what is available on Angaur and from the production of compost. It is recommended that the dry land root crops be planted as part of an agroforestry system involving appropriate timber trees, spices and fruit trees. The Taiwan Technical Mission (TTM) has a long standing involvement in Palau's horticultural sector. This would make TTM an appropriate partner for such a pilot initiative. A decision on expanding the reclamation would be based on the outcomes of the pilot initiative. However, any future consideration of bringing in top soil from outside the island would need, apart from an economic evaluation, to be subject to a thorough environmental impact assessment. The perception of this study is that the importing of soil to Angaur is unlikely to be environmentally sound.

Any program to plant food crops has to be based on the assumption that the macaque monkey population are eradicated, or at the very least brought down to manageable levels.

A severe shortage of labour for agricultural activities

A major constraint to food production on Angaur is insufficient management and labour resources to do the work required. Angaur's population is disproportionally skewed toward the very young and elderly.

It was reported that there are only three elderly women involved in any form of legal agricultural activity. Any sustainable expansion of local food production would require some reverse migration of younger people back to the island. To reverse a long term trend of outmigration would require a concerted effort from the wider Angaur community and in particularly from the Angaur State Government. The improvement of the quality of life on Angaur through the eradication of feral monkeys, the reestablishment of clean drinking water supply, and improved transportation links, would be important necessary steps in the process. However, the establishment of broader and attractive employment opportunities will be critical if young people are to be attracted back to the island. Such opportunities are unlikely to be found in agriculture, as perceived by young Palauans. It is in the area of eco-tourism and related industry that the most enticing opportunities are likely to be found.

Inadequate transportation links

A decade ago, the UNDP IESL Project identified a range of specialty niche value added agricultural and marine products associated with Angaur that could be shipped to Koror and beyond. However, any such 'export' product development is severely constrained by the island's lack of air freight links and problematic sea freight links. The improvement in these services is likely to be related to investment in eco-tourism development. Eco tourism development is also likely to create the demand for many of these identified products in the form of 'suit case' exports.

Natural resource utilisation opportunities for Angaur

To determine Angaur's development opportunities there is a need to assess the Island's comparative advantage in natural resource utilisation. Angaur's major advantages would seem to lie with the island's unique environment, together with its historical cultural heritage. This could be complemented by growing high value hardwood timber, that is suitable to Angaur's hash limestone environment. Two major natural resource utilisation opportunities have been identified for Angaur:

- High value, low impact eco-tourism development based on a unique natural environment and history.
- The development of low labour, input agroforestry built around hardwood timber.

High value, low impact eco-tourism development based on a unique natural environment and history

The physical environment is distinctive and aesthetically attractive, despite underlying ravages of resource degradation. This forested raised limestone island lies within a world renowned marine environment. Angaur's biodiversity, while substantially degraded, remains significant and unique. Even the macaque monkey, could be converted from a liability to a unique eco-tourism asset within a ' jungle' environment, if their population could be substantially reduced. Given the island's isolation, these environmental assets on their own would unlikely be sufficient to attract a significant number of visitors to Angaur. However, the island offers a unique set of eco-tourism attractions when environmental assets are combined with its rich historical and cultural heritage. Perhaps Angaur's main tourism marketing asset is its World War II heritage. As the theatre of the fiercest battles of the Pacific campaign, the island, and its neighbour Peleliu, are in-situ museums of battle relics and shrines. If the

battle relics are not soon preserved, they will be lost forever and with them the tourism opportunity they provide. There is a small, but steady flow of Japanese visitors to the Japanese shrines on the island. There is also the occasional visitor from the United States. The small number of tourist arrivals is not surprising considering:

- there are no scheduled flights to the island;
- trips by sea are dangerous in inclement weather;
- there is no suitable accommodation for tourists on the island; and,
- there seems to be little or no promotion of Angaur as a destination in Palau's tourism promotion campaigns.

All these limiting factors would need to be addressed before a sufficient number of high value tourists could be attracted to Angaur. Angaur's contaminated water would also need to be dealt with before significant tourist numbers could be accommodated. The water supply problem would not seem to be insurmountable given that there were an estimated 10,000 residents on the island at the height of US military presence in World War II.

There would be opportunities for a phased eco-tourism development based initially on day trips taking advantage islands airstrip. With the proof on concept in place investment in appropriate accommodation could then follow.

The realisation of Angaur's eco-tourism potential would require substantial investment from visionaries who recognised the benefits that could be obtained. Technical assistance can help in the identification appropriate investors and in promoting Angaur as a high value, low impact eco-tourism tourism investment opportunity. It can also have a role in the promotion of the island as a unique visitor destination. It is expected that the greatest potential for tourism development on Angaur is at the top end of the market. Thus any investment promotion would be targeted accordingly. The fact that Angaur already has a substantial airstrip already in place will make this promotion an easier task.

The arrival of 500 to a 1,000 visitors a year, spending an average of 3- 4 days on the island, could potentially transform the economic and social landscape of the island. Tourism could create the type of jobs that would attract young Angaurians back to the island and create the critical mass of population. In particular, tourism opportunities are likely to attract women back to Angaur and help address the severe gender imbalance. Tourism could also generate the demand for high value agricultural products to be consumed on the island and in the suitcases of tourists when they leave the island. It would also mean an improvement in transportation links that would allow the marketing of agricultural products.

The development of low labour input agroforestry built around hardwood timber

Current labour supply on Angaur is only sufficient to undertake minor subsistence activities. In contrast, the growing of timber is a far less labour intensive activity, which is not adversely affected by the presence of feral monkeys. High value timber trees can be planted and initially maintained utilising supplementary labour resources provided by government departments.

The leading candidate high value tree is dort or iron wood (*Intsia bijuga*). Dort, which is native to Palau[26], grows well in limestone rock that is porous and fractured allowing the roots to penetrate to find pockets of soil and organic matter. Thus the tree is well adapted to Angaur, Peleliu and the limestone rock islands. *Intsia bijuga* is found to thrive under similar conditions elsewhere in the Pacific islands – notably on Kabara in Fiji's Lau group and in the Torres Islands in northern Vanuatu where it grows along coastal strips and coral plateaus. In deep well drained soils, *Intsia* grows to a large tree reaching 7 - 25 m in height at maturity, and in exceptional cases reaches 40 m (Thaman *et. al.* 2004). The trees grow upright in full sun, and the trunk can attain 0.5–1 m in diameter. Under Angaur conditions significantly smaller, but none the less valuable, trees can be expected.

Plate 25*: Intsia bijuga*

Intsia, which trades under the Indonesian name of Merbau, is one of the most highly valued trees in the Pacific islands, both in terms of its traditional cultural importance and its value as commercial timber. Apart from being a fine timber species, it has a number of uses. In Fiji, traditional kava bowls (tanoa) are carved from *Intsia* (vesi) grown on the limestone island of Kabara.

For medicinal purposes, Intsia is used widely throughout the Pacific Islands in traditional herbal preparations (Cambie and Ash 1994). It is also used as an insecticide as an insect repellent comparable to that made from neem (*Azadirachta indica*) can be made from the seeds. The wood is also highly valued for making handicrafts. It is used to make canoe keels, weapons, and other implements such as mallets for beating bark in the production of tapa cloth. In Fiji and Samoa, it is the preferred wood for making kava bowls and in the Solomon Islands it is used for walking sticks, food bowls, and carvings. In Palau, the traditional story board is carved from dort (plate 26). In pre-European times, the Tongans voyaged to Fiji to obtain double-hulled canoes made of this hard, durable wood.

Plate 26: A traditional Palaun story board made from dort(www.janesoceania.com/Palau-storyboard/index.htm)

[26]*Intsia bijuga* is native to the western Pacific and Indo-Malaysian region, from New Guinea and Palau in the west to Fiji, Tonga and Samoa in the southeast, and to the Mariana, Caroline and Marshall Islands in the north and northeast in the Pacific (Thaman *et al.* 2005).

Intsia heartwood timber is extremely dense (641 kg/m3), has limited shrinkage over time, and insect repellent properties (Thaman *et.al.* 2004). The wood has reasonable resistance to saltwater and is easily cut. These favourable physical and mechanical characteristics, combined with high natural durability and an attractive appearance make *Intsia* suitable for a wide range of purposes, from heavy duty structural timber through to furniture and handicrafts. The ITTO November 2005 Tropical Timber Market Report describes Merbau as a:

> popular timber for joinery applications in Europe particularly in Belgium and the Netherlands. Its grain and growth ring figure together with its dark red-brown colour gives it a very attractive appearance which is suitable for high class joinery including door and window frames and facades. The timber is also used for interior panelling, strip and parquet flooring and other decorative uses. (p. 4).

An Australian National University study for the Australia Centre for International Agriculture Research (ACIAR) on high value tree species in PNG describes the environment best suited to *Intsia:*

> Kwila (*Intsia)* prefers wet hot climates but can tolerate annual dry seasons. The tree occurs most frequently in coastal and lowland forest on well-drained or swampy areas. It is also found in tropical rainforest, in primary or old secondary and open forests. Kwila is a pioneer species. It is notable that the tree is found in areas of degraded forest and in tree groves in shifting agricultural areas. The preferred elevation range is up to 450 meters. The species is said to prefer saline soils of coastal regions, although there are populations of kwila that grow well inland in PNG and Fiji. Kwila is particularly tolerant to drought, although groves can be destroyed by fires associated with drought. It is a resilient species that can regenerate after fires. Soerianegara *et. al*. report that the extensive stands of merbau occur in northern New Guinea on sites destroyed by fire during natural droughts. The stands in the Gogol River valley were probably established after the 1918-1920 droughts (Kanowskiet.al 2008, p. 7).

Accordingly, this explains why the tree is so well adapted to the harsh environment of Angaur.

Globally, *Intsia* is seriously threatened due to its overexploitation. Commercial overexploitation throughout its natural range has led to its nomination for inclusion in Appendix 2 of CITES (Chen 2006). The World Conservation Union's (IUCN) Red List of Threatened Species 2006 has categorised *Intsia* as 'facing a high risk of extinction in the wild in the near future,' with logging and habitat destruction being the major threats (IUCN. http://www.iucnredlist.org/). However, its inclusion in international law to protect threatened species (Appendix II of CITES) has been thwarted by objection from Malaysia. The scarcity of merbau has steady driven up its prices in real terms. In 2008 the average cif price for sawn merbau into Japan was USD 234/m^3(ITTO 2010 p,120)[27]. Current prices can only be a limited guide to the value of a tree that is not going to be harvested until 50-years in the future. FAO staff have attempted to forecast changes in world forestry prices 50-years into the future (Morell 2001). For trees like *Intsia*, their study concluded that over the period to 2050:

[27]Kwila has by far the highest value of PNG saw/veneer grade log exports, with an average fob value of USD109/m^3 (ITTO Tropical Timber Report 16-30 November 2005). The next nearest logs are PNG Mersawa (USD83/m^3), Pencil Cedar (USD78/ m^3) and Calophyllum (USD75/ m^3) (Global Wood Trade Network).

> More wood will be requested, but more of it will be in the form of wood fibre. There will be increased demand for composite boards, less for sawn timber and face veneer. Solid wood will be at a premium, especially rare, high-quality hardwood grown in tropical natural forests. Prices of these timbers will be very high and international trade will be strictly controlled by private stewardship organizations (p. 76).

The major constraint to attracting private investment into planting *Intsia* is the long rotation of the tree. Growth rate will vary according to the environmental conditions. Despite an initial phase of rapid growth, the trees take up to 75–80 years to mature[28]. In PNG a 50-year rotation for natural stands has been reported as suitable, but in Malaysia it has been estimated that a rotation of 120-years would be required (Soerianegara *et. al*. 1994, p. 268). Rotations of 50-80 years are likely to be necessary to produce the solid wood sizes necessary for some of its principal uses. Thus the reality is that those who plant the tree are unlikely to harvest the tree. This does not mean that there are no significant benefits to the current generation. Shorter term benefits to the tree planter, the community and the wider environment might include:

- The psychological benefit of planting something that will benefit the ones children and grand children: While most Pacific island farmers are likely to have a short term time preference in terms of making investment decision, there are examples of Pacific island communities planting trees such as *Intsia* and teak motivated primarily by benefits to future generations. Cocoa producing communities on Bougainville are one such example (see AusAID 2006, p. 5). However, it is likely that the Angaur State Government, in collaboration with the national government, would need to take the lead in *Intsia* planting for the benefits of future generations of Angaurians.

- Soil conservation and land regeneration: *Intsia* can be used to regenerate land, especially land degraded by gully erosion. In addition to being a nitrogen fixer, the tree is known to have a high uptake of subsoil calcium and to enrich calcium levels in the surface soil (International Center for Research and Agroforestry 2004). Soerianegara *et. al.* note that after logging, dormant seeds in the soil can germinate abundantly in gaps around the stumps. These seeds tolerate fire, which seems to encourage germination (1994). *Intsia* is a successful secondary forest tree and has been used to encourage rehabilitation of clear felled forest areas. Accordingly, the planting of *Intsia* on Angaur could make a substantial contribution to the island's environmental rehabilitation.

- As a primary tree crop in an agro forestry system: *Intsia* could be used as the main shade tree in an integrated agroforestry system[29]. Timber and spice crops that could be considered in an agro-

[28] Thaman *et. al.* report the following growth rate information: trial plots conducted in the Solomon Islands using germinated seeds or collected wildings recorded 2 m per year in height for the fastest growing individuals. In Bogor, Indonesia, 8 year-old seedlings attained an average height of 10.7 m and a diameter of 15 cm. The average height growth increment in Samoa during the first three years was 77 cm per year, but thereafter height growth increased. Studies by Whistler in Samoa in 1994 showed that vesi had a growth rate of 14–18 mm in diameter per year (over 14 to 22 years).

[29] Trial plots conducted in the Solomon Islands using germinated seeds recorded 2 m per year in height for the fastest growing individuals (Kanowski *et.al*. 2008). These trees would be suitable for use as shade tree within 2 to 3 years.

forestry system include timber such as sandalwood and spices such as nutmeg/mace, cinnamon, cloves. These agroforestry systems could also include food crops, once the monkey population has been brought under control.

Apart from early growth data, yields over the life cycle of *Intsia* are not known. Currently harvests are primarily from native stands, which have led to depletion of natural populations to the point of disappearance of the species in many areas. *Intsia* is easily propagated, and appears to grow well in a variety of environments ranging from the semi-natural to the highly modified, but relatively little is known about appropriate management regimes under cultivation. Thus any plantation/agro forestry activity on Angaur should involve a significant long term applied research program, which would be of value to similar locations throughout the Pacific islands region. For example FAO forester, Aru Mathias, who is very familiar with *Intsia* in Vanuatu's Banks islands is of the view that that trees would be best planted in clumps to encourage straight upward growth (pers. comm. May 2011).[30] Such a planting system would warrant trialling. Other research issues to be explored would include the use of nitrogen fixing cover crops such as velvet bean or mucuna beans (*Mucuna pruriens*). Mucuna beans have been used on shallow alkaline soils in Belize and on Mexico's Yucatan Peninsula, for the restoration of the 'Milpa' production systems, which are always on shallow soils over limestone or old coral in this region (Coultas et. al. 1996 and Bunch 1991). GIZ would seem particularly well placed to conduct this type of research. A research project combining Nauru would seem to be of particular interest given the island similar phosphate mining history.

- Income generation for the planters of long rotation trees: Intsia trees planted today would not be harvested and sold for timber for some 50-years into the future. Thus there is no direct financial benefit for the planters of the tree. A possible income source for Angaur's current generation is through voluntary carbon markets – that is payment for the sequestration of carbon and restoration of ecosystems through tree planting. Voluntary carbon credits (VER) are predominantly purchased by the private sector. Corporate social responsibility (CSR), public relations and to a lesser extent, general philanthropy, are the most common motivations for buying carbon credits. Accordingly, the 'story' behind the credits plays a crucial role in voluntary markets. Agriculture, Forestry and Land Use (AFOLU) projects are noted as being particularly valued for their social and environmental benefits, as they deal directly with people's livelihoods and the protection of ecosystems (FAO 2010).

  Within the voluntary carbon markets, there are a number of forest carbon standards, of varying relevance to the micro scale of Angaur island. Standards refer to a set of rules or guidelines that a forest carbon sequestration project should comply with to ensure that the project is generating real and measurable net carbon gains. In the context of Angaur, where less than 300 to 400 hectares can realistically be afforested, the net carbon gains are insignificant on a global scale. To this could be added additional tree planting on nearby Peleliu, which was involved in some phosphate mining and war activity. Accordingly, the 'story' of Angaur will be a determining factor in how/if a carbon

[30] Aru.Mathias@fao.org

sequestration project could be established on the island, with sufficient return to Angaur residents to make it worthwhile. Further investigation will need to be undertaken to identify the likely purchasers of credits (i.e. philanthropic organisations with a strong interest in 'righting the wrongs' of previous colonial powers, etc). GIZ, with its on-going support to forestry initiatives, national forest policy development and forestry carbon projects (REDD) in the Pacific, could be well placed to lead this.

A detailed project feasibility/design activity will be required for the planting of *Intsia bijuga* as part of an agroforestry system. It is envisaged that technical inputs for this could be obtained from GIZ/FAO/SPC. Consideration would be given to prospects of security carbon credits from a forestry rehabilitation program. It is envisaged that the implication of the tree planting would come under the auspices of the Forestry Division of the Bureau of Agriculture.

A list of potential activities to support Angaur's agricultural and natural resource rehabilitation

This study identifies a number of activities to support Angaur's agricultural and natural resource rehabilitation. These are:

- Technical assistance for the eradication/control of feral macaque monkeys.
- Technical assistance adaptation of food production to the presence on monkeys
- Adequate long term funding to achieve appropriate monkey eradication/control/adaptation objectives
- Hydrological investigations beneath the taro patch to determine the cause of saltation and determine if appropriate remedial measures can be taken.
- Design and implement, if feasible, appropriate remedial measures for the rehabilitation of the taro swamp.
- Design and implement, if feasible, appropriate remedial measures for the rehabilitation of the potable water supply.
- Investigate the feasibility of a small scale pilot reclamation of an appropriate mining pit using top soil and compost assembled on Angaur. The objective would be to plant dry land root crops as part of an agroforestry system involving appropriate timber trees, spices and fruit trees.
- Technical assistance in identify appropriate investors and in promoting Angaur as a high value, low impact eco-tourism tourism investment opportunity.
- A detailed project feasibility/design activity for the planting of *Intsia bijuga* as part of an agroforestry system.
- Support for a applied research program on appropriate management regimes for *Intsia bijuga* and other suitable high value timber species that are cultivated as part of an agroforestry systems. The applied research would be for Angaur and for similar locations throughout the Pacific islands region.
- Assistance in the design and marketing of a carbon sequestration project for Angaur and Peleliu.
- A possible project to coordinate and facilitate the various activities listed above.

Conclusions

Angaur has suffered considerable land degradation due to past phosphate mining as well as military action during WWII. Land degradation problems in recent years have been compounded by El Niño–Southern Oscillation (ENSO) high tides made worse by a gradual increase in average sea level attributed to climate change.

The people of Angaur find themselves in a precarious position with respect to food security. They have relatively low incomes and have very limited capability to grow their own food. This is due to a combination of factors:

- Salt contamination of the last remaining taro patch means that the preferred staple taro can no longer be effectively grown.
- What little taro that is still grown (mainly now for customary purposes) is severely damaged by monkeys.
- It is not possible to grow dryland taro due to insufficient depth of soil resulting of past phosphate mining.
- Fruit, of any kind (including coconuts), are rarely available for harvest due to the predatory of feral monkeys seeking moisture and food.

The identified constraints to agriculture and food production on Angaur are:

- A large and aggressive feral monkey population.
- Degradation of the islands' remaining taro patch through salt contamination.
- Insufficient topsoil for upland root crop production.
- A severe labour shortage.
- Inadequate transportation links.

The eradication of the monkey population, or at least substantially reducing it to a manageable level, is a necessary condition for any worthwhile food production on Angaur. The first step in removing this overwhelming constraint to food security and agriculture on Angaur is an unambiguous national government priority to eradicate/control the macaque monkey population. An appropriate project to implement this policy needs to be designed. It is expected that specialist technical assistance will be required, with adequate long term funding to achieve the desired objectives.

The saltation of the remaining taro patch has reached a level whereby the taro (*colocasia esculata)* can no longer be viably grown. Taro is traditionally the most important food for the people of Angaur. Superficial observation suggests that the remaining taro swamp is permanently damaged and beyond repair. However, hydrological investigations beneath the taro patch are necessary to confirm if this is true, and if not, whether appropriate and economic remedial measures can be taken. An investigation of Angaur's drinking water wells should also be a supplementary component of the hydrological investigation, with the view of taking remedial measures.

Dry land taro and sweet potato production were traditionally important on Angaur and significant volumes were grown in pockets were there was sufficient depth of top soil. The blanket removal of top soil for phosphate mining means that such areas no longer exist. It is recommended that a pilot reclamation, with sufficient top soil, of one of the smaller mining pits that has already been partially reclaimed during the post-World War II period, be undertaken.

A major constraint to food production is the management and labour resources to do the work required. Angaur's population is disproportionally skewed toward the very young and elderly. Any sustainable expansion of local food production would require some reverse migration of younger people back to the island. To reverse a long term trend of outmigration would require a concerted effort from the wider Angaur community and in particularly from the Angaur State Government. The improvement of the quality of life on Angaur through the eradication of feral monkeys, the reestablishment of clean drinking water supply, and improved transportation links, would be important necessary steps in the process. However, the establishment of broader and attractive employment opportunities will be critical if young people are to be attracted back to the island. Such opportunities are unlikely to be found in agriculture, as perceived by young Palauans. It is in the area of eco-tourism and related industry that the most enticing opportunities are likely to be found.

Angaur's major advantages would seem to lie with the island's unique environment, together with its historical cultural heritage. This could be complemented by growing high value hardwood timber, that is suitable to Angaur's hash limestone environment. Two major natural resource utilisation opportunities have been identified for Angaur:

- High value, low impact eco-tourism development based on a unique natural environment and history.
- The development of low labour, input agroforestry built around hardwood timber

The physical environment is distinctive and aesthetically attractive, despite underlying ravages of resource degradation. This forested raised limestone island lies within a world renowned marine environment. Angaur's biodiversity, while substantially degraded, remains significant and unique. Given the island's isolation, these environmental assets on their own would unlikely be sufficient to attract a significant number of visitors to Angaur. However, the island offers a unique set of eco-tourism attractions when environmental assets are combined with Angaur's rich historical and cultural heritage. Perhaps Angaur's main tourism marketing asset is its World War II history.

Angaur's contaminated water would also need to be dealt with before significant tourist numbers could be accommodated. The realization of Angaur's eco-tourism potential would require substantial investment from visionaries who recognized the benefits that could be obtained. Technical assistance can help in the identification appropriate investors and in promoting Angaur as a high value, low impact eco-tourism tourism investment opportunity. The fact that Angaur already has a substantial airstrip already in place will make this promotion an easier task.

The arrival of 500 to a 1,000 visitors a year, spending an average of 3- 4 days on the island, could potentially transform the economic and social landscape of the island. Tourism could create the type of

jobs that would attract young Angaurians back to the island and create the critical mass of population. Tourism could also generate the demand for high value agricultural products to be consumed on the island and in the suitcases of tourists when they leave the island. It would also mean an improvement in transportation links that would allow the marketing of agricultural products.

Current labour supply on Angaur is only sufficient to undertake minor subsistence activities. In contrast, the growing of timber is a far less labour intensive activity, which is not adversely affected by the presence of feral monkeys. High value timber trees can be planted and initially maintained utilising supplementary labour resources provided by government departments.

The leading candidate high value tree is Dort (*Intsia bijuga)*. Dort, which is native to Palau, grows well in limestone rock that is porous and fractured allowing the roots to penetrate to find pockets of soil and organic matter. Thus the tree is well adapted to Angaur, Peleliu and the limestone rock islands.

Intsia is one of the most highly valued trees in the Pacific islands, both in terms of its traditional cultural importance and its value as commercial timber. Globally, *Intsia* is seriously threatened due to its overexploitation. The scarcity of *Intsia* has steady driven up its prices in real terms. The major constraint to attracting private investment into planting *Intsia* is the long rotation of the tree. A detailed project feasibility/design activity will be required for the planting of *Intsia bijuga* as part of an agroforestry system. It is envisaged that technical inputs for this could be obtained from GIZ/ /SPC. Consideration would be given to prospects of security carbon credits from a forestry rehabilitation program. It is envisaged that the implication of the tree planting would come under the auspices of the Palau Forestry Division of the Bureau of Agriculture.

A list of potential activities to support Angaur's agricultural and natural resource rehabilitation have been identified aimed at improving the livelihoods of the residents of Angaur. The success will depend on how effective they are in encouraging the people from Angaur to stay/return and work in eco-tourism, food production and forestry. There is also a close linkage between the various activities proposed. Control of the feral monkey population is a prerequisite for food production; any eco-tourism development depends on an improved water supply; eco-tourism development is needed to attract Angaurians back to the islands and to create a demand for agricultural products.

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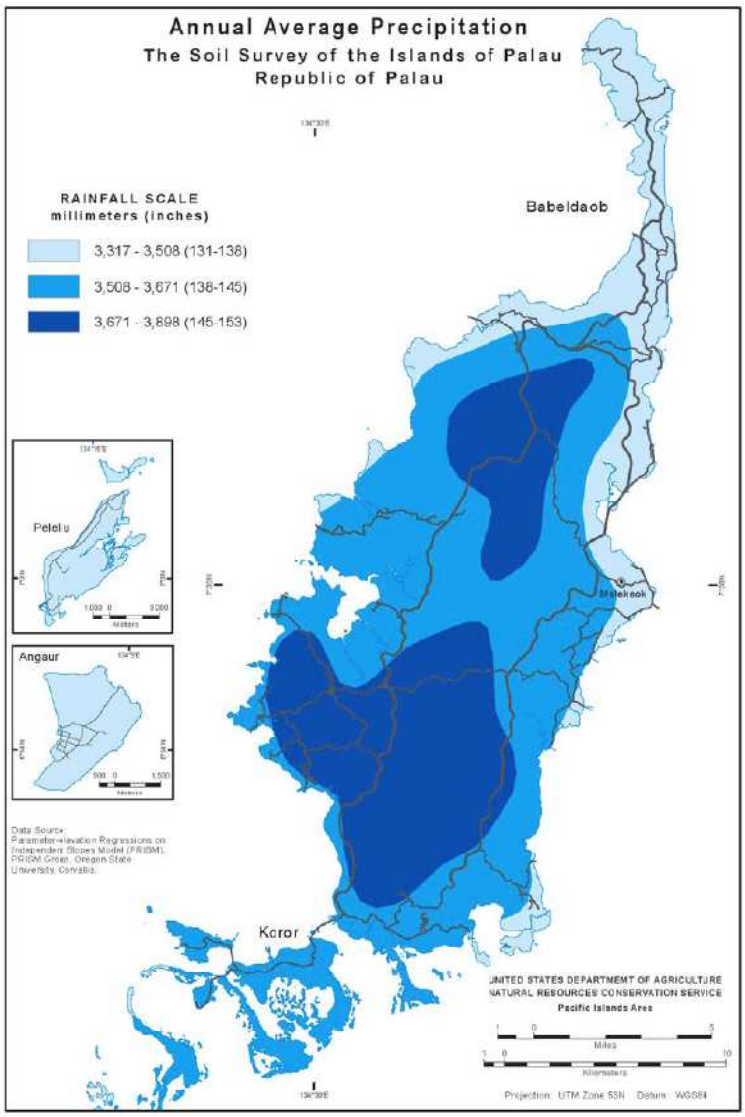
Annex 1: List of Persons Met

Governor Maria Gates-Meltel	Governor Angaur State
Joshua Lewis	President of the Angaur State Legislature
Delegate Horace N. Rafael	Chairman of the Committee on Public Works, Infrastructure & CIP, Palau National Congress
Ambassador Carlos "Hiros" Salii	Head of the Mission of the Republic of Palau to the Federal Republic of Germany
Theodosia Blailes	Designated Angaur Historian
Tamae Gabriel	Angaur farmer and community leader
Gabriel Meskebech	Angaur community elder
Masayuki Alfred Shiro	Angaur community elder
Gino Henry	Angaur based entrepreneur
Dr. Aurora G. Del Rosario	Researcher and Extension Specialist, Palau Community College
U. Pau Michael	Head of Forestry, Bureau of Agriculture, Ministry of Natural Resources, Environment and Tourism.
Trebkul Tellei	Bureau of Agriculture
Gow-Shyang Suen	Leader, Taiwan Technical Mission in the Republic of Palau
Dr. Patrick L. Colin	President, Coral Reef Research Foundation
Maria Ngemaes	Meteorologist – In – Charge. Republic of Palau, National Weather Service, National Oceanic & Atmospheric Administration
Amena Yauvoli	Head, Secretariat of Pacific Community Regional Office, FSM

Annex 2: Average annual precipitation for Palau



Annex 1: Invasive species of environmental concern present on Angaur*

Scientific Name	Common Names (abridged)	Family	Habit
Acacia auriculiformis	Papuan wattle, auri, earleaf acacia, northern black wattle, ear-pod wattle	Fabaceae	tree
**Agave sp.*	American aloe, century plant	Agavaceae	succulent
Alpinia purpurata	red ginger	Zingiberaceae	herb
Bothriochloa bladhii	blue grass, Australian beardgrass, Caucasian bluestem, desum (Palau)	Poaceae	grass
***Casuarina equisetifolia*	casuarina, ironwood, Australian pine, she-oak, horsetail tree, beefwood, agas (Palau), agasu (Palau), ngas (Palau), ngasu (Palau)	Casuarinaceae	tree
†*Cenchrus brownii* †*Cenchrus echinatus*	burr grass, burr grass, sand-bur, slimbristle sandbur burr grass, sand-bur, southern sandbur	Poaceae Poaceae	grass grass
Chloris barbata *Chromolaena odorata*	swollen fingergrass Siam weed, triffid weed, bitter bush, Jack in the bush, ngesngesil (Palau)	Poaceae Asteraceae	grass shrub
Clerodendrum buchananii var. fallax	red clerodendrum, pagoda flower, butcherechár, butecherechar (Palau)	Lamiaceae	shrub
**Clerodendrum paniculatum*	pagoda plant, pagoda flower, butcherechár (Palau), butecherechar (Palau)	Lamiaceae	shrub
**Clerodendrum quadriloculare*	bronze-leaved clerodendrum, kleuang (Palau)	Lamiaceae	shrub
Cynodon dactylon	Bermuda grass, giant Bermuda grass, bahama grass, devil's grass, couch grass, Indian doab, grama, devilgrass, couchgrass, balama grass	Poaceae	grass
Cyperus rotundus	nut grass, nutsedge, purple nutsedge, cocograss	Cyperaceae	sedge
Digitaria ciliaris	Henry's crabgrass, smooth crabgrass, tropical crab grass, large crab grass, southern crabgrass, fingergrass, summer grass	Poaceae	grass
Eleusine indica †*Hyptis pectinata*	goosegrass, wiregrass, goose foot, crow's foot, bullgrass, deskim(Palau), kelelamalk (Palau), keteketarmalk (Palau) comb hyptis, comb bushmint, mint weed, purple top	Poaceae Lamiaceae	grass herb
†*Ipomoea aquatica*	aquatic morning glory, swamp cabbage, water spinach, ung-choi, kang kong, kankum (Palau), kangum (Palau), kangkum (Palau)	Convolvulaceae	aquatic herb
Lantana camara	lantana	Verbenaceae	shrub
Leucaena leucocephala	leucaena, wild tamarind, lead tree, telengtungd (Palau)	Fabaceae	tree
Mimosa diplotricha	giant sensitive plant, nila grass, mechiuaiu (Palau)	Fabaceae	shrub
Mimosa pudica		Fabaceae	herb
Muntingia calabura ***Operculina turpethum*	jam tree, strawberry tree, Jamaican cherry, Singapore cherry, Panama cherry, Panama berry, ornamental cherry, calabura, sirsen, budo (Palau) Other: ongucheta rekung (Palau)	Tiliaceae Convolvulaceae	tree vine
Paspalum conjugatum	T grass, ti grass, sour grass, sour paspalum, buffalo grass, carabao grass, Hilo grass (Hawai'i), udel ra ngebei (Palau)	Poaceae	grass
Paspalum paniculatum	Russell river grass, galmarra grass	Poaceae	grass
Passiflora foetida	love-in-a-mist, wild passion fruit, passionflower, stinking passionflower, kudamono (Palau)	Passifloraceae	vine
Pluchea indica	Indian fleabane, Indian pluchea, Indian camphorweed	Asteraceae	shrub
Psidium guajava	guava, guabang (Palau), kuabang (Palau)	Myrtaceae	tree
Ricinus communis	castor bean, castor-oil plant, gelug (Palau), maskerekur (Palau), uluchula skoki (Palau)	Euphorbiaccae	shrub
**Samanea saman*	monkeypod, rain tree, saman	Fabaceae	tree
***Sporobolus indicus var. major*	smutgrass, wiregrass, Indian dropseed	Poaceae	grass
Stachytarpheta cayennensis	blue rat's tail, dark-blue snakeweed, false verbena, nettleleaf velvetberry, louch beluu (Palau)	Verbenaceae	herb
Syngonium angustatum **Tecoma stans*	arrowhead plant, goosefoot plant yellow bells, yellow-elder, yellow trumpetbush	Araceae Bignoniaceae	vine small tree
Timonius timon	liberal (Palau)	Rubiaceae	tree
Tradescantia spathacea	oyster plant, boat plant, boat lily, moses in a boat, kobesos (Palau)	Commelinaceae	herb
Tradescantia zebrina	wandering zebrina, wandering jew, inchplant	Commelinaceae	herb
Turnera ulmifolia	yellow alder, sage rose, West Indian holly	Turneraceae	shrub
***†Urena lobata*	hibiscus burr, aramina, caesarweed, pink Chinese burr, urena burr, bur mallow, chosuched e kui (Palau), osuched a rechui (Palau)	Malvaceae	shrub
Wedelia trilobata	wedelia, trailing daisy, Singapore daisy, creeping ox-eye, ngesil ra ngebard (Palau)	Asteraceae	herb

*Cultivated
**Native/Micronesian introduction
†Reported present by Fosberg *et al.* (1979)

Source: Space et.al. 2003