

**A feasibility study of the eradication
of Oriental fruit fly (*B. dorsalis*) and
breadfruit fly (*B. umbrosa*) from the
Republic of Palau**

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Cover photograph: Pacific almond (*Terminalia catappa*) grown on the rock islands (photograph A. McGregor)

Introduction: Exotic fruit flies in Palau and the proposal for their eradication

1. There are three exotic economically important fruit flies in Palau: Oriental fruit fly (*Bactrocera dorsalis*), breadfruit fly (*Bactrocera umbrosa*) and mango fly (*Bactrocera frauenfeldi*). The later two fruit flies probably were present in Palau from before the Second World War. The introduction of the Oriental fruit fly dates back to only the mid – 1990s. It is reported that prior to the arrival of Oriental fruit fly, fruit flies in Palau did little obvious damage. Now, most of Palau's fruit and fleshy are effected by fruit flies with varying degrees of severity. The consequences are particularly severe in terms of food security and nutrition. The presence of Oriental fruit fly has severely limited the agricultural development opportunities for this small nation.

2. The arrival of Oriental fruit fly in Palau can be seen as a “biological” disaster the costs of which are potentially far greater than a major physical disaster, such as a severe typhoon. A recently published study by the South Pacific Disaster Reduction Programme on disasters on agriculture in the Pacific islands concluded:

An introduction of a pest or a disease can cause a far greater long-term disaster than a cyclone or a volcanic eruption. A cyclone may last anywhere from several hours to several days but has a discrete end, after which relief and rehabilitation begin. A drought can last much longer, but is eventually broken. The impact of an incursion of a major pest and disease, by comparison, is open-ended and may never end. There are also social costs resulting from lost livelihoods and environmental costs associated with control programs (McGregor and McGregor 1999 p,8).

3. The most prominent biological disaster in the region in recent years was the incursion of taro leaf blight into Samoa. This meant the loss of the country's most important staple and major export earner. The incursion of Oriental fruit fly into Palau represents a similar type of disaster.

4. If conditions of isolation apply, it is possible to eradicate Oriental fruit fly using the technique of male annihilation. The principle of the technique is that male flies are attracted to methyl eugenol, a very powerful male attractant. Blocks impregnated with methyl eugenol, combined with an insecticide, are spread around at the required density. After repeated blockings the male population is reduced to the point that no mating occurs and the species is eliminated. Oriental fruit fly has been successful eradicated from Okinawa (Japan), Rota (CNMI) and most recently from Nauru using this technique.

5. The Nauru fruit fly eradication program was coordinated by the Regional Management of Fruit Fly Project (RMFFP). With the efficacy of the male annihilation technique proven for the small isolated island, attention turned to Palau. The RMFFP conducted a technical feasibility in August 1999 (Allwood et.al. 1999). This study concluded that it would be technically feasible to eradicate the Oriental

fruit fly and the breadfruit fly on Palau for an estimated cost of USD1.21 million. The Government of Palau, following this favourable technical feasibility study, requested assistance from the Secretariat of the Pacific Community to undertake a full economic feasibility study of the eradication proposal.

Section 1: The socio-economic context of fruit fly eradication in Palau

The physical and agronomic environment

- Location* 6. The Palau group comprises around 340 islands with a total land area of 488 km². The four larger islands (Babeldaob, Arakabesan, Koror, and Malakal) are all volcanic. The remainder are raised coral limestone islands, with the exception of the northern island of Kayangel, which is a low atoll. The archipelago lies between 6° 50' and 8° 15' North latitude and 133° 50' and 134° 45' East longitude. Palau lies in close proximity to South East Asia and Papua New Guinea. This has implications for quarantine security from fruit flies and other pest and diseases. The Philippines are only 800 km to the west and the Southwest islands are closer to Indonesia than they are to Koror. So close are Palau's Southwest islands to Indonesia, it is reported that small boats from Indonesia regularly visit to barter food¹. Here currently they face no quarantine border controls.
7. Babeldaob (the Big Island) is by far the largest island with an area of almost 400 km². It also contains most of Palau's limited arable land. The islands have a remarkably diverse flora. Almost 75% 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 are characterised by a surprisingly rich vegetative cover. Thus the incursions of exotic fruit flies that have occurred have found an abundance of host fruits on which to thrive. Pacific almond (*Terminalia catappa*), *Calophyllum inophyllum*, noni (*Morinda citrifolia*) are found throughout the islands, even on the Rock Islands (Report cover).
- Climate* 8. Palau's climate is tropical and wet. The mean annual rainfall on Koror is around 3,700 mm, with little monthly variation. The mean annual temperature on Koror is 27°C, with the average diurnal range being only 7°C. The archipelago's proximity to the equator means that it is outside the normal typhoon zone, although typhoons do occur from time to time. Thus, Palau offers excellent climatic conditions for growing a wide range of tropical fruit and vegetables.
- Soils* 9. Generally, Palauan soils can be described as infertile, highly acidic, and highly erodible. Only approximately 14% of Palau's land (16,600 acres) 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.

¹ Personal communication Marcello Brell Quarantine Supervisor and Remoket Ngiriou Chief Division of Agriculture.

10. A recent mission of the Taiwan Agricultural Research Institute on tropical fruit culture noted, with respect to Palau's soils:

Acid, shallow and poor fertility of tillage soil are popular in Palau. Furthermore heavy rainfall induce severe soil erosion without better soil conservation, the fertility will become poor and worsen year by year. Therefore, along the contour line and the alleyway it is essential to plant cover crops prior to the establishment of a new nursery. Well-decomposed compost is essential, instead of partial inorganic fertiliser, for sustainable production in the future. Organic matter will improve the structure of the soil and the ecosystem will be kept more in balance and stable (Teng p, 3)

11. The major portion of the land classified as arable is in the volcanic uplands that lie in the flood plain of Babeldaob's rivers. These soils are described by the USDA Soil Survey as being "very deep, well drained, to nearly level to very steep". These areas are suitable for fruit and vegetable production, although addition of lime, organic matter, and crop rotations are required to achieve good sustainable results (Cheng 1996). Low lying wet lands are also used for taro production. The Soil Survey describes these soils as "very deep, very poorly drained to somewhat poorly drained, level and nearly level". Poor drainage may preclude most of these low lying areas from successful fruit and vegetable production. The soils around urban Koror appear adequate for reasonable fruit production and satisfactory vegetable production can be undertaken with the addition of organic matter.

12. Land-use planning needs to take full account of the limited availability of good arable land. Considerable pressure can be expected from tourism (particularly golf courses) with the completion of the Babeldaob Compact road.

Demographic considerations

13. In terms of population, Palau is one of the smallest countries in the world. Amongst Pacific Island Countries and Territories (PICTs), only Nauru, Tuvalu, Wallis and Futuna, and Tokelau are smaller. At the time of the 1995 Census, Palau's population stood at 17,225, of which only 12,774 were classified as Palauan. Population has been growing at a high annual rate of 2.34%, with the 1998 population estimated at 18,638 (Palau Statistical Year Book 1999). However, this high population growth reflects the influx of foreign workers. The estimated annual population growth rate for Palauans has averaged only 0.6% - the result of the combined effect of declining fertility and high out-migration to the United States (Palau National Committee on Population and Children 1997 p, 13). At anyone time, there is likely to be an additional 3,000 tourists in the country, with annual tourist arrivals at around 75,000.

14. Palau, unlike most PICTs, is an urbanised country. At the time of the 1995 Census, 71% 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 35 persons/km². However, for Koror the density was 683 persons/ km². These

demographic factors have important implications for the prospects and nature of agricultural development.

Public health and nutrition

15. Palau enjoys a high standard of health, demonstrated by low infant mortality (18 deaths per 1,000 live births) and high life expectancy (67 years). 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) 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 (p, 109).

16. This feasibility study gives particularly attention to the implications of fruit and vegetable consumption in the context of changing dietary patterns. The CoPopChi concluded that besides tobacco, the single greatest factor affecting the health of Paluans is diet and related obesity (p, 116). The prevailing dietary patterns, which contribute to overweight and associated ill health 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.

17. 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 recently completed National Plan for Action in Nutrition points to in particular the dramatic increase in diabetes.²

18. Specific micro-nutritional deficiency problems are now becoming apparent – notably nutritional anaemia amongst women of reproductive age and Vitamin A

² There are currently 650 on the official diabetes registry (Palau Bureau of Public Health p, 13).

deficiency amongst children³. It has been postulated that one of the reasons why Palauans may not have suffered the micronutrient/vitamin deficiencies of other nearby territories was because of higher fruit consumption (Bishop 2000). However, the arrival of the Oriental fruit fly probably means that this is no longer the case.

19. All of these diet related health problems reduce the wellbeing of individuals and households. They also bring with them substantial economic and financial costs to the community at large in terms of lost productivity and increased expenditure on health care. The adequate consumption of fruit and vegetables has a critical contribution to make in addressing these health problems and to reducing their cost to society.

The economy: an impressive record but vulnerable

20. Palau is one of the world's smallest economies, with an estimated Gross Domestic Product (GDP) in 1998 of USD129.3 million (Bank of Hawaii 2000 p, 4). Yet, despite its remoteness and size, Palau enjoys a per capita GDP of approximately USD7,000, the highest of any independent Pacific island country. UNDP's 1999 Human Development Report for the Pacific Islands ranks Palau the highest of all PICTs in terms of the Human Development Index (HDI)⁴. 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 less than a quarter of Hawaii (Bank of Hawaii 2000 p, 15).

21. There is an inherent fragility in the economy, which is heavily biased toward services and public sector infrastructure development. All services, including public services and tourism, accounted for 71.8% of GDP in 1998. Public administration's contribution to GDP was 22.9%. Payments under the Compact of Free Association (the Compact) with the United States have enabled Palau to maintain a large public service and high levels of public sector investment.⁵ The vulnerability of small

³ The National Plan for Action in Nutrition notes: "while overt manifestation of Vitamin A deficiency have not been recorded in Palau, so diet recall studies have indicated the probability of sub-clinical Vitamin deficiency among children in Palau" (Palau Bureau of Public Health p, 18)

⁴ The HDI from the 1999 UNDP Human Development Report Pacific Islands are: Palau .860; Cook 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.

⁵ 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 – of which half has already been dispersed (Bank of Hawaii 2000 p, 6). 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 2000 p, 6).

island economies heavily dependent on high levels of public sector expenditure for employment has been shown by the recent experience of Cook Islands, CNMI, FSM, the Marshall Islands and Nauru. Without sound economic management, and a degree of good fortune, such small economies can rapidly fall down the GDP/capita and the HDI totem poll.

22. The income generating sectors of the economy are tourism (11.3 % of GDP in 1998) and agriculture and fisheries (4.8% of GDP in 1998). There is also a fledgling garment industry based on preferential access to the United States and cheap imported labour⁶. The policy option of significantly expanding the garment industry is currently a matter of intense public debate in Palau.

23. Most analysts would agree that tourism offers the best prospects for the sustainability of the Palauan economy at current consumption levels. However, there are divergent views on the rate and direction of this development (CoPopChi p,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 prospects for commercial agricultural development are linked closely to the fortunes of tourism.

24. Palau, like many economies of comparable size and structure, has a large merchandise trade deficit. In 1998, total exports (mainly fish, some garments, and a small quantity of betel nut) totalled USD11.6 million, while imports were USD63.2 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. Fortunately the difference has been more than made up by tourist receipts and Compact payments and grants. Thus, Palau, unlike a number of other PICTs, does not have a balance of payments problem.

25. The level of food imports is of particular interest to this feasibility study. According to the Bureau of Revenue, Customs and Taxation, the value of food imports was USD11 million (about 20% of total imports). This is high and there is no doubt scope for improvement. However, to put Palau's food imports into perspective, they are not greatly out of line with those of most other PICTs. Even for Fiji, regarded as having relatively vibrant farming community and a strong subsistence base, food imports have been around 15% of total imports.⁷.

⁶ The value of garment exports in 1996 was USD836,000 (Palau Statistical Year Book 1999).

⁷ Value of food imports in Fiji as a percentage of total imports:

Year	Value of food imports (USD,000)	Value of total imports (USD,000)	Food imports as % of total
1985	80,057	507,993	15.7
90	128,047	888,779	14.4
95	182,314	1,218,934	14.9

Source: *Fiji Current Economic Statistics (Various Issues)*

26. An enviable feature of the Palauan economy is the low and declining level of foreign debt. The recent Bank of Hawaii Economic Report notes that Palau “has neither credit problems in global capital markets nor pressure to pay for debt service from scarce export earnings” (p, 12). Still, the Bank cautions “a widening gap between merchandise exports and imports has the potential to create problems in the long run”.

Agriculture and food in Palau

Agriculture in the economy.

27. During the period of the Japanese administration prior to World War II, Palau developed a significant commercial agriculture sector. During this period, the “copra industry was developed and expanded, and the growing of tapioca, rice, and oil palm introduced (Pacific Islands Year Book p, 429). Today, with the exception of subsistence tapioca production, none of these industries remain.

Contribution to GDP 28. As noted above, agriculture and fisheries estimated contribution to GDP is a little less than 5%. The Bank of Hawaii study suggests that agriculture’s contribution to the sub-sector was less than half this amount (p, 11). Estimation of the agricultural sector’s contribution to GDP have been notoriously inaccurate in PICT national accounts. Problems particularly arise in measuring the subsistence component of GDP. Often, the contribution of subsistence is greatly underestimated (see McGregor 1999). In the case of Palau, it is unlikely any account is taken of “back-yard” consumption of fruit.

Exports 29. Palau’s agricultural exports are restricted to insignificant quantities of betel nut (*Areca catechu*) and cassava to Guam.⁸ 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.

Domestic food production 30. A significant volume of food is produced for sale on local markets, or consumed or given away by the household, which grows the food. Measuring this production is much more difficult than measuring exports.

31. Until recently the Division of Agriculture collected data on domestic commercial sales of staples, fruit and vegetables. These data show the following

⁸ For FY 1998, agricultural exports to Guam were as follows:

Commodity	Weight (lbs)
Betel nut	795
Cabbage(Nappa)	85
Piper leaf	94
Tapioca	100

Source: Department of Agriculture Plant Protection and Quarantine, Fiscal Year 1998 Annual Report

volumes traded in the FY 1997.⁹ These figures suggest a commercial trade of around USD500,000 annually in locally grown food.

Commodity	Volume (lbs)	Value (USD)	Value/lbs (USD)
Staples (mainly cassava and taro)	78,881	85,667	1.09
Fruit (including drinking coconuts)	71,749	53,821	0.75
Vegetables	466,764	359,540	0.77
Total	617,394	499,028	0.81

Source: Palau Statistical Year Book 1999.

Informal marketing and subsistence food production

32. To these commercial sales has to be added the quite sizeable sales of the informal sector, who market any surplus to subsistence requirements. The informal sub-sector mainly grow staple root crops (cassava and some taro), betel nut and some fruit. In 1996, the Informal Employment and Sustainable Livelihoods (IESL) Project tried to estimate the value of these sales for each of the 16 States. The methodology used involved a series of participatory planning workshops. Estimates were also made of the value of subsistence food production and food used in traditional exchanges (funerals, wedding, "house parties" etc.). The total estimated value of this production is almost double that of formal commercial sales (table 1).

Table 1: The estimated annual value of informal sector of agricultural production and marketing by State

State	Value sold in market (USD)	Value used in traditional exchange (USD)	Value consumed at home (USD)	Total value (USD)
Aimeliik	26,853	16,804	13,407	57,064
Airai	55,440	7,920	15,840	79,200
Anguar	13,000	5,200	7,800	
Hatothobei	11,520			11,520
Kayangel	5,011	576	173	5,760
Koror	92,640	12,352	18,529	123,520
Peleliu	39,375		4,375	43,750
Melekeok	57,016	7,595	7,595	71,120
Ngardmau	80,472	37,322	37,896	155,700
Ngaremilengui	20	6,143	18,217	24,570
Ngatpang	4,410	245	245	-
Ngaraard	10,836	1,357	2,003	14,196
Ngarchelong	54,520	6,815	6,815	68,150
Ngardmau	83,607	37,332	37,521	158,460
Ngaremlengui	210	2,421	7,897	10,530
Ngchesar	119,425	7,025	14,050	140,500
Ngiwal	195,585	26,078	39,117	111,540
Sonsorol	57,016	2,400	5,616	71,120
Total	635,791	121,816	165,874	923,481

Source: Palau Informal Employment and Sustainable Livelihood Project and Rarick 2000

⁹ Data is available for 1998, which shows considerably lower production. However, 1998 was an extreme El Niño year which can be regarded as atypical.

33. Fruit sales were usually not disaggregated in the ISEL surveys. However, one hamlet in Airai State reported selling banana, papaya, and pineapple for a combined annual value of USD14,400 (IESL 1996).

34. The value of the informal fruit consumption component of the above data is probably considerably under estimated, at least before the arrival of the Oriental fruit fly. This might be explained by the Palauan concept of food, which is discussed in some detail later in this report. The underestimation of fruit consumption is an important issue in determining the benefits of fruit fly eradication.

*The value of
betel nut
production*

35. Betel nut is by far the most important traded agricultural crop in Palau. It has been estimated that betel nut sales are in excess of USD9 million per year (Pestelos 1997 p, 1). Betel nut plays a similar role in the economy of Palau as kava does in economies of Vanuatu and Fiji.

Similarly, excessive betel nut consumption has serious health and nutrition consequences.

36. Based on the above discussion, the contribution of agricultural production to Palau's GDP would be well above the 2% suggested in the Bank of Hawaii Report.

Employment and the structure of the agricultural sector

*Commercial
agriculture*

37. According to the preliminary 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. This could be classified as the commercial agricultural sub-sector.

38. 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. The commercial farmers appear to be the dominant supplier of the hotels and supermarkets. Available statistics of the production and marketing of vegetables largely reflects the output of the commercial sub-sector (Tables 3 and 4).

*The informal
sub-sector*

39. The informal sub-sector represent a much larger component of the agricultural sector. The participatory ISEL survey cited above estimated that a total of 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. A breakdown by reporting States is presented in table 2 below.

Table 2: The estimated participation informal agricultural food production and marketing by State (9 states reported)

State	Males involved	Females involved	Total number involved
Aimeliik	0	54	54
Airai	0	99	99
Koror	0	46	46
Ngardmau	0	99	99
Ngaremilengui	0	30	30
Ngaraard	0	60	60
Ngarchelong	0	46	46
Nchesar	80	80	160
Ngiwal	10	61	71
Total	90	575	665

Source: Palau Informal Employment and Sustainable Livelihood Project

The “back-yard” sub-sector 40. Some 70 percent of the population live in and around Koror’s civil and commercial centre. Thus, back-yard food production for the households of urban wage earners is relatively important in Palau. Fruit trees dominate the “back-yard” sub-sector – although there is some vegetable and root crop production.

Fruit and vegetable production in Palau.

Vegetable production 41. Vegetables are largely grown by the commercial farmers. Table 3 presents Division of Agriculture estimates of marketed vegetable production for 1997 (this list also includes some cucurbit fruits).

Table 3: Production and marketing of locally produced vegetables (FY 1997)

Product	Quantity (lbs).	Value (USD)
Head Cabbage	395	304
Chinese Cabbage	42,521	34,141
Leaf Lettuce	97	73
Cucumber	67,625	50,719
Tomato *	255	200
Green Onion	3,185	3,276
String Beans	17,885	19,043
Bean Sprouts	3,065	2,374
Eggplant*	30,455	22,841
Bell Pepper*	2,561	2,130
Radish	35,005	26,254
Kung Kong (a tuber)	27,584	20,688
Ginger Roots	148	141
Pumpkin	50,256	37,692
Squash	42,483	31,862
Corn	2,035	1,526
Cantaloupe	4,743	3,557
Melon	3,995	2,996
Okra	20,550	15,413

Watermelon	100,319	75,239
Markoso (bitter melon)	9,966	7,475
Hot Pepper*	1,486	1,486
Leek	150	113
Total	466,764lbs	USD359,540

* Regarded as a fruit fly host

Source: Palau Statistical Year Book 1999

Fruit production 42. The commercial farms are far less dominant in fruit production than they are for vegetables. For fruit, informal producers and self-sufficiency backyard producers make a major contribution – although this cannot be quantified from the data available. Table 4 presents Division of Agriculture estimates of marketed fruit production for 1997. Banana is probably substantially underestimated in this table – as this fruit is a favourite of the informal sector and self-sufficiency backyard producers. Notable omissions from table 4 are mountain apple and star fruit, both of which are now severely damaged by Oriental fruit fly. Some star fruit was listed in 1996 data, which may be indicative of the worsening fruit fly damage problem.

Table 4: Production and marketing of locally produced fruit (FY 1997)

Product	Quantity (lbs).	Value (USD)
Banana*	96,325	48,163
Papaya*	41,627	20,814
Pineapple	5,595	2,798
Avocado*	4,390	2,195
Orange	541	271
Tangerine	15	8
Lemon	56,548	30,645
Soursop*	7,439	3,720
Coconuts(Drinking)	82,310	41,164
Mango*	290	145
Rambutan*	390	195
Mangosteen*	65	33
Total	295,535lbs	USD150,147

* Regarded as a fruit fly host

Source: Palau Statistical Year Book 1999

Fruit and vegetable consumption and food security in Palau

Fruit in the Palauan concept of food

Staple fruits 43. Food is considered differently in different cultures, which has implications for consumption and nutrition. The cultural context in which fruit is consumed will also have a bearing on the effect of damage caused by fruit flies and the benefits from their eradication and control.

44. In Palau, *kall* is a general term for food, which consists of four major groups: *ongraol*, *odium*, *kliou*, and *ilumel* (Akimichi 1980). *Ongraol* is the term used for

starch foods such as cassava, sweet potato, taro, **breadfruit**, **cooking bananas**, and imported rice. These foods are usually paired with *odium* (animal derived – including marine products) to make up a meal. In Pacific island cultures, starchy staples are usually considered as “real” foods (Pollock 1985). In this respect, Palau appears to be no exception. In most PICTs, the staple fruits, breadfruit and cooking bananas, are of considerable importance in terms of food security.

45. Breadfruit makes a major contribution to the diet in most PICTs, particularly on atolls and smaller islands where it is the every-day staple (fresh and in former times preserved). The crop is an excellent source of dietary fibre and Vitamin A. Palau appears to be an exception in this respect, with breadfruit now a relatively minor food crop. No doubt it was much more important food crop in the past for it features prominently in Palauan legends – *cheldech duch ra meduu ribtal* (Bishop, 2000). Table 5 shows how insignificant breadfruit now is as a traded staple. A single Tuvaluan household would consume more breadfruit in a year. Considerably more subsistence consumption of breadfruit in Palau is likely. However, even this subsistence consumption is probably quite modest.

Table 5: Production and marketing of locally grown staples(FY 1997)

Product	Quantity (lbs)	Value (USD)
Yam	55	41
Taro	91,440	68,580
Breadfruit*	175	131
Cassava	101,665	76,249
Sweet Potato	13,404	10,053
Cytosperma	63,157	56,555
Coconut		754
Sugar Cane		1,975
Xanthosoma	250	188
Total		214,526

* Regarded as a fruit fly host

Source: Palau Statistical Year Book 1999

46. Worldwide, the most import fruit is banana (*Musa* spp.). Roughly half of the bananas of the world are eaten cooked as a starch. For much of Vanuatu, Solomon Islands, island and coastal Papua New Guinea and Samoa, banana is often the major food crop. In these locations the arrival of a major banana pest or disease would have serious food security implication. In Palau, while cooking bananas are certainly more important than breadfruit, they are a relatively unimportant staple compared with cassava, taro, and particularly, imported rice. Cooking bananas are not even shown in table 5. Since they were observed in a number of stores they have probably lumped together with the eating bananas presented in table 4.

47. The general conclusion reached is that, in Palau staple fruits (breadfruit and cooking bananas) are relatively unimportant. Thus, in Palau a fruit fly that damaged only staple fruits would not be of great consequence. However, the damage caused by fruit flies now precludes the promotion of traditional staples in nutritional programs.

Non-staple fruit 48. A wide range of other fruits and fleshy vegetables can be classified as non-staple fruits. In most PICTs, non-staple fruits are of distinctly secondary importance compared with breadfruit and cooking bananas. Palau would appear to be an exception to this norm. Yet, even when non-staple fruit is of secondary importance, it makes an important contribution to the nutrition of Pacific island households.

49. Most fruit consumption in Palau fits into the non-staple category. Fruit eaten with meals would fall into the Palauan food classification *kliou* – which is somewhat analogous to the western concept of desert. If fruit is consumed outside a meal it would either not be considered or considered a “snack”.

50. A recent report of the impact of the Project on the Regional Management of Fruit Flies in the Pacific (RMFFP), found that the nutritional contribution of non-staple fruit to nutrition is often substantially underestimated. The reason is that surveys based on household meals would normally show little or no non-staple fruit consumption (McGregor 1999). Yet, most non-staple 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.

51. The fruit consumption patterns found in Palau are fully consistent with this model. To quote Robert Bishop, National Informal Livelihood Project Co-ordinator:

Fruits are rarely listed on 24-hour recall or other recalls of diet. This has lead to some to mistakenly conclude that are not a) an essential nutrient element of the average Palauan’s diet, b) a significant portion of the diet and c) culturally important. When participants were questioned why they did not list fruits, they stated it was not sustaining “real” food but rather snack food. Many considered it more “kid” food than adult food. Observations reveal that while little fruit is eaten at meals, much fruit is eaten out-of-hand when the opportunity presents itself – in the bush, on the farm, in the back-yard, on the road side fruits are (or were before the arrival *Oriental fruit fly*) regularly and casually eaten. Around nearly every household you will find banana, guava and carambola, three of the most popular snack foods. Fruits are processed into pickles and deserts and sought after and regularly eaten. Malay apple is fermented and further processed into a delightful desert. “Green” fruits are dipped into soy source, “Kool-aid”, or salt by kids and adults alike (Bishop 2000).

52. In Palau, in former times, fruit consumption as *kliou* would have made a useful supplementary contribution to the diet. However, it may not have been all that critical to the health of the community. Food derived from a traditional taro based food garden, if supplemented by outside sources of protein, would readily satisfy the nutritional requirements of the household. Work of the South Pacific Commission dating back to the 1950s has found “that a mixed diet of yams, taro, or sweet potato with green leaves would supply a balance of amino acids necessary for an adequate diet” (Peters 1959). Such was the traditional Paluan diet. This has now dramatically changed. As the Palau National Plan for Action in Nutrition points out “with greater

affluence and urbanisation, diets tend to become richer on average in energy and fat, especially saturated fat, have less fibre and complex carbohydrates and more refined carbohydrates and salt” (Palau Bureau of Public Health p, 13). In this dietary context, the supplementary role of fruit consumed as *kliou* is far more critical today for the health of the community. If fruit fly infestation mean that this fruit is not readily available – then is very serious indeed for the health of the community.

53. In most other PICTs, a pest or disease that effects a particular non-staple fruit would not be expected to have a major impact on the household’s overall food consumption and nutrition. A particular fruit is unlikely to be a major part of the household’s diet and in most situations there are likely to be a number of alternative fruits are available. However, the situation is different in Palau. The host range of Oriental fruit fly is so wide, and damage so great, that there are few readily available alternatives available. The consumption of these fruits is “**opportunistic**” in nature – if the opportunity is not there then they will not be consumed.

54. A measure of the extent to which the community is feeling the loss of *kliou* fruit is reflected in the intense interest in the proposed fruit fly eradication project by everybody this consultant meet – from high government officials to taxi drivers. Such a high level of community interest augers well for the implementation of the project, should it proceed.

The contribution of fruit to health and nutrition

Staple fruit 55. Staple fruits are, by definition, high in energy, but they contribute more to household nutrition than just energy. Breadfruit is the leading staple in terms of dietary fibre, while cooking bananas beats all starchy staples and imported cereals in terms of potassium. Cooking bananas are amongst the best possible source of vitamin A and β -carotene. Breadfruit also provides a good source of vitamin A, and more riboflavin than any other staple food. The promotion of these traditional staple fruit should be emphasised in any nutritional awareness programs. It would seem that breadfruit’s place in popular traditional stories is something that could be taken advantage of in nutritional promotion.

Non-staple fruit 56. In contrast to staple fruit, most non-staple fruits, while sweet, are low in calories. They are, however, a further source of dietary fibre and are packed with nutrients, especially vitamins.

The role of fruit in food security and reducing vulnerability

57. Most Paluans are relatively prosperous and have the capacity to meet most of their requirements for sustenance through purchasing imports. Yet despite Palau’s enviable economic record, the economy is inherently fragile with development options limited. Material prosperity depends largely on capital inflows from abroad and income generated by tourism. Tourist arrivals in turn depend largely on the prosperity of Palau’s Asian neighbours. The recent Asian economic crisis has shown how transitory high per capita incomes can be and how vulnerable urban communities are. Fortunately, Palau is not burdened by the debt levels of these countries.

However, severe economic down turns must be expected from time to time in the future, regardless of how prudent Palau's economic managers are. During these down turns the ability of households and the nation to import will be greatly diminished. If there is no self-sufficiency food production, including fruit, to fall back on, the social consequences are likely to be severe.

*The Nauru
experience: a
salutary lesson*

58. The recent experience of Nauru provides a salutary lesson to import dependent small island economies. Due to the high income from phosphate mining, the island experienced a rapid transition in lifestyle from one of subsistence to almost total dependence on imports and outside labour. During the 1980s, phosphate mining royalties gave Nauru's 10,000 people one of the highest per capita incomes in the world - USD20,444 in 1989 (East-West Center p, 65). However, the last few years have seen this income fall sharply to stand at less than USD3,500 in 1998 (UNDP 1999 p, 13). This decline can be attributed to depleting phosphate reserves and a poor out-turn from many of Nauru's offshore investments.

59. Nauruans had become almost totally dependent on a diet of refined imported food with exceptionally high calorie and fat intake. However, with the economic crash, they had no traditional agricultural production base to fall back on¹⁰. With a sharp fall in income levels, there was even greater pressure to buy the lowest cost, usually poorest quality, imported calories available.

60. The island had some 1,400 bearing mango trees originally planted by the Japanese during the War. With the arrival of the Oriental fruit fly, no ripe fruit could be harvested from these trees. Thus, Nauru's successful recent fruit fly eradication program could not have been more opportune. The availability now of some 15 to 20 tonnes of mango annually might not be considered particularly significant. However, in the context of Nauru's present economic and nutritional circumstances, these mangoes have become of immense value.

*Samoa: the
contrasting
situation*

61. In contrast, Samoa provides an example of the surprising resiliency of small island economies if they have a strong traditional agricultural base. In the space of 5 years, Samoa experienced two "100 year" typhoons and the almost complete loss of taro due to a disease. Taro was the country's most important staple food and main export earner. For most countries, this would be a disaster of catastrophic proportions. The equivalent would be a disease eliminating most of Thailand's rice crop or the blight that destroyed Ireland's potato crop last century. Yet for Samoa, there was no famine and export levels have now been restored. Farmers simply adjusted by growing other food crops, particularly bananas (see McGregor 1999a). Economic activity in Samoa is now buoyant and is now the best performer of any economy in the South Pacific. The

¹⁰ The traditional local diet consisted entirely of fish, coconut, pandanus, and some breadfruit. Nauruans never had the range of food enjoyed by most Pacific islands due to the limestone structure of their island and the lack of good soil (the abundant phosphate is unusable for plants until it has been converted into superphosphate). Ethnographic reports indicate that, before the commencement of phosphate exports, the population was quite healthy despite the very narrow diet (Pollock p, 209).

Samoan experience is testimony to the “hidden strength” of the seemingly weak Pacific island economies that lies with their traditional food production systems.

Prospects for expanding Palau’s agricultural sector

62. To evaluate benefits from fruit fly eradication,

it is first necessary to consider the prospects for expanding the agricultural sector.

63. Bank of Hawaii’s economist, Wali Osman, in his recent review of the Paluan economy concluded: “The reason for agriculture’s limited role is Palau’s small market, which cannot take advantage of economies of scale that make agriculture financially successful” (Bank of Hawaii 2000 p, 150). Small market size and diseconomies of scale are undoubtedly factors constraining the development of the Paluan agriculture. However, even within these limitations there are opportunities for agriculture to play a more important role.

64. The Bank of Hawaii’s report shows little understanding of the role and opportunities of agriculture in small Pacific island economies. In particular, it ignores the potential role of tourism linked niche markets. Hawaii itself provides no better model of the demand tourism creates for products such as tropical fruits and flowers.

65. Finally, and most importantly, recognition is not given to the important role that household food self-sufficiency can play in the success of a small Pacific island economy, as the Samoan example above illustrates. Unfortunately, the economic contribution of traditional food production in the Pacific Islands tends not be fully recognised by agricultural and national planners and generally substantially underestimated in national accounts. This has had a distorting effect on agriculture policy formulation and its implementation. For example, Paulson and Rogers note that key Department of Agriculture personnel in Samoa were not impressed by the diverse mixed gardens of traditional food crops which had sprung up after the blight (p, 182). These officials “held a vision of a much more export-orientated, commercialised agricultural system modelled on those of industrialised countries.”

The President’s Task Force on Agricultural Development in Palau

66. There appears to be an increasing recognition amongst policy makers in Palau of importance of agriculture and food production in the viability of the nation’s future. This is reflected in the President declaring the Year 2000 The Year of Agriculture. A National Task Force on Agricultural Development (NTFAD) by established by Executive Order, in April 1999. The NTFAD was mandated to “review national government public policies regarding agriculture and aquaculture and to periodically report to the President its findings and recommendations for strengthening and implementing public policies that could lead to a diversified and increased agricultural and aquaculture production in Palau” (NTFAD p, 2). Specific areas of attention identified for the Task Force are:

- encouraging greater consumption of locally grown fruits and vegetables;

- improving the level of nutrition of the Palau people;
- increasing the prospects of food security and sustainable livelihoods and the family and village level;
- satisfying local markets to increase money circulation within Palau;
- providing income from the sale of locally grown produce to the 60,000 to 70,000 visitors; and
- reducing the reliance on the importation of fruits and vegetables.

To facilitate the work of NTFAD a number of committees have been established, including a **Committee on Fruit Fly Eradication** and a **Committee on Quarantine Rules**.

An evaluation of opportunities for expanding fruit and fleshy vegetable production

*Palau
competitive
advantage in
fruit production*

67. This is an economic feasibility study of eradicating fruit flies. Thus, the primary interest is in fruit and fleshy vegetable production. However, in passing, it should be noted that Palau can not expect to approach self sufficiency in food production. Items such as imported rice will always make up a substantial part of the diet. Furthermore, the availability of cheap imported rice plays an important role in food security – particularly for a society that is largely urbanised. Thus, emphasis needs to be on growing things for which Palau has a competitive advantage. Tropical fruit and some fleshy vegetables fall into this category. Palau’s competitive advantage in growing tropical fruit lies in the combination of ability to grow these products (now threatened by fruit flies), consumer preference (including tourists who expect to eat tropical fruit when they come to a tropical “paradise”), and the unavailability or high cost of imported substitutes.

*The production
capability of
fruit and
vegetables*

68. Palau has the agronomic conditions to successfully grow a wide range of tropical fruits. A lower frequency of devastating typhoons provides a major advantage compared with other nearby countries. Suitable soils are, to some extent, a limiting factor. However, there would seem to be sufficient suitable land available for a many-fold increase in fruit production. Fruit tree crops are somewhat less demanding in terms of soil requirements than field crops – although site selection and good soil management is still required. There are a few fruit crops, notably pineapples, which have a preference for acid soils. It is surprising that more pineapples are not grown, given they are not a fruit fly host and the potential role they can play in soil conservation.

69. Palau has benefited from ongoing agricultural technical assistance from Taiwan since 1985. Over this period, a wide range of superior tropical fruit cultivars have been introduced. Thus, Palau does not have a planting material constraint often faced by other PICTs.

70. Discussions with resident agriculturists, and perusing the reports of various Taiwan agricultural missions, suggest a number of fruits with excellent commercial

production potential. These include guava, carambola, papaya, and avocado. Papaya, for example, has achieved outstanding yields of 30 tonnes/acre.¹¹ Palau has high rainfall, and fairly even seasonal distribution, and thus is ideally suited papaya, provided it is associated with good drainage. Supplementary irrigation is seldom a requirement in Palau – although during 1998 El Niño induced drought would have been an exception. On the other hand, this rainfall pattern precludes the prospect of good quality mango production. Mango requires a sustained dry period to induce good flowering and fruit set and to maintain fruit quality.

71. Walking the streets of Koror reveals a numerous and wide range of good quality fruit trees – carambola, mountain apple, banana, soursop etc (see Plates 2,3 and 4). In the view of this writer there is a better stock of fruit trees in Koror than in any other PICT capital. The IESL Project reports distributing over 4,000 fruit seedlings and cuttings over the period September 1998 to August 1999 (IESL 1999). There is no doubt scope for expanding self-sufficiency and informal sector fruit production. However, there is now little incentive to plant fruit trees, if the fruit is rendered useless by the infestation of fruit flies.

The Compact road and its implications for agricultural development

72. The construction of a new road around Babeldaod (known as the Compact road) will commence shortly. This road represents Palau's biggest every capital investment project, costing an estimated USD113 million (Bank of Hawaii 2000 p, 8). The road will take 4 years to construct. This road will remove a major constraint to agricultural development – access to markets. The present road is very rough and makes it difficult and expensive to transport fruit and vegetables to market in reasonable condition. The road can also create new markets, with a new capital planned and several new resorts are in the pipeline. With good access, it is anticipated that many of the residents of Koror will return to live on Babeldaod. The hope is that some of the returnees will become involved in commercial fruit and vegetable farming if they have access to suitable land.

73. It is difficult to predict what the agricultural production response to this new road might be. However, the experience in other PICTs has been that the construction of strategically located roads leads to a substantial and rapid production response. For example in the case of Fiji, the 1999 Asian Development Bank Agricultural Sector Review concluded that: "strategically located roads opened up significant markets for traditional food crops and provided an incentive for increased plantings as shown by farmers response to the construction of the Waidina Valley road near Suva" (ADB 1996 p, 17).

74. In the case of Palau, the construction of the Babeldaod road, is seen as a necessary, although probably not a sufficient requirement for substantial agricultural development.

¹¹ Personal communication Dr James Dzou Head of the Republic of China Agricultural Technical Mission.

*Agricultural
exports –
shipping to
foreign markets*

75. Discussion of agricultural development opportunities tends often to focus on export opportunities. Thanks to tourism Palau has numerous flights to foreign markets – particularly Guam and Japan. This in theory offers opportunities for horticultural and floricultural products. Hawaii, again provides a model here. However, Palau's current agricultural exports are minuscule – confined to small quantities of betel nut.

76. Currently, Palau fruit fly status precludes virtually all horticultural exports. USDA lists 103 fruits and vegetables not admissible for entry into Guam as the “are declared to be hosts and possible carrier of Oriental fruit fly (Guam Department of Agriculture 1998). Yet, it is of note that there are no cut flower exports to Guam or Japan, where no quarantine constraint applies. Thus, there are more factors than Oriental fruit fly impeding exports.

77. Even if Oriental fruit fly was eradicated, along with Breadfruit fly, it would still leave mango fly. The male annihilation technique using methyl eugenol will not eliminate the mango fly. Thus, exporting fruit and fleshy vegetable to Guam will still require quarantine treatment, unless a non-host protocol can be negotiated¹². High temperature forced air treatment (HTFA) would be the most likely treatment. For these units to be successful, they must be operated by the private sector. The South Pacific experience has shown that management problems in operating these facilities cannot be underestimated. Furthermore, currently the only expertise available for installation and servicing these units resides in New Zealand.

78. Japan may allow shipment of certain fruit without quarantine treatment, once the Oriental fruit fly was eradicated. Mango fly is considered a far less damaging fruit fly with a much narrower host range. It is not on Japan's list of damaging fruit flies. To minimise the risk of such exports, it is strongly advised that they be associated with a protein bait spray program – regardless of whether this is a requirement of the Japanese authorities. If Japan does require quarantine, it will likely insist on the use of vapour heat treatment. The capital cost of Japanese vapour units is considerably more than the US developed HTFA technology. In addition, at least in the case of Hawaii, a Japanese Quarantine officer is required on site. The costs would be prohibitive for the small volumes involved.

79. Another consideration in the exporting of fruit from Palau is the type of aircraft involved. The 727s and 737s do not carry cargo containers. Thus, individual cartons would have to be loaded and unloaded. This is an expensive and labour intensive operation. These smaller aircraft are used for shipping fresh tuna out of Palau. However, whether the price of fresh fruit would justify such additional cost remains to be seen.

80. A number of constraints to exporting fresh fruit have been identified. However, while Oriental fruit fly is present, exporting fresh fruit is not even an

¹² Hawaii has commenced exporting to the US Mainland and Guam, certain varieties of bananas at the green stage under a non-host protocol.

option. At least with the removal of this fruit fly, exporting fresh produce becomes an alternative for policy makers and private investors to consider. This in itself can be seen of value for a small country like Palau that has few development options available.

*Exporting via
tourists*

81. The direct exports of fruit and vegetables from Palau to foreign markets is seen as problematic for the foreseeable future. However, indirect exports via the “suitcases” of tourists offers a realistic, albeit modest, opportunity. Hawaii provides the model here, where a multi-million dollar business has developed selling tropical fruit, cut flowers, and macadamia nuts as carry-on items for tourists.

82. Japanese tourists are the main segment of the carry-on market in Hawaii. The Japanese are renown for their propensity to purchase souvenirs from countries they visit. A recent survey in Guam found that Japanese tourists spent USD16.05 per person per day on souvenirs, compared USD7.22 for those from China and USD1.67 for other countries (Li 1988 p, 15). For the Japanese traveller, it is culturally obligatory to return with gifts (*omiyage*) for family, friends and associates. Presentation packs of highly prized fruit, such as papaya, make an ideal *omiyage* gift. A regular complaint of Japanese visitors to PICTs is that are few suitable locally produced gifts can be found. Palau is no exception in this respect.

83. For Palau, Japanese tourists (which make up 30% of arrivals) are the only realistic carry-on market. Even after the Oriental fruit fly has been eradicated, it would not be possible to sell to US tourists without quarantine treatment. Taiwanese tourists are unlikely to be interested in purchasing tropical fruit. European tourists would be discouraged by weight restrictions and the long distance to be travelled.

84. Currently, around 22,000 Japanese tourists visit Palau annually. Steady, although not spectacular, growth in these numbers can be expected. Assume 1 in 50 Japanese tourists purchases a gift carton of papaya containing fourfruits. This would represent an annual market of about one tonne of premium quality fruit. Similar markets might also be expected for fruit such as carambola and avocado. In total, this would represent, about a USD20,000 business, with reasonable growth prospects. This is probably too small to justify as a stand-alone venture. However, as an ancillary operation to a larger business supplying quality fruit to the hotels, it could be viable.

85. Again, the question has to asked why Palau is not already selling cut flowers to departing tourists. Cut flowers are an ideal product for the carry-on market that face no quarantine restrictions. There is no reason to suggest that tropical fruit would be any more profitable than cut flowers.

*Expanding local
commercial
markets*

86. Expanding local commercial markets for fruits and fleshy vegetables can be divided into sales to the local resident population and sales to tourists. Both would appear to have considerable scope for expansion.

87. The prevailing high prices for available fruit and fleshy vegetables in supermarkets and stores indicates a substantial market opportunity. For example, at the time of the writer's visit to Palau, papaya were retailing for 75 to 90 cents per lb, eating bananas averaged 75cents per lb and cooking bananas 60 to 65 cents per lb. In 1997 the average farm gate price for fruit of various kind was 50c per lb (Palau Statistical Year Book 1999 table 9.1). At these prices, the production of most fruit would seem to be profitable with reasonably efficient production. It is beyond the resources available for this study to compile farm budgets.

88. It is not possible to estimate how much more of a particular fruit a consumer would be willing to buy at different prices (elasticity of demand). However, discussions would suggest that the banana, the most important fruit, is highly price elastic - i.e. considerably more of the fruit could be sold at current prices if supplies were available. Bob Bishop, Coordinator of the National IESL Project, went as far as to suggest "that the market could absorb a four fold increase in banana sales at prevailing prices if supplies were available". Thus, at present, the market for fruit appears to be supply driven. However, there are marketing constraints, including the absence of a produce market.

89. According to the last household income expenditure survey carried out in 1997, purchases of fruit and vegetables account for 5% of total household expenditure (Office of Planning and Statistics 1998 p, 4). This represents a total annual expenditure of approximately USD1.2 million. Based on the data present in Tables 4 and 5 the local sales of fruit and vegetables were USD510,000 (42%). The doubling of the sales of locally produced fruit and vegetables would not seem to be unreasonable expectation if these were readily available at reasonable prices. This would involve a combination of increased fruit and vegetable consumption and import substitution. This would still leave fruit and vegetable consumption at less than 7% of total household expenditure. However, even such a modest gain is out of question in the presence of Oriental fruit fly.

90. The tourist sector offers possibly an even greater market opportunity for fruit. The dive market is the most important segment of Palau's tourism. These people largely come from Japan, Europe, and the United States. Diver's tend to be relatively high income, adventurous and are probably health conscious. They have paid a lot of money to visit tropical "paradise" – and they expect to see and eat exotic tropical fruits. Every tourist consuming only one papaya during their visit, represents a market of over 40 tonnes. At a farm gate price of 70c/lb, this would generate an income valued in excess of USD60,000. Similar figures could be generated for other tropical fruit. Thus, it would not be difficult to come up with a conservative market estimate of some USD300,000 farm gate for tropical fruit in the tourism industry. This market would grow in line with growth in tourist arrivals. However, while the Oriental fruit fly remains no such market can be developed – and the tourists will have to be largely satisfied with imported apples grapes and melons. The end result is that the tourist's image of Palau is so much the poorer.

*Self sufficiency
production*

91. The planting of fruit trees by households is a feature of contemporary food production in Palau, particularly in urban areas.

However, the value of these plantings has been greatly undermined by the arrival of Oriental fruit fly. With the eradication of this pest, production could be quickly restored as the trees are already in place. There is scope for further planting, particularly as the population moves back to Babeldaod.

Constraints to expanding agriculture

92. A detailed analysis of the constraints to expanding agriculture production is beyond the scope of this feasibility study. However, to evaluate the benefits of eradication some consideration of these constraints is necessary.

Labour supply 93. The labour force, and most of the management, in the commercial agriculture sector is made up of imported workers from the Philippines, China, and Bangladesh. This has brought with it the advantages of relatively cheap and productive labour and a degree of skill in growing market garden crops. However, the limited involvement of Palauans, particularly the younger generation, raises issues of the long term sustainability of commercial agriculture. Numerous reports lament the lack of interest of young Palauans in primary production and trade activities, in preference for white collar employment. An excellent example of the challenges faced in attracting young people to agriculture is presented in the Palau Human Development Report, to quote:

OISCA is a Japanese foundation that operates a demonstration and training farm in Aimeliik. Places are available for fifteen high school graduates in an intensive two-year agricultural training program available at zero cost to the student or his her/family. Successful students are eligible for advanced training in Japan. Since 1990, all the OISCA students are from other Micronesian islands with no Palauan enrollees. A recent survey by the Agriculture Division found that of the Palauans who graduated before 1990, none are practicing farmers (p, 51).

94. It will be no easy task to reverse such entrenched mind sets. However, what needs to be demonstrated to young people is that if they have access to suitable land they can earn a good income from agriculture, provided they have the appropriate skills and are prepared to work hard. Presumably, the younger generation will become more receptive to the idea of a career in agriculture as the size of the public sector starts to be cut back. Also, the building of the Babeldaod road will make farming more attractive. However, what Palau lacks are successful young role models in agriculture.

95. In contrast to the commercial agriculture sub-sector, the informal sub-sector is entirely based on Palauan labour, predominantly women. Thus, labor supply presents far less of a constraint to the expansion of this sector.

Availability of suitable land 96. If Palau was to embark on a large scale commercial agricultural development program, a constraint of suitable land would soon be encountered. However, there would seem to be ample arable land available for fruit and vegetable development based on niche exports via tourists, expanding domestic commercial production and improving self-sufficiency

consumption. Care needs, nevertheless, to be taken in conserving the limited arable land that is available. This involves insuring that:

- new tourist development (including golf course development) on Babeldaod does not encroach on good agricultural land when alternative land is available;
- sustainable land management practices are followed; and,
- minimising the incidence of wild fires.

Capital and interest rates

97. Entry into commercial fruit production does require capital, even if the scale is relatively small. Land has to be cleared and prepared, planting material and fertiliser has to be purchased, and labor paid. Palauan farmers are fortunate that investment in expensive irrigation systems is usually not required. For tree crops such as guava and carambola, it will be several years before any income is generated. In Palau, household incomes are relatively high, with a reasonable amount of disposable income apparent. Thus, some may be able to finance entry into commercial fruit production with their own resources, particularly if land does not have to be purchased. However, if loan finance is necessary then there is a major constraint. Commercial bank interest rates currently stand at around 18%. No agriculture investment project is likely to give a return that justifies borrowing at this rate – particularly when the risks involved are taken into account. Thus, there is little wonder that the Palau Master Development Plan notes that “few loans have been made for the establishment of agricultural enterprises by the Palau National Development Bank or by private lending institutions”.

98. The United States Department of Agriculture is currently considering the establishment of a supervised farm credit program in Palau. It is reported that this scheme would make loans available to farmers from USD1,000 to USD100,00 at an interest rate of 5%¹³.

Marketing infrastructure

99. A notable feature of agricultural marketing in Palau is the absence of a produce market. Municipal markets are usually a bustling central feature of most PICT urban centres. A substantial quantity of locally produced fruit and vegetables can be traded at these markets. For example, it is estimated for Samoa’s Fugalei and Savalolo markets that over 2,000 tonnes of banana, 800 tonnes of pumpkins, and some 200 tonnes of cucumber are traded annually (Johnson 1999). In Tonga at the Nuku’alofa’s Talamahu market, it is estimated that around 1,900 tonnes of fruit and vegetables are traded annually (Taufatofau and Taufatofau 1999 p, 5). These are both small counties, with populations well below 200,000.

100. The President’s National Task Force on Agricultural Development identified the establishment of a central market as a priority and a sub-committee was created to look into the issue. The recommendations of this sub-committee were:

¹³ Personnel communication Herman Francisco, Director of Natural Resources and Development.

1. The President of Palau is urged to direct the Minister of Resources and Development to find ways and means and build a well equipped central market for agriculture and aquaculture products.
2. The President of Palau is urged to direct the Division of Agriculture and Mineral Resources to assist in the operation and setting of schedule of collection, transportation and sale of products at the central market after it is built.

101. This report fully endorses the first recommendation. Particular care must be taken in selecting a good site for the market both from the viewpoint of both sellers and buyers. It is important that the market provides good shelter and adequate space. Providing and maintaining good sanitation facilities, and keeping the market clean, is critical for its success. The market needs to be in a place that people want to visit. It should also not be bogged down with excessive regulations. It would be a retrograde step to allow only farmers to sell at the market. To facilitate marketing development middlemen and traders need to be encouraged. As general rule, the more time farmers spend growing their crops, rather than selling them, the better.

102. Considerable caution, however, needs to be given to the implementation of the second recommendation of the sub-committee. Civil servants have a universally poor record in marketing agricultural products. There seems to be no reason to think that the situation in Palau would be any different. The involvement of DAMR officials in the collection, transportation, and sale of produce will discourage the participation of middlemen and traders. This can only be to the long term detriment of Palauan farmers. The private marketing sector involvement in marketing needs to be encouraged, not discouraged.

Fruit flies

103. Throughout this evaluation of opportunities for expanding fruit and fleshy vegetable production, the constraint of fruit flies repeatedly appears. The presence of Oriental fruit fly has the following implications:

- Shipping of fruit and vegetables to foreign markets is not an option without quarantine treatments.
- The selling of fruit to tourists departing Palau is not an option.
- It is not possible to take anywhere near full advantage of the tourist demand for tropical fruit while they are in Palau.
- Domestic commercial sales of fruit to the non-tourist sector is severely constrained.
- The income generating opportunities of the informal sector are significantly reduced – this impacts disproportionately on poorer households, particularly women; and,
- Finally, and most importantly, the nutritional standards of the community are reduced. This reduces the wellbeing of individuals and households. This has a cost to the economy in terms of decreased productivity, increased health care costs, reduced food security and increased vulnerability.

104. If the Oriental fruit fly is eradicated, along with breadfruit fly, then all these costs become the benefits of the eradication program. The benefit cost analysis presented in Section 2 of this report endeavours to quantify these benefits and compare these with the financial costs of eradication.

Section 2: The Feasibility Study of Eradicating Oriental fruit fly and Breadfruit fly

The damaged caused by fruit flies in Palau

105. A particular fruit fly will have a range of fruit which serve as hosts for its eggs and larvae. The female fly lays her eggs under the skin of the host fruit. The subsequent feeding of the larvae will cause severe damage to the fruit, and in some cases premature fruit drop. The extent of damage for a particular fruit can range from a very small percentage of the crop to virtually the entire crop. The earlier the stage of ripeness at which a particular species of fruit fly infests the fruit, the greater the loss is likely to be. A fruit fly that does little damage may be of little significance for household consumption and domestic markets. Yet it will preclude exports to foreign markets that do not have this species.

106. There are three exotic fruit flies in Palau: Oriental fruit fly (*Bactrocera dorsalis*), Breadfruit fly (*Bactrocera umbrosa*) and mango fly (*Bactrocera frauenfeldi*). The first two are attracted to the male lure methyl eugenol and third is attracted to cue-lure. There is a native species, Calophyllum fruit fly (*Bactrocera calophylli*). It is not regarded to be of economic significance because its only known host is *Calophyllum inophyllum*. It is not attracted to either of the two lures.

The methyl eugenol attracted species

Oriental fruit fly 107. Oriental fruit fly is considered as one of the ten worst fruit flies in the world (Allwood et.al. 1999 p, 5). It has a very wide host range which includes many economically valuable fruits and fleshy vegetables. It has been recorded from or intercepted by quarantine authorities in over 200 fruit and vegetable hosts (USDA 1983). Oriental fruit fly occurs in Taiwan, Vietnam, Cambodia, Laos, Hong Kong and Sri Lanka, Nepal, Bhutan, Myanmar, northern and central Thailand, southern China, parts of India, and Mauritius. In the Pacific islands, it is only found in Hawaii, Palau and French Polynesia (Tahiti and Moorea). Until very recently, Oriental fruit fly was also found in Nauru. However, it was declared eradicated on Nauru in December 1999, following a male eradication program similar to that now being proposed for Palau. The Oriental fruit fly has now been found throughout the Palau archipelago, except for Kayangel and the Southwest Islands.

108. Fruit collection in Palau of commercial/edible fruit has been very limited. Thus it is not possible to obtain any exact measure of the damage caused by this pest. It is necessary to rely on damage assessments from elsewhere and anecdotal informal information from Palau. On this basis indicative estimates of the damage caused to ripe fruit in Palau are presented in table 7. Far more precise base line data on damage caused by Oriental fruit fly is necessary before any eradication program begins.

Table 7: Indicative estimates of damage caused to ripe fruit by Oriental fruit fly in Palau

Fruit	Estimated percentage of fruit damaged
Guava	80-90%
Mountain apple	80-90%
Starfruit	80-90%
Soursop	60-80%
Mango	60 -80%
Papaya	40-70%
Avocado	40 -70%
Citrus	30 - 60%
Capsicum	20 - 40%
Banana (Cavendish and Maad varieties)	10%-30%

Breadfruit fruit fly 109. Breadfruit fly is widely distributed throughout South-East Asia and occurs in Palau, PNG, Solomon Islands, New Caledonia and Vanuatu in the Pacific region. It is a major pest of the *Artocarpus* spp. – notably breadfruit and jackfruit. With this limited host range, it represents a far less of a pest than Oriental fruit fly. Due to the wide distribution of breadfruit through Palau, this species has been recorded in all islands, including Kayangel where Oriental fruit fly has not yet been found.

98. No damage data is available for breadfruit fly in Palau. A recent study in North Ambrym in Vanuatu indicated 70 to 80% infestation rates (Farm Support Association 2000). At the peak of breadfruit season, large surpluses of fruit are usually available. What the North Ambrym case study showed was that fruit flies seldom render the breadfruit completely unusable (as is the case with most other fruits), except in the case of unharvested over-mature fruit. Breadfruit is boiled, baked, pounded, or grated. Thus, it is of little consequence if some of the fruit is discarded. Therefore, consequences of 70 to 80 percent infestation rates may not be as great as they might appear for self-sufficiency consumption. Trying to sell fruit fly infested breadfruit is of course a different matter.

The Cue-lure attracted species

Mango fruitfly 110. The mango fly, while not as devastating as Oriental fruit fly, is still regarded as a major pest. It is found throughout Palau and is particularly prolific in FSM. Contrary to its common name, it is not a major pest in mango. In Nauru, for example, it caused only about 8-9% damage compared with over 90% damage for Oriental fruit fly (Allwood et.al. 1999 p, 6). It is an important pest of guava, papaya, breadfruit, citrus and mountain apple. There is no damage assessment data available for mango fly in Palau, although indications are that it likely to be considerably less than that of Oriental fruit fly. Allwood et.al. note that: “anecdotal evidence from local farmers and the government personnel suggest that, although mango and breadfruit fly were present in Palau from before the Second World War,

damage from fruit flies was not obvious until after the establishment of Oriental fruit fly in the mid-1990s” (p,7).

111. Unfortunately, mango fly is not attracted to methyl eugenol. Thus the eradication campaign proposed for Oriental fruit fly will not eliminate this species. The experience from Nauru shows that baiting with cue lure is only effective in reducing, but not eliminating, the population. Further pressure can be placed on the population by using protein bait spray to reduce the female population.

The technical feasibility of eradication

112. The eradication of Oriental fruit fly, along with the breadfruit fly is seen as technically feasible. This conclusion is based on the recent success of the Nauru eradication campaign and the findings of the Allwood technical feasibility report. These are considered briefly below.

The Nauru fruit fly eradication experience

113. Melon fly, mango fly, Oriental fruit fly, and Pacific fruit fly *B. xanthodes*, became established on the island during the 1980s. This was a time when no quarantine restrictions were applied to widely travelled Nauruans. The presence of melon fly and Oriental fruit fly in Nauru was perceived as posing a major quarantine threat to the region. The losses caused by fruit flies also had serious nutritional implications for Nauru’s 10,000 residents. The little fruit that was previously available from time to time all but disappeared. Furthermore, in recent years, less income and less travel meant that imported fruit has become an increasingly scarce luxury.

114. Thus the RMFFP designed the Nauru Fruit Fly Eradication Program (FFERAD), which had three main aims to:

- Reduce the risk of the incursion of melon fly and Oriental fruit fly into other PICTs by eradication of these species from Nauru.
- To provide staff from the PICTs with hands-on training in fruit fly eradication. This is to equip regional departments of agriculture personnel with the capability to mount rapid reaction programs in response to the incursion of an exotic fruit fly. For most countries, eradication is only an option in the short period before a newly arrived fruit fly becomes dispersed and established.
- To improve Nauru’s food security.

115. The eradication program started in October 1998. Teams of 4-6 people distributed fibreboard blocks (50mm x 50 mm x 12.7 mm) soaked with the male fruit fly attractant (methyl eugenol) plus the insecticide Fipronil. By mid-September 1999 six blockings, at eight week intervals, had been completed. By September 1999, Oriental fruit fly has not been recorded in traps of for about 36 weeks (the equivalent of 9 generations) and melon fly has not be recorded in traps for 32 weeks. Numbers of

mango flies in traps have decreased from 1,500 flies/trap/week to less than 10 flies/trap/week. The use of protein bait sprays incorporating a new insecticide formulation is being used on a weekly basis in all areas around the coastline. In December 1999 Nauru was declared free of Oriental fruit fly and melon fly. Pacific fruit fly has not been recorded in methyl eugenol traps for nine weeks. Mango fly, a cue-lure attractant fly, still occurs, but in very much reduced numbers.

Evaluating the benefits and cost of the Nauru eradication program

116. The efficacy of the male annihilation technique has been proven for a small isolated island. For the first time in a decade, Nauruans can now enjoy some fruit grown locally. However, the benefits of the Nauru eradication program will only be transitory if Nauru does not put into place quarantine controls that minimise the risk of the re-incursion of fruit flies.

117. The benefits of the Nauru FFERAD program can be listed as:

- The risk of spread of exotic fruit flies from Nauru to other PICTs substantially eliminated.
- The emergency response capability of the PICTs enhanced.
- Improvement of nutrition and food security in Nauru.

118. The cost of the Nauru fruit fly eradication program to date has been AUD 280,000. Allowing for annual ongoing cost of AUD10,000 for the next five years, a total cost of AUD 330,000 is estimated. The initial indicative annual benefit estimated above from this expenditure was estimated at AUD 470,000 (McGregor 1999 p 121). This is made up of the following components:

- Enhanced emergency response capability from the PICTs - AUD 440,000
- Improved nutrition and food security in Nauru – AUD 30,000. This figure can be expected to increase over time as new plantings of mangoes, breadfruit and papaya start bearing edible fruit.

The technical feasibility of Palau fruit fly eradication

119. In August 1999, the RMFFP conducted a technical feasibility of eradicating the fruit flies attracted to methyl eugenol in Palau (The Allwood Report). The team was headed by Allan Allwood (Chief Technical Advisor RMFFP) and comprised Konrad Engleberger (Plant Protection Trainer, SPC Plant Protection Trainer - Micronesia), Dr John Armstrong (Research Entomologist USDA-ARS, Hilo, Hawaii) and Fred Sengebau (Agriculturalist DAMR Palau). The Allwood Report concluded that it would be feasible to eradicate Oriental fruit fly and breadfruit fruit fly by adopting the same male annihilation technique that was used in Nauru. This was supplemented by a protein bait spray program and the release of parasitoids to reduce the population to be annihilated. The major difference in the proposed Palau program was the use of a helicopter due to the difficult terrain and numerous islands that have to be covered.

*A summary of
the proposed
method*

120. The method proposed in the Allwood Report for the Palau Fruit Fly Eradication Program (PFFEP) will include:

- Fibreboard blocks (50mm x 50 mm x 12.7 mm) soaked in a mixture of methyle eugenol and the insecticide Fipronil will be distributed every 8 weeks for 6-8 applications. The distribution in most areas will be by helicopter at a rate of 300 blocks per km². Ground teams will be used in Koror, villages and in watersheds.
- Helicopter drops will be done on the basis of runs at 200 metre intervals, probably in east-west and west-east direction.
- A helicopter will be brought from Guam every eight weeks. Costings have been made at commercial rates. However, it is recommended that a request be made by the Government of Palau for the use of a US military helicopter.
- Technical feasibility depends on the use of the insecticide Fipronil. Fipronil, which was used in the Nauru eradication, is an extremely effective contact insecticide. It is not water soluble and is used at much lower quantities than the alternative insecticides malathion and Naled. Fipronil, unlike the alternatives, is odorless. This is a critical consideration when the blocks would have to be handled in the confined space of a helicopter. Fipronil is registered for a variety of uses in Australia, but not by the US Environmental Protection Agency (EPA). The use of Fipronil for the Palau eradication program remains an outstanding issue that must be resolved. This is discussed below under environmental considerations.
- The fibreboard blocks (both cutting and treatment) will be prepared under contract to private companies or institutes in Palau.
- Protein bait sprays¹⁴ will be used in institutions where the populations of Oriental fruit flies and breadfruit fly persist and are difficult to control. These areas are referred to as “hot spots”. The protein bait sprays will be applied by ground teams using small pressurised sprayers. Mauri Pinnacle Protein Insect Lure was used as the bait, and Fipronil as the insecticide in the Nauru program.
- There is presently no fruit fly parasitoids found in Palau. Thus, it is recommended that one or more parasitoids be introduced to provide some level of biological control over both Oriental fruit fly and mango fly (and possibly breadfruit fly). These would be sourced from the United States Department of Agriculture – Agricultural Research Station (USDA-ARS) in Hilo Hawaii. Consideration needs to be taken on the possible negative impact of fruit fly parasitoids on the tephritid biological control agent that has been released to control a weed pest in Palau (Allwood, pers. comm.).

¹⁴ All female fruit flies require a feed of protein before they are able to lay viable eggs. This requirement is used to control fruit flies in commercial crops. Small amounts of a bait made of protein autolysate or hydrolysate plus an insecticide are applied to the leaf surface. The female fruit flies are attracted to the protein and are killed by the insecticide as they feed.

Management requirements

121. Fruit fly eradication involves a complex biological campaign somewhat akin to a military campaign. As a single small island, Nauru, presents a technically easier proposition than the scattered islands of Palau. However, Palau is likely to be better placed than Nauru in terms of supporting infrastructure and local resources available.

122. Success will depend of good planning and the timely implementation of the plan. Good leadership with the required technical and management skills is essential. The team leader must have sufficient resources at his or her disposal to implement the plan according to the proposed timetable and to meet contingencies when they arise. It must be recognised that such a complex biological campaign will not go exactly to plan. The Allwood Report highlights that there is “no point in commencing a complex program like this without being completely committed to the operations of the program and the associated costs” as illustrated by the French Polynesia Oriental fruit fly eradication program.

123. Particular attention must be given to the appointment of the right person as PFFEP Manager, as this will be critical for success of the program. The Allwood report defines the role of the PFFEP Manager “is one of managing the overall programme and ensuring their effective liaison and linkages between the administrative, regulatory, scientific and field operational staff. This person needs to have a sound understanding of the eradication process, be able to access resources, and have very good people and communication skills.” It needs to be recognised that such a person may not be readily available.

Environmental considerations

Impact on indigenous fruit flies

124. A problem sometimes faced with exotic fruit fly eradication program is that an indigenous species of fruit fly is put at risk. Palau does have native fruit fly species- *Bactrocera calophylli*. However, fortunately this species is not attracted to either methyl eugenol or cue-lure.

The use of insecticide

125. An insecticide is used in both the eradication (blocking) and the complementary control (protein bait spraying) program. In any situation where an insecticide is used there are associated environmental issues. In Palau, with its unique marine ecosystems, these concerns are heightened.

126. The insecticide Fipronil would be used in both the blocking program and in the complementary protein bait spray program. Without the use of Fipronil, it is doubtful if this eradication program could proceed. There are two formulations used in fruit fly eradication and control.

Protein bait spray 127. Protein bait spraying is seen as a benign means of fruit fly control. The use of bait-sprays is based on the ability of hydrolysed protein to attract fruit flies - female flies need to ingest protein before they lay viable eggs. Protein hydrolysate on the leaf surface induces rapid bacterial growth that results in odours being given off that attract fruit flies. The flies ingest the protein, along with the added insecticide and are killed. The bait is sprayed onto the underside of the leaves, where fruit flies normally feed. Because the bait attracts the flies, it is not necessary to cover spray the entire foliage, thus reducing the risk of pesticide residue in fruit and loss of pollinators and other desirable insects.

128. The Fipronil formulation used in protein bait spraying is a fine powder that is mixed with Xanthane gum to make the bait thick enough to adhere better to the leaf surfaces during rain. Miniscule loss of Fipronil into the environment can be expected in the protein bait spray program. Application will be by ground team using small pressures sprays thus no loss into marine environment would be anticipated.

Blocking 129. The Fipronil formulation used in the eradication blocking is in a water insoluble form that is combined with methyl eugenol. Each block is treated with 8-10 ml of the mixture. Each block should contain no more than 0.03 ml of commercial Fipronil per block, which is equivalent to 0.08g of active ingredient per block. The blocks are distributed at about 300-400 per km². This translates to 2.4 – 3.2g of insecticide per km² – this is an extremely small dosage compared with other insecticide applications. Thus, the blocking is seen to be environmentally very sound.

Concerns of the EQPB 130. Fipronil is registered in Australia for numerous uses. These include the control of banana weevil borer, rice seedling pest in an aquatic environment, plague locusts, turf pests, ticks in dogs and cats. This insecticide is also used for integrated pest management of pests of crucifers, brassicas, and cotton. Fipronil was used in the Nauru fruit fly eradication program, with no apparent ill effects on the environment.

131. Before a chemical can be used in the Republic of Palau approval is required from the Environmental Quality Protection Board (EQPB). The EQPB, as a small organisation in a small country, normally seeks advice on the use of new chemical from the United States EPA, although Palau, as an independent country, is not legally bound to this advice. Unfortunately, data on Fipronil have yet to be submitted to the EPA for registration.

132. In August 1999 a consolidated environmental assessment report on Fipronil by Environment Australia was submitted to the EQPA. EQPA in turn submitted the Environment Australia report to the EPA for comment. As of March 2000 no reply had been received from the EPA.

133. The key concern of EQPB officials in their discussion with this consultant was the water solubility of Fipronil. The Environment Australia report showed toxicity to aquatic life – although these were at concentrations well above that envisaged in the fruit fly eradication/control program. The Environment Australia report supports the claim of the manufacturers that Fipronil is water insoluble. However, the discussion

is conclusionary in nature and lacks little concrete/definitive data. Further information on this critical issue has now been requested by the RMFFP.

134. The EQPB's Legal Advisor indicated to the consultant that an environmental impact assessment (EIA) may be necessary. It is unfortunate that this issue was not raised by EQPB at the time of the technical feasibility study in August 1999. The EQPB estimated cost of an EIA would be between USD15,000 and USD50,000. If an EIA is required, then this will have to be included as a Project cost.

Economic feasibility of eradication

Costs

The Allwood Report provides very detailed estimates of the eradication program. These are summarised in table 8. The total estimated cost of eight campaigns, spread over 1.5 years, is USD1.21 million.

Table 8: Summary cost estimates of the Palau fruit fly eradication program

Item	2000	2001	Total
Human resource	224,330	199,800	420,100
Equipment and supplies	101,200	14,400	115,600
Sub-contracts	30,000	18,000	48,000
Training	24,000	9,500	33,500
Publications and public relations	49,000	5,000	54,000
Communications	8,000	8,000	16,000
Transport	7,300	5,300	12,600
Utilities	5,000	5,000	10,000
Helicopter	126,200	45,400	171,600
Attractants and chemicals	184,840	61,280	246,120
Contingencies	40,000	40,000	80,000
Total	799,840	411,280	1,211,120

Additional costs to be considered

Minimising the risk of exotic fruit fly re-entry

135. The reintroduction of exotic fruit flies in the short to medium term would negate the benefits of the eradication program. The Allwood Report lists a number of preconditions for minimising this risk. These were:

- an efficient and effective quarantine service;
- well-trained and motivated quarantine personnel;
- continuing support and commitment from Government and the public sector;
- sound risk assessment and decision making based on scientific information;
- adequate equipment and facilities for the Quarantine service; and
- a well informed travelling public.

136. Palau has the advantage of having most of these conditions already in place. However, the Allwood Report specifically highlighted the need to increase the number of quarantine inspectors from 6 to 8. The Government responded quickly to this recommendation by allocating an additional provision of USD13,000 in the Fiscal 2000 Budget. This is an encouraging indication of the Government's commitment to the eradication program. However, the additional expenditures incurred to prevent re-introduction must be attributed as a cost to the eradication program.

137. Additional areas of expenditure to minimise the risk of re-entry are necessary. The Southwest islands were identified as a particular weak link. These islands are so close to Indonesia that small boats visit to barter food. Here, currently they face no quarantine border controls. The locating of a quarantine officer in the Southwest islands would seem to be a necessary component of the eradication program.

138. In the benefit cost analysis an indicative allowance of USD50,000 is allowed for as the expenditure required to bring the risk of re-entry of exotic fruit flies to an acceptable level.

139. The estimate for the use of the helicopter may be low, based on recent information from the cost of helicopter usage in French Polynesia. It is estimated that a further USD 154,000 may be needed (Allwood, pers. comm.)

Allowing for the probability of the eventual re-incursion of exotic fruit flies

140. The geographic and economic circumstances make Palau an inherently high risk location for the entry of exotic fruit flies. Meeting the preconditions listed above can only bring this risk to manageable levels, not eliminate it.

141. The combination of factors to give Palau an inherently high risk of exotic fruit fly incursions include:

- An archipelago in close proximity to Southeast Asia a source area for numerous damaging fruit flies.
- Palau's numerous beautiful islands are major attraction for yachts. Yacht's sailing from Southeast Asia are seen as particularly high risk with respect to introducing exotic fruit flies. It is reported that yachts often anchor in the Rock Islands for extended periods before proceeding to Koror to meet customs and quarantine formalities.
- Numerous Asian boats fish (some illegally) in Palau's EEZ. As with yachts this is a particularly high risk group. Fishing boats are legally required to come to Koror for quarantine and other clearances before they commence fishing. It is reported that some of these boats will make several return trips to their homeport on a single clearance. Illegal fishing boats pose a particular problem for quarantine. It is again reported that confiscated vessels are sometime towed directly to Koror, without first being subject to quarantine clearance.

- The large number of Asians who work in Palau are another high risk group.

142. Thus, even if all appropriate measures are taken, it would be reasonable to assume that some time in the future there would be a re-incursion of exotic fruit flies into Palau. If the recommended emergency response program is in place, then cost of eradicating any re-incursion will be considerably less than the USD1.2 million estimated for the current eradication program. In undertaking the benefit cost analysis, it would be prudent to take account of the probability that sometime in the future there will be a re-incursion of a damaging exotic fruit fly. In the sensitivity analysis, allowance is made for various re-incursion scenarios.

The Benefits

143. The benefits from the Oriental fruit fly eradication program can be listed as follows:

- the prospect of shipping of fruit and vegetables to foreign markets;
- selling of fruit to tourists departing Palau;
- selling fruit to tourists while they are in Palau;
- increased sales of fruit to the non-tourist sector;
- increased self-sufficiency consumption of fruit;
- the improved nutritional standards of the community; and
- the improved quarantine security of the region.

144. All these can all be regarded as an economic benefit to which in principal a dollar value can be assigned. These dollars benefits can then be compared with the dollar cost of the eradication program. Each of the benefits is discussed briefly in turn below:

Direct fruit exports

145. Currently, Palau fruit fly status precludes virtually all horticultural exports unless quarantine treatments are developed. The eradication of Oriental fruit fly and breadfruit fly would make such exports theoretically possible. However, such exports are unlikely to be viable for the foreseeable future. The reasons are as follows:

- After the eradication program, mango fly will still remains. Thus, exports of most fruits to Guam will still require quarantine treatment. With the small volumes involved, a HTFA unit unlikely to be commercial viable.
- If Japan requires quarantine treatment, an even more expensive (and less viable) vapor heat facility would likely be required.
- Only 727 and 737 aircraft service Palau. These do not carry cargo containers. The cost of loading and unloading individual cartons will substantially increase costs .

146. Due to these constraints, it is projected that no fresh fruit will be directly exported in the 10 years following the eradication of Oriental fruit fly.

147. A likely exception is betel nut, which is regarded as a host for Oriental fruit fly. Sizeable markets exist in Taiwan, FSM and Guam. Oriental fruit fly is present Taiwan – so this market is already available. With the construction of the Babeldaob road, the establishment of sizable betel nut orchards is a realistic prospect. Thus, it assumed following the eradication of Oriental fruit fly two tonnes of betel nut will be exported annually to Pohnpei and Guam and this will increase to 30 tonnes over a 10-year period. A fob price of USD3,000 per tonne is assumed. It is advisable that non-host status studies on betel nut be done for all fruit fly species in Palau.

Selling fruit to departing Japanese tourists

148. While the direct export of fruit, with the exception of betel nut, is unlikely for the foreseeable future, the sale of fruit to departing Japanese tourists is a realistic prospect once Oriental fruit fly has been eradicated. It is estimated, based on the discussion in Section 1, that these sales would be valued at USD20,000 two years after eradication, increasing to USD30,000 10 years after eradication (paragraph 84).

Selling fruit to tourists while they are in Palau

149. The estimated the tourist market for fruit was estimated to be in the vicinity USD300, 000 (para 90). It would take several years after the eradication of Oriental fruit fly before this market could be realised. However, these sales could be entirely attributed to the eradication program. It is assumed that sales to the tourism sector will reach USD300,000 5 years after eradication and reach USD400,000 after 10 years.

Commercial fruit sales to the non-tourist sector

150. The current non-tourist commercial sales of fruit and vegetables was estimated to be in the vicinity of USD500,000 (paragraph 89). The doubling of the value of these sales was seen as a reasonable expectation if the fruit was available at reasonable prices. The eradication of Oriental fruit fly would allow the achievement of this modest goal within two or three years after eradication.

Increased self sufficiency consumption of fruit

151. The critical important of subsistence/“back- yard” fruit consumption in the health and nutrition of Palauan households was discussed at length in paragraphs 52-54. Due the incursion of the Oriental fruit fly, this consumption has been largely lost. As a consequence the nutritional standards of the community are reduced. This reduces the well being of individuals and households. This has a cost to the economy in terms of decreased productivity, increased health care costs, reduced food security and increased vulnerability. Overall the loss of this subsistence/“back-yard” fruit production was seen as probably the biggest cost to society arising from the arrival of Oriental fruit fly. Thus, the restoration of “back-yard” fruit production represents the largest benefit from the eradication of this pest.

152. Such benefits are difficult to quantify in dollar terms. However, some indicative approximations of dollar values are useful even if they are not used in the formal benefit cost analysis.

153. In 1997, commercial fruit sales were estimated at USD150,000 (table 4). “Backyard” fruit consumption could quite easily increase ten fold if the fruit was available. The consumption of this fruit would mean a healthier community which is more productive and needs to spend less on curative health care. The value of these benefits runs into many millions. For example, if improved nutrition leads to 1,000 less days lost due to sickness, the value of wages alone exceeds USD1.5 million.

Improved quarantine security for the region

154. Oriental fruit fly is considered as one of the worst fruit flies in the world (Allwood et.al. 1999 p. 5). It has a very wide host range which includes many economically valuable fruits and fleshy vegetables. It now is present in Palau and French Polynesia and as such poses a major threat to the food security and economic well being of the region. For example in Fiji the economic value of fruit production is estimated to be around USD15 million (McGregor 1999 p. 113). If Oriental fruit fly became established, it could be expected that a high percentage of this production would be lost. To the domestic fruit consumption losses have to be added losses of some USD1 million current export earnings and future potential export earnings.

155. Improving the quarantine security of the region is not of direct immediate benefit to Palau, other than being a good citizen of the region. It is, however, in Palau's long term interest to keep Oriental fruit fly out of the rest of the region, particularly its closest neighbours. The spread of Oriental fruit fly to Guam or Pohnpei would undermine the viability of any future eradication program by increasing the probability of reincursion.

156. No attempt is made to quantify these benefits in an analysis that looks at direct benefits and cost from the viewpoint of Palau. However, regional quarantine security benefits should be an important consideration for donors looking to support Palau's eradication program as they did with the Nauru eradication program.

Comparing benefits with costs

157. Table 9 compares the estimated costs of the eradication program with projected economic benefits. The benefits and costs are expressed in 2000 dollars. The total cost of the eradication project over a 10-year period is estimated at USD1.8 million. This compared with a total estimated benefit over the period of USD5.8 million. The B/C ratio, applying a 10% rate of discount is 2.38, with the program yielding an internal rate of return (IRR) of 26%.

158. Thus, on the projection made, the eradication program is seen as a highly viable investment. This is particularly so since no account is taken of the benefits of increased self-sufficiency fruit consumption, which is probably the largest benefit accruing to the eradication program.

Sensitivity Analysis

Allowing for the re-incursion of fruit flies 159. As discussed above, it would be reasonable to assume that, at some time in the future, there would be a re-incursion of exotic fruit flies into Palau, even if all reasonable measures to enhance quarantine security were taken. Thus, Table 10 models the situation when there is a re-incursion in year 10. It is assumed that because an effective permanent quarantine surveillance and emergency response program is in place the cost of eradication on this occasion is only half of the present proposed program. The B/C ratio falls to 1.81 and the IRR to 22%. Thus even if there is a re-incursion 10 years into the future, the proposed eradication program remains highly viable.

160. Because the re-incursion modelled in table 10 occurs well into the future, it only has a modest effect on the viability of eradication. However, the less resources and attention paid to quarantine surveillance and security, the greater the probability of an earlier re-incursion. If this happens then the viability of the proposed eradication is greatly undermined. For example, if a re-incursion occurs in year 7, the B/C ratio falls away to a meagre 1.14 and the IRR to only 8%. These figures, while only indicative, highlight the important of enhanced quarantine security and surveillance in the post eradication phase.

Conclusions

161. The eradication of Oriental fruit fly and breadfruit fly in Palau is technically feasible provided there is a high level of management capability in place.

162. The major benefits of the eradication program are:

- Improved health and nutrition from increased self-sufficiency consumption of fruit.
- A significant increase in the commercial sale of fruit to local consumers and to the hotel sector
- The opportunity to sell fresh fruit to tourists departing Palau.
- The enhancement of the quarantine security for the region

163. The value of these benefits significantly exceeds the cost of the eradication program.

164. The implementation of the program is subject to the approval of the insecticide Fipronil.

165. There is a high risk of the re-incursion of the eradicated fruit flies and other exotic fruit flies. It is essential that enhanced quarantine control and surveillance emergency response measures be put into place to minimise these risks.

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