GUEST ARTICLE

THE CURRENT STATUS AND PROSPECTS OF PLANT GENETIC RESOURCES IN PAPUA NEW GUINEA

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ABSTRACT

Papua New Guinea is rich and diverse in its Plant Genetic Resources and is one of the world's major secondary centre of genetic diversity for at least 17 species of food plants. Many other species of such plants are worthy of attention but are unknown outside the country. Over 600 medicinal plants have been reported but only 448 species have been identified. It is estimated that 60% of orchids and 50% of the fern species in PNG remain to be discovered. Policies and legislations needed to safeguard these resources and prevent further genetic erosion are discussed.

1. PAPUA NEW GUINEA'S AGRICULTURAL ECONOMY

1.1 Introduction

The general vegetation of Papua New Guinea (PNG) varies with elevation and rainfall. Its flora has some similarities with those occurring in Indonesia, Malaysia, Australia and the other Pacific Island countries. The tropical rainforest areas of the central and the north western parts of mainland PNG are rich in species of plants and animals, many of which are unique to this part of the world.

It is believed that man first entered PNG about 60,000 years ago (Golson 1974), most probably from South East Asia through the Indonesian archipelago during the Ice Age. The first immigrants were probably hunters and gatherers but agriculture developed later in the coastal and highland areas. Food crops such as yams, taro and banana species were introduced from South East Asia as well as pigs, chicken and other small ruminants.

Traditionally, subsistence agriculture is practised by over 80% of the population of PNG. Farmers in PNG maintain, multiply and distribute their own planting materials. Almost all the crops grown are vegetatively propagated and planting materials of crops such as banana (*Musa* spp.), taro (*Colocasia* spp.), cassava (*Manihot esculenta* Crantz), aibika (*Abelmoschus manihot* L. Medik) and other leafy vegetables are maintained in old garden sites until the new gardens are made. Seeds of Amaranths (*Amaranthus* spp.) and other vegetables are usually wrapped up in leaves and stored above the fire places for as long as one month before planting. For Yams (*Dioscorea* spp.), good tubers are selected and stored in specially built Yam Houses to allow the tubers to sprout before they are planted out. In the Trobriand Island of Milne Bay Province the yams are stored in yam houses for a longer period of time for eating as well as for planting.

1.2 Farming systems

The farming systems in PNG are diverse and complicated. The indigenous people of the country belong and have their bases in villages. The land is owned by clans or families and an individual is given the right as a member of that clan/family to use the land. There is no

individual land ownership, unless it is officially purchased or there is a sole heir to the ownership of the land. A farmer in PNG lives in an agricultural system that is not easily definable. The farmer may grow subsistence food crops of which the surplus may be sold in the local markets for cash income. Yet the farmer hunts and collects food from the forest, and catches fish from water ways and the sea including other marine products. The farmer is also expected to participate in traditional and social events in the village.

A subsistence farmer in PNG lives very closely with nature. He turns to the forest for all his basic needs and learns to appreciate and value the richness nature provides in these forests. There are certain forested areas in PNG that are regarded as 'sacred grounds' by the locals. These areas are not touched for any agricultural activities for fear that something drastic may happen to their lives. In their own small ways and for whatever reasons, the locals help the nature to ensure continuity of genetic evolutionary process in these sacred grounds.

1.2.1 Crop Based Systems

Subsistence farmers in PNG grow a diversity of food crops. Different crop species are planted in a mixed cropping manner, usually at very high densities. The succulent leafy vegetables are planted first, followed by root crops, then tree crops like bananas, fruits and nut trees.

In any subsistence garden there is always a crop that is more predominant than others. Sweet potato (*Ipomoea batatas* L. Lam.) is the most predominant crop in the highland areas of the country. The subsistence farmers in the highland region follow a sweet potato based system.

In the lowlands, the cropping systems are diverse and vary from one area to another. The dry coastal areas of the Central Province follow a Banana-Yam-Cassava based system. Yams (*Dioscorea* spp.) are usually harvested first, followed by number of harvests of banana (*Musa* spp.) and cassava (*Manihot esculenta* Crantz).

Taro (*Colocasia esculenta* L. Schott) is more predominant in the wet lowland areas of Morobe Province and the atoll environment of the North Solomon Islands.

The diploid bananas are widely cultivated in the Madang, New Britain, New Ireland, Morobe and the Sepik Provinces. The triploid and tetraploid bananas are more suitable to the drier areas of the Markham/Ramu valleys and Central Province.

Yam (*Dioscorea* spp.) based cropping systems are practised at some inland areas of East Sepik, Madang and the Trobriand Islands of Milne Bay Province.

Sago (*Metroxylon* spp.) is predominant in low marshland areas throughout the country. This crop is still being harvested from the wild. People from the wetland areas of the Fly, Sepik, Ramu and Purari deltas closely follow the Sago based cropping system. They grow root crops and leafy vegetables in marginal arable land as supplement to their sago.

1.2.2 Livestock System

The domesticated pig is the main animal used in the traditional systems with village fowls and chickens. The rest of the livestock for food are hunted from the wild in the forests. The domesticated pigs play a significant role in the livelihood of the people in the Highland areas. Pigs are regarded as a form of wealth and are used mainly in traditional marriage ceremonies and death feasts. These domesticated livestock are generally free ranging. Sweet potato tubers and vines and split-up coconuts are fed to pigs. There is no organised livestock system, traditionally. The pigs, fowls and the village chickens comprise the total livestock complex system the subsistence farmer belongs to.

With changes in the life style and emphasis in the monetary economy, farmers all over the country are now going into livestock businesses, including cattle, sheep and goat ranges,

piggeries and poultry sheds for both layers and broilers. These are intensive systems and a farmer has to make changes to his subsistence way of life to cater for these changes.

1.2.3 Fish and Other Aquatic Systems

The livelihood of the coastal and the river people of PNG evolves around the sea and the water ways. These people live on what they can harvest from the sea and the river systems. The coral reefs surrounding the islands and the coastal areas of PNG are rich in marine life which include diversity of fish, shells, lobsters, crabs, sea weeds and variety of others. The water ways are also rich in fresh water fishes, prawns, crabs and other river food. The main river systems in the country include; Sepik, Fly, Ramu, Markham and Purari river.

The people from the coast and the river systems also practise shifting cultivation for production of fresh vegetables and staple root crops to supplement their aquatic diets. Sago is the main staple food crop for the people living on the plains of the Sepik, Fly and Purari deltas. The plant grows wild in the river plains and swampy areas throughout the country and is harvested whenever needed. Due to shortage of arable land for cultivation, the river people establish social contacts with the mountain and the inland people for barter purposes. They exchange their fish and other river food for root crops and other vegetables.

1.3 Agricultural Economy

Agriculture is the most important economic sub-sector in the country today, and being a renewable resource will continue to be the major economic sector in PNG. It provides a livelihood for about 85% of the economically active population of PNG, and employment for 25% of the workforce in the formal sector of the economy. It contributes 14% in foreign exchange earning and 25% in Gross Domestic Product (GDP).

The agriculture sector comprises of subsistence, semi-subsistence and commercial subsectors. Smallholder farmers are the most prominent producers. They produce 96% of all agricultural produce, 75% of coffee, 65% of cocoa, 66% of copra and 35% of oil palm and almost all food crops.

The structure of the sector could be expressed in terms of the proportion of population engaged in the subsistence and commercial activities. The 1980 census indicated that 8.5% are purely subsistence, 87% are semi-subsistence or semi-commercial engaged in both subsistence and commercial activities and 4.5% are purely commercial.

It is the long term objective of the PNG Government to improve agriculture's role in the economy by instituting policies and strategies to enhance productivity on a sustainable basis.

1.3.1 Export Crops

Export Crops contribute significantly in export earnings with an average of K259.6 million between 1985 and 1993.

Coffee is the most important crop in terms of foreign exchange earnings and employment with about 50% of all rural households producing over 70% of the crop annually. About 64,500 hectares (50,000 ha smallholders and 14,500 ha plantations) are under coffee.

Cocoa is the next important crop with 22% of the value of major agricultural exports. About 11% of all rural households produce 66% of the crop and the balance from plantations annually. Cocoa has an area of 116,600 hectares with 49,900 ha under estates and 66,700 ha under smallholders.

Oil Palm is the third major crop with 14% of the value of exports annually. It covers an area of about 58,000 hectares (33,000 ha estates and 25,000 ha smallholders involving about 7,000 families). The estates produce 65% of the output and 35% from the smallholders.

In the coconut industry, copra and coconut oil account for 11% of the value of the major

agricultural exports and supports about 111,000 households cultivating an area of about 100,000 hectares.

Rubber and Tea are small in terms of production, acreage and foreign exchange earnings. About 8,000 households are growing rubber and the production in 1993 was 2,800 tonnes with export value of K2.2 million.

Current estimates show that more than 83,000 households are engaged in the growing of spices and other alternative cash crops. The spices are chilie, cardamom and pyrethrum. The export value of these crops in 1992 was K8.2 million.

1.3.2 Forest Resources

Log exports during 1991 were of 942 tonnes which the country earned K62,130 million. In the same period 3,704 tonnes of timber lumber were exported, bringing in K1,417 million for the country. A total of 106 tonnes of woodchips with the value of K5,456 million were exported in the same year. If illegal exports are considered than real export figure could be higher than the official figure.

1.3.3 Marine and Water Resources

A total of 890 tonnes of prawns and crayfish were exported in 1991, bringing in K7,633 million to the country. Tuna export was 773 tonnes with a value of K469 million. The export of shells was 235 tonnes for K1,605 million. The 1991 Barramundi export was 44 tonnes with a value of K270 million. In the same year 749 tonnes of Crocodile skins were exported which earned the country K872 million.

1.4 Food Production Trend

The 1980 Census indicated that over 85% of the population are engaged in semi-subsistence food production. Production of staple foods remains the most important economic activity for most of the rural population. Semi-subsistence food production is based upon the traditional systems of shifting cultivation. Pressures of development and modernization, such as urbanization, rising population pressure in some areas, and the growing desire for cash among the rural people are likely to cause a gradual change towards more sedentary systems of production.

Commercial production of food crops is limited by the size of the domestic market, while the marketing of traditional staple crops is adversely affected by their low value-for-weight ratio and perishability.

Sugar is commercially produced in the country and is essentially for the domestic market and is protected with an imposition of an import ban. Papua New Guinea is now self-sufficient in sugar.

The Livestock industry consists of a few intensive broiler chicken operations that also supply feed and chicks to out-growers, a few intensive piggeries and cattle ranches. Since independence the poultry and pork industries have reached self-sufficiency levels with Government protection. Papua New Guinea is now self-sufficient in egg, chicken and pork production. These industries developed under the protection of import bans and are now protected by high import tariffs.

The government is making efforts to develop a small sheep industry in the highlands to increase local production and consumption of meat.

2. INDIGENOUS PLANT GENETIC RESOURCES

Papua New Guinea is diverse in wildlife and culture. The people are intrinsically inter-related with the environment that the past is still very much alive. Not only in the social cultures and traditions, but also in the use of primitive methods and techniques in growing, preserving, conserving and utilizing the indigenous plant germplasm for food, clothing and shelter.

The country has a rich diversity in the total Plant Genetic Resources (PGR) and is very fortunate that a good part of these resources are still

growing in their natural habitats in forested areas throughout the country. How long will these forest habitats remain is only a matter of time.

The rich genetic diversity of food crops and forest tree species including their wild progenitors are found in the tropical regions of the world. Some of the premium timber tree species are indigenous to this part of the world which are being heavily logged, causing devastating damages to the natural environment which were once rich store houses for these invaluable germplasm.

Papua New Guinea is the centre of diversity of various root/tuber crops, banana species particularly the diploid types, certain leafy vegetables and the commercial sugarcane species, *Saccharum officinarum*. The 'Noble cane' of the *S. officinarum* species is believed to have originated from the Highlands of Papua New Guinea. The wingbean (*Psophocarpus tetragonolobus*) or the 'as bin' as locally known in PNG is an old crop cultivated throughout the highland areas of the country for its tubers and is also believed to have the centre of diversity here (IBPGR 1981). The largest herb in the world belongs to the Family Musaceae, known as *Musa ingens* and is found only in PNG. Some of these unique germplasms are growing wild in their natural state and can easily go extinct if their habitats are disturbed or disrupted.

The high rainfall areas of the country particularly the central part of mainland PNG are homes to rich diversity of timber tree species, two of the most important ones are; the hoop pine (*Araucaria cunninghamii*) and the klinkii pine (*Araucaria hunsteinii*). While the *eucalyptus* species, *E. deglupta* dominates the dry coastal areas of the southern part of the main island.

The rich forest habitats are homes to a wide range of succulent leafy vegetables such as the ferns, creepers and shrubs which constitute the daily diet of the indigenous population. These vegetables are still being harvested from the wild. Some of these species for example the *Stenochlaena palustris* (climbing fern) is very difficult to domesticate or cultivate in ex-situ plantings.

The rural population is still very much dependant on the forest for their livelihood, and many still turn to the forest for their medicinal needs. Numerous plant species in various forms are being used by the local people for medicinal purposes. A random survey of plants in PNG has shown that approximately 2% are alkaloidal. 12% of the plants used in traditional medicine contain alkaloids and over 40% of the plants tested are been used internally to treat malaria and fevers have found to have alkaloid properties (Holdsworth 1977).

With the increasing population pressures and fast depletion of natural resources, it is now necessary to explore the new and wild plant resources in order to meet the growing needs of the population who have been relying on few plants with narrow genetic base in the past. Many of these wild plant resources have great potential for exploitation in view of the value of their economic products for use as food, fodder, medicine, energy and industrial purposes. The useful indigenous plant resources of the country will be discussed in this chapter.

2.1 Forest Genetic Resources

The forest flora of PNG is one of the most diverse in the Old World Tropics. The diverse forest flora is attributed largely to the climatic, edaphic and topographic conditions which prevail. Although actual figures of the floral biodiversity are not known, it is estimated to be around 15,000 to 20,000 species of vascular plants in PNG. These plants include more than 2,000 species of orchids, about 2,000 species of large trees and about another 2,000 species of pteridophytes (ferns and allies) and the rest are species of vines, epiphytes, small trees, shrubs and herbs.

Virtually all the 38 million hectares of PNG's forests are customarily owned by the indigenous inhabitants. These forest lands are under pressure from four major factors:- commercial agricultural development, subsistence shifting agriculture, logging and fire. In some areas, par-

ticularly in the lowlands, all these factors may be present and interacting. The nature of forests and land ownership means that attempts at both *in-situ* and *ex-situ* genetic resources con-servation techniques, are liable to be frustrated.

The National Herbarium located within the PNG Forest Research Institute in Lae, currently holds about 290,000 preserved plant specimens collected from all over the country. Henty (1980) identified and recorded some of these plants as harmful to both man and livestock.

The main indigenous forest tree species found in the country include; the *Araucaria* species (*A. hunsteinii* and *A. cunninghamii)*, the *Agathis* species, the *Eucalyptus* species (*E. deglupta, E. tereticornis* and *E. pellita)*, the *Acacia* species (*A. mangium, A. crassicarpa, A auriculiformis* and *A. aulacocarpa*), the *Incia* species and the *Diospyros* species. Some exotic species are *Tectona grandis*, *Gmelina arborea, Ochroma lagopus* and *Pinus* species.

2.2 Genetic Resources of Food Crops

There are significant number of food plant resources that have never been officially recorded or adequately investigated by botanists or agriculturalists in the country. It is not known how many kinds or species of these food plants exist in the wild. Information on landraces or farmers rare cultivars is also very patchy at this stage. The following discussion gives some idea of the kind of genetic diversity that exists in the indigenous food plants of PNG. Only the identified and common species are discussed. The actual list is inexhaustible.

The food crops research programme plus the multiplication and distribution of planting materials of these crops to farmers are executed and coordinated by the Research Division of the Department of Agriculture and Livestock (DAL). All major food crops distributed by DAL to farmers for planting are selected landraces or farmer cultivars from farmer's fields within the country. The landraces or farmer cultivars are collected and assembled in ex-situ collections held at various DAL Research Stations in the country. Through varietal assessment studies and preliminary screening and selection process, the elite landraces are selected, multiplied and distributed to farmers for planting. Food crop farmers are encouraged to grow their own cultivars or landraces. It is a common practise between farmers to exchange planting materials of their local landraces. This is commonly practised for crops such as taro, sweet potato, yam, banana, cassava and aibika.

Food crop farmers in PNG prefer their own landraces because of their eating qualities. The farmers have over the years acquired certain preference for taste for the staple food crops they grow and consume and it is often very difficult to get the farmers to change to something new. The Government through the Research Division of DAL has in the past introduced superior varieties of certain crops like yams (*D. rotundata*) from the International Institute of Tropical Agriculture (IITA), Nigeria. These yam varieties were introduced to the yam growing areas of the Sepik and Central Provinces but have not taken off. The farmers prefer their own *D. alata* and *D. esculenta* varieties.

2.3 Genetic Resources of Root Crops

The root crops constitute the main staple diet of the indigenous population. Sweet potato (*Ipomoea batatas* L. Lam) is the main root crop in the country in terms of production and consumption. It is considered to be a native of Central America, but some scientists believe that it is of Polynesian origin (IBPGR 1981). In PNG sweet potato is widely cultivated from sea level up to 2700 m with the main production sites in the Highland provinces. Over the years a total of 1,044 accessions of sweet potatoes were collected and assembled in ex-situ establishments in the country (Kambuou 1993). Mostly these are landraces, farmers cultivars and common varieties. Sweet potato is a plant that actively seeds and is constantly undergoing sexual reproduction in field conditions particularly in the high altitude environments. This has contributed to its great genetic diversity in the country. Another *Ipomoea* species that is cultivated for

its tuber in the Transfly area of Western Province is *I. tuba*. There is no information on the genetic variation of this species. *Ipomoea aquatica* or locally known as kangkong is an aquatic, floating herbaceous perennial plant cultivated for its young succulent terminal shoots and leaves which are used as spinach in the local diet. There are a number of wild *Ipomoea* species found here of which the common ones are *I. digitata* L., *I. hederifolia* L., *I. plebeia* R. Br. and *I. triloba* L. The wild germplasms are growing in their natural habitats. No attempts have been made to conserve these wild resources in ex-situ collections.

The second most important root crop of PNG is taro (*Colocasia esculenta* L. Schott). It is believed to have originated from South East Asia but is widely cultivated in West Africa, the Caribbeans and the Pacific Islands. Taro is considered as one of the indigenous traditional food crops of PNG and is predominantly grown in the lowlands rainforest areas of moderate fertility. Papua New Guinea has the world's largest genetic diversity of taro and is being grown from sea level up to 2700 m altitude. A total of 600 indigenous accessions were collected and assembled in ex-situ collections in the country.

Most of these accessions are landraces and farmer cultivars. A survey of wild taro carried out by the team of taro scientists based at Bubia Agricultural Research Centre, Lae, PNG has shown that there is relatively low diversity within the wild taro population observed in 21 locations throughout the main taro growing areas. Other species of Araceae commonly grown in the country include chinese taro (*Xanthosoma sagittifolium* L. Schott), swamp taro (*Cyrtosperma chamissonis* Schott Merr.), giant taro (*Alocasia macrorrhiza* L. Schott) and elephant foot yam (*Amorphophallus campanulatus* Blume). Except for a few cultivars of chinese taro the rest of these species are growing in natural stands in the wild. The polynesian arrowroot (*Tacca leontopetaloides* L.O. Kuntze) from the Family Taccaceae are commonly seen growing wild in the coastal areas up to 200 m altitude.

The yams or *Dioscorea* species are the third most important root crops of the country. Purseglove (1988) mentioned that 600 species of *Dioscorea* are found in the tropic and subtropic regions of the world. Eleven of these species have edible tubers and six are found in PNG. The diversity of genetic materials are found in two commonly grown species, the *alata* and the *esculenta*. These species are widely cultivated throughout the country for food and are very important ceremonial crops in some areas. Other species not so commonly cultivated are; aerial yam (*D.bulbifera* L.), five leaflet yam (*D. pentaphylla* L.), bitter yam (*D. hispida* Dennst.) and *nummularia* yam (*D. nummularia* Lam.). Some 400 accessions of yams were collected and assembled in ex-situ collections in the country. The genetic diversity of the less common species have not been fully explored. Most of these germplasms are growing in their natural habitats.

An important staple root crop in areas of poor soils and harsh conditions with prolonged dry season is cassava (*Manihot esculenta* Crantz.). This crop has its centre of origin in South America, but is widely cultivated in the tropic and subtropic areas of the world. It is the main staple root crop in the dry coastal areas of the country. A total of 115 accessions mostly landraces and farmer cultivars have been collected and assembled in ex-situ collections maintained by the Department of Agriculture and Livestock (DAL). *Manihot esculenta* is not known in a wild state (Purseglove 1991). There are few cultivars grown as ornamentals and temporary shades in towns and villages. There is no information on the germplasm of the ornamental cassava.

French (1986) reported other minor edible root crops such as Hangar (*Operculina turpethum* L. S. Manso.), Kudzu (*Pueraria lobata* Willd. Ohwi), Yam bean (*Pachyrrhizus erosus* L. Urban) and Winged bean (*Psophocarpus tetragonolobus* L.D.C.). Except for wing bean, very little is known about the genetic diversity of other minor root crops in the country.

2.4 Genetic Resources of Leafy Vegetables

There are over 40 species of edible green leaf vegetables in PNG. The most popular species include, Aibika (*Abelmoschus manihot* L. Medik), *Amaranthus* spp., Tulip (*Gnetum gnemon* L.), Rungia (*Rungia klossii* S. Moore), Water dropwort (*Oenanthe javanica* D.C.), Blackberried nightshade (*Solanum nigrum* L.), Kumu mosong (*Ficus* spp.), Kangkong (*Ipomoea aquatica* Forskal), Watercress (*Nasturtium* spp.), Valanguar (*Polyscias* spp.), Kumu grass (*Callipteris prolifera* Lam. Bory.), Choko tips (*Sechium edule* Jacquin Swartz) and Pumpkin tips (*Cucurbita moschata* Duch et Lam). All these leafy vegetables are either cultivated in gardens or grown wild in in-situ conditions. Some of these crops have great intra-specific variations. For example Aibika, has well over 140 accessions collected from all over the country. This crop is unique to Indonesia and the South Pacific but has the greatest diversity in PNG. The collected accessions are all landraces and farmer cultivars. There is little known about the wild species of *Abelmoschus* in the country.

The second most popular leafy vegetables are Amaranths, believed to be originated from tropical America then spread throughout the tropics. Six species are grown and eaten in PNG namely *A. caudatus* L., *A. cruentus* L., *A. dubius* Thell., *A. tricolor* L., *A. lividus* L. and *A. viridus* L. There are intra-specific variations in some of these species. The crop establishes well in new gardens and cultivated areas. Henty *et al.* (1975) recorded *A. spinosus* L. as a weed of gardens and agricultural land, sometimes appearing in pastures. Except for the common varieties grown in subsistence gardens, the rest of the genotypes grow naturally in forest clearings, water holes, near rivers and along road sides.

Tulip (*Pnetum* spp.)is a small tree about 10 m high and grows naturally in rainforest areas. Its young leaves, flowers and fruits are cooked and eaten as spinach and the fibre from its bark is used as ropes or woven into fine threads for making string bags. The centre of origin is not known, but the area of distribution of the species is from Assam to Fiji. There is genetic diversity in the landraces and farmer cultivars grown in PNG, much of which is still being harvested from the wild.

The Blackberried nightshade and Valanguar plants are cultivated and eaten mainly in the islands of New Britain and New Ireland. Valanguar originated from the Pacific area and is now widely distributed as far as Europe. The exact number of species existing and utilised in the country is not known but there is certainly a great genetic variation in this crop. Five edible species have been recorded by French (1986) in New Britain and New Ireland namely; *Polyscias cumingiana* (Presl) F. Vill., *P. fruticosa* (L) Harms., *P. macgillivrayi* (Seem) Harms., *P. scutellaria* (Burm.f.) Fosb. and *P. verticillata* Stone. Blackberried night shade or karakap as locally known is commonly self sown in newly cleared garden sites throughout the country. There is some intra and inter-specific variation in this crop which has not been formally recorded. Apart from the few farmer cultivars most of the landraces are still being harvested from the wild.

The three species that grow well in the moist or damp conditions are Kangkong, Watercress and Water dropwort. Kangkong is widely cultivated in South East Asia and in PNG it is a common sight in waterways, ditches and damp areas. Only few varieties of this crop are grown, there is no significant genotypic variation in this crop in the country. Watercress is native to West Asia and commonly occurs in Europe, North America and many temperate areas of Asia. In PNG it is naturalized in streams and lakes in the mountainous areas. Two edible species are recorded in PNG, the *Nasturtium officinale* R. Br., and *N. schlechteri* O.E. Schultz. Not much intra-specific variations occur in these crop species.

The Water dropwort commonly occurs in Indo-China, Korea, Japan and Australia. In PNG it grows wild in swampy areas, along ditches and moist pasture areas. It is a popular leafy vegetable in the highland areas. Several genotypes

occur in the country with different colours and leaf sizes.

Many species of *Ficus* are found in PNG, but five are recorded as edible to the indigenous people. The most common species are *F. copiosa* Steud. and *F. wassa* Roxb., locally known as Kumu mosong. These are tree crops and can grow up to 10 m high. Their young leaves and fruits are eaten. Most of the landraces are harvested from the wild in rainforest areas. Few farmer cultivars are grown near villages or in old garden sites. The other edible species are; *F. dammaropsis* Diels, *F. pungens* Reinw. et Bl. and *F. tinctoria* Forst. The latter species occurs wild in the atoll areas of the country. The young leaves are picked and eaten and the fruits are recorded eaten as well. *Ficus dammaropsis* is either cultivated or grown wild in the highland areas and the young leaves are cooked and eaten with pig meat. *Ficus pungens* normally grows near streams and drains and are mostly self sown. Young leaves are cooked and eaten with meat. There is genetic variation in all the *Ficus* species in the country that needs to be properly investigated and recorded.

The rainforests, stream banks, wetlands and other damp areas are very rich in ferns. French (1986) reported seven different edible species of ferns in PNG. The most commonly utilized species is *Callipteris prolifera* (Lam.) Bory from the Family Athyriaceae. This fern is locally known as Kumu grass. It grows wild mostly along river sides and swampy areas. The other common species is the climbing swamp fern *Stenochlaena palustris* (Burm) Bedd belongs to the Family Blechnaceae. This fern grows wild and mainly climbs sago palms and tree trunks and likes warm water-logged partly cleared forest sites. There are genotypic variations in their leaf colour. Three edible *Diplazium* species are; *D. asperum* Bl., *D.cordifolium* Bl. and *D. esculentum* Swartz. These species are grown wild in wet lowland areas and are gathered and eaten whenever required. The tree fern has three species that are edible namely; *Cyathea angiensis* (Gepp) Dom, C. *contaminans* (Wall ex Hook.) Copel and *C. rubiginosa* (Brause) Domin. These species occur naturally and in areas ranging from 600 - 2800 masl. They are important green leafy vegetables at pig feasts in the highlands of PNG. Another edible fern is *Nephrolepsis biserrata* (Sw.) Schott. from the Family Davalliaceae. It grows wild in open rocky areas and also as epiphytes on the trunks of palms. The young fronds are gathered for food whenever required. There is great genetic diversity in this group of plants that needs to be further investigated.

Other leafy vegetables consumed in large quantities are Pumpkin and Choko tips. These crops are grown for both their fruits and their tips. There is intra-specific genetic variation in these crops which has not been recorded. Tips from the commercial varieties of pumpkins like the 'Queensland Blue' are not eaten because of the bitter taste produced after cooking.

A number of other edible greens mainly harvested from the wild have not been identified nor recorded. Some of these species are listed in Appendix 1.

2.5 Genetic Resources of Bananas

Papua New Guinea is an important centre for wild banana distribution, although Malaysia is the recognised centre for the origin of bananas (Simmonds 1956).

The country is unique in having the greatest genetic diversity of botanically primitive diploid cultigens amongst the large number of cultivars. Bananas are grown everywhere in the country and they are important staple food crops in areas around Port Moresby, Rabaul, Cape Vogel, the Markham/Ramu Valley and the Amele area of Madang.

Two genera of family *Musaceae* are found in PNG. Genus *Ensete* is represented by one species, *Ensete glaucum* and genera *Musa* by nine species in three of the five sections of the genus (Argent 1976). Some 800 accessions of both cultivated and wild bananas from PNG were collected and assembled at the University farm in Lae in the early seventies. More collecting expeditions were undertaken which resulted in

the transfer of the national banana germplasm collection to Laloki Research Station, outside Port Moresby.

The national field collection currently holds following *Musa* species namely; *Musa acuminata, M. balbisiana, M. maclayi, M. acuminata* spp. *M. banksii, M.boman, M. peekelii, M. angustigemma, M. ingens, M. schizocarpa* and one species of *Ensete, E. glaucum.*

2.6 Genetic Resources of Indigenous Vegetables

French (1986) reported well over 60 species or kinds of vegetables grown and eaten in PNG. Many of these species have been recently introduced in the country and are gaining popularity in village gardens and in the local diets. Few species are indigenous to the country and these include; the Highlands pitpit (*Setaria palmifolia,* Koenig. Stapf), Coastal pitpit (*Saccharum edule* Hasskarl), Ginger (*Zingiber* spp.), Choko (*Sechium edule* (Jacq. Swartz), Cucumber (*Cucumis sativus* L.), Pumpkin (*Cucurbita moschata* Duch et Poir), Wingbean (*Psophcarpus tetragonolobus* L. DC), Arenga palm (*Arenga microcarpa* Becc.), Small bamboo (*Bambusa forbesii* (Ridl. Holt.), Bamboo (B. *vulgaris Schrad* and *Nastus elatus* Holttum), Job's tears (*Coix lachryma-jobi* L.), Lotus (*Nelumbo nucifera* Gaetn.) and Waterlilies (*Nymphaea pubescens* Willd.).

The Highlands pitpit is like grass with broad leaf blades which are folded as fans to house the clump of edible shoots. Number of landraces and farmer cultivars are grown in village gardens in the Highlands. Some wild species occur in the same areas but have not been identified or officially recorded.

The Coastal pitpit is from the sugarcane family and grows in old garden sites and near villages. The crop is widely cultivated in the coastal areas throughout the country. The edible portion is the unopened flower and can be eaten raw or cooked. There is a marked genetic variation within the cultivated species. Few wild species are found in the country. Kambuou (1988) reported 28 accessions of *Saccharum eduli* Hasskarl and 12 of S. *spontaneum* L. collected throughout the country and maintained in ex-situ collections. There is genetic diversity in the *Saccharum* species in their natural stands and in subsistent gardens.

Three species of bamboo are consumed in PNG, mostly by the people of the mountain areas. The common species is *Nastus elatus* Holttum, cultivated throughout the Highland areas for their shoots as vegetables and their hallow stems are used as water containers. The other edible species are: *Bambusa forbesii* (Ridl.) Holt. and B. *vulgaris* Schrad. These bamboos are very rarely cultivated, they grow in the wild and their shoots are collected whenever needed. There is genetic variation in these plants that has neither been identified nor recorded.

The Lotus (*Nelumbo nucifera* Gaertn.) and the Waterlily (*Nymphaea pubescens* Willd.) plants are eaten by the local people living along and in the river basins. Almost all parts of the Lotus plant is eaten raw or cooked. For Waterlily only the small seeds are eaten. There is not much genetic variation in these aquatic plants.

The Arenga palm (*Arenga microcarpa* Becc.) or Sanis as locally known grows wild in the lowland areas. Its young shoots are cooked and eaten as vegetables. The rainforest areas house numerous species of wild palms that have not been officially identified or recorded.

A number of Cucumber species are found in the country. The common indigenous species of the Highland region is *Cucumis sativus* L. Its long greenish white flesh are eaten raw and the young leaves and tips are cooked and eaten as spinach. The kernels of the seeds are also eaten. There are other species cultivated in village gardens throughout the country which have not been identified.

There are many wild indigenous plant species eaten by the locals as minor vegetables. Some of these species are given in Appendix 2.

2.7 Genetic Resources of Fruit and Nut Species

The South East Asian region including PNG is recognised as one of the centres of diversity of tropical fruits and nuts (IBPGR 1980). This means that the region possesses a large number of native species showing great variability. In PNG most of the common landraces or farmer cultivars of fruit and nut trees are grown in village gardens, courtyards, village boundaries or small sized orchards. The wild species are all grown in their natural stands in forested areas. The demand for land required for developmental purposes will affect the fruit and nut tree populations and the genetic variability they contain. It is time an action programme be undertaken to preserve these invaluable resources. The majority of fruits and nuts in PNG particularly the wild species are native to the country and it is highly possible that the genetic diversity of these germplasms is not found anywhere else in the world. Scientifically the native species of fruits and nut trees have not received the appropriate attention. Only the species that have been identified or recorded will be discussed in this section.

2.7.1 Fruit Tree Species

Mangoes (*Mangifera* spp.) are common in the lowlands but their productivity is restricted mainly to areas of prolonged dry spells. The widely cultivated species is *M. indica* L. It has been recorded that the seeds and young leaves are also cooked and eaten. There are a number of edible wild species growing in forested areas throughout the country which have not been investigated. *Mangifera minor* Bl. is a common wild species eaten in some lowland areas.

Bukubuk (*Burckella obovata* Forst. Pierre) is a native fruit on the atolls of PNG. It is a highly preferred fruit in East New Britain, New Ireland and other small islands. There is some genetic variation in the species but it has not been investigated.

Marita (*Pandanus conoideus* Lamarck) grows throughout PNG from sea level to 1600 m altitude. The ripe Marita fruit is cooked and the juice is mixed with water to make a sauce that is eaten with other food. There is genetic variation in this crop which requires further study.

Taun or *Pometia pinnata* J.R. & G Forster and Hoft is a large tree with the wild stands occurring throughout the lowlands and the lower montane forests. The fleshy layer (aril) around the seed is eaten when ripe. It is a very popular fruit when in season. The inedible species occur mostly along the ridges and is a useful timber tree. There is intra-specific variation in *P. pinnata* but very little information is officially recorded.

Golden plum/apple (*Spondias cytherea* Sonnerat) grows up to 15 m tall and occurs wild in the lowland rainforest areas. Fruiting is seasonal and are eaten after peeling. The young leaves are edible raw or cooked. There is intra-specific diversity in this crop as suggested by the size and the quality of the fruits but this has not been identified. A wild species *S. philip-pinensis* (Elmer) Airy Shaw & Forman, occurs naturally in the Sepik area. Its fruits are edible but very sour.

The tree cucumber or Bilimbi (*Averrhoa bilimbi* L.) grows wild in secondary forests in many coastal areas of the country. The tree is 7 m high and bears clusters of cucumber shaped fruits on the trunk and older branches. The fruits are used in souring dishes. There may be some genetic variation in the crop that requires further study.

A number of *Citrus* spp. are grown in the country, many of which may have been introduced years ago. The indigenous species of the country is *C. hystrix* (L.) D.C., occurring wild in most coastal areas. The leaves and fruits are used to make drinks and flavour food. Other species cultivated include; Lime (*C. aurantifolia* Christm. Swing.), Sour orange (*C. aurantium* L.), Pomelo (*C. grandis* L. Ossbeck), Lemon (*C. limon* L. Burm. F.), Citron (*C. medica* L.), Grapefruit (*C. paradisi* Macf.), Mandarin (*C. reticulata* Blanco) and Orange (*C. sinensis* L. Osbeck). Genetic diversity exists between and within the species.

Most of the cultivated or commonly consumed species are grown in villages or in small orchards on various base-camps or stations in the country.

Clymenia polyandra (Tanaka) Swingle is related to Citrus and occurs only in PNG. It is cultivated in the islands of Manus and New Ireland. The edible portion is the fruit which is eaten fresh. There are genetic variations in this crop as reflected by the varied quality of its fruits but this has not been scientifically investigated.

Another native fruit of Manus Island is *Corynocarpus cribbianus* (F.M. Bail) L.S. Sm. It is an important fruit on Manus and some small islands near Madang. The tree flowers and fruits throughout the year. The fruits are edible and can be eaten raw or cooked. Not much is known about the genetic diversity of this fruit.

Baccaurea papuana Bailey or Mabewa as locally known occurs in several lowland areas from sea level up to 1600 m altitude. The fruits are eaten mainly in the Gulf and Milne Bay areas. Apart from this basic information there is little known about its genetic diversity.

The New Guinea Walnut (*Dracontomelon dao* Blanco Merr. & Rolfe) or Mon as commonly known is a large tree up to 50 m tall and occurs wild in the high rainforest areas of the country. The juicy flesh of the fruits are eaten. The flowers and young leaves can be cooked and eaten as vegetables. It is a most popular fruit in Madang. Not much is known about its genetic variation in the country.

There are many species of *Eugenia* occurring in the country. Six species are reported to be eaten; *E. aromatic* (L) Bill., *E. aquea* Burm.f., *E. jambos* L., *E. javanica* Lam., *E malaccensis* L. and *E. uniflora* L. These plants occur mostly in coastal areas from sea level up 1600 m altitude. Their juicy ripe fruits are eaten fresh. The dried flower buds of *E. aromatic* are used for flavouring foods. The commonly cultivated species are *E. aquea* or Watery rose apple and *E. malaccensis* or Malay apple. Other species mostly occur in the wild.

Three *Flacourtia* species are reportedly eaten in the country. These include *F.inermis* Roxb. or Lovi-lovi as known locally, *F. jangomas* (Lour.) Raeusch or Coffee plum and *F. rukam* Zoll. & Mor. or Rukam. The Lovi-lovi is a small tree which occurs naturally in New Britain area. Their small round fruits are eaten fresh or cooked. Some genotypes have sour fruits which are suitable for making jam. Fruits of the Coffee plum and Rukam are eaten but are not very popular. Not much is known about the genetic variation of these species.

Four *Rubus* or Raspberry species are reported to be eaten in PNG and they occur mostly in the Highland areas. These species include; *R. fraxiniflius* Poir., *R. moluccanus* L., *R. rosifolius* Smith and *R. lasiocarpus* Sm. The latter species produce black juicy fruits and is gaining importance as a fruit in villages and compounds in the highlands. The first three species all produce red fruits which are very popular with children. There are genotypic variation in these species but those have not been identified.

The Alpine strawberry (*Fragaria vesca* var. *semperflorens*) grows from 1600 m to 3500 m and mostly occurs around the Mt. Wilhelm area. The juicy fruits are edible. Not much is known about the genetic variation in this crop.

Five species of *Passiflora* were introduced into PNG but the local wild species is *P. foetida* L. which grows abundantly in the lowland areas and fruits throughout the year. The small yellow fruits when ripe are eaten mostly by children.

A fruit tree species *Parartocarpus venenosus* (Zoll. & Mor.) Becc grows wild in the humid rainforest areas in the country. The dry yellow flesh of the brown fruit is eaten and the seeds are also edible after they have been soaked in sea water for a few days. There is no record in the genetic variation of this species in PNG. The minor indigenous fruit crop species are listed in Appendix 3.

2.7.2 Nut Tree Species

Coconut is a widely occurring and cultivated

nut species consumed throughout the country. It is also a main cash crop for the country and therefore it will be discussed with other commodity crop species.

The Betel nut (*Areca* spp.) or Buai as locally known is grown throughout the country. *Areca catechu* L. is a lowland species and grows from sea level up to 900 m altitude and *A. macrocalyx* grows between 1000 m and 1900 m. The mature or young nuts are chewed with lime and betel pepper as a masticatory. The heart of the palm is believed to be eaten in some places in PNG. There is great genetic diversity within *A. catechu* which needs to be identified and recorded.

Six *Pandanus* species are recorded as eaten in the country, these include; *P. jiulianettii* Martelli, *P. brosimos* Merrill & Perry, *P. antaresensis* St. John, *P.* odoratissima L.f., *P. tectorius* (Parkinson) Soland and *P. englerianus* Mart. The first three species occur commonly in the high altitude areas throughout the country. While the latter three species are found mostly in the coastal areas. The nut or the kernel of the fruit is eaten raw or cooked. The red outer layer of the fruit of *P. englerianus* is cooked with hot stones to make a sauce. There is intra-specific variation in these species but has not been studied.

French (1986) reported four edible *Canarium* species found in PNG. The most popular species is locally known as Galip nut or Canarium almonds (*Canarium indicum* L.). It occurs in the lowland rainforest areas of the islands of New Britain and the North Solomons. The kernels are eaten raw or roasted. The other species are: *C. kaniense* Laut., *C. salomonense* B.L.Burtt and *C. schlechteri* Laut. These species occur wild in their natural stands in lowland rainforest areas. Their oily seeds are eaten raw or roasted. There is genetic diversity in this crop but no proper scientific investigation was undertaken to identify them.

There are five edible *Terminalia* species reported in the country. The most common species is *T. kaerrbachii* Warb or locally known as Okari nut. It occurs in the lowland areas throughout the country. The kernels are very popular and highly prized in the local markets. The other species are; *T. catappa* L., *T. copelandii* Elm, *T. impediens* Coode and *T. megalocarpa* Exell. These species occur wild in the lowland forested areas of the country and their fruits and kernels are eaten raw or roasted. There may be other wild species in the country that have not been identified.

Another common and popular nut tree species in some coastal areas is *Barringtonia novaehebernae* Laut or locally known as Pao. The kernels inside the nuts are eaten raw or roasted. The other edible species is *B. procera* (Miers) Knuth. There are genotypic variations in the edible species as shown by their fruit colours. A non-edible wild species is *B. asiatica* (L) Kurz occurs along the foreshore and is used as a fish poison.

The PNG oak or Castanopsis chestnut (*Castanopsis acuminatissima* Bl. A. DC) is a tree that occurs throughout much of PNG and forms pure stands in lower montane rainforests between 500 and 2000 m altitude. The seeds are eaten after being boiled. The wood also provides useful timber for building houses. There is no record of the genetic diversity existing in this nut crop.

The Finschia nut (*Finschia* spp) occurs in the lowlands and some mountainous areas of the country. It is an important nut tree in several areas of PNG. The two edible species are *F. chloroxantha* Diels and *F. ferruginiflora* C.T. White. The seeds are cooked and eaten. Not much known is about the genetic variation of this nut tree in PNG.

The Tahitian chestnut or Aila as known locally is a tall tree and occurs in the lowland forest areas near rivers and swamps. It occurs in other Pacific Islands as well. The seeds are cooked and eaten. The edible species that occurs in PNG is *Inocarpus fagifer* (Park). Not much is known about the genotypic variation of this crop in the country.

The Candle nut (*Aleurites moluccana* L. Willd) is also a tall tree and occurs in the lowland rainforest areas. The hard shelled nuts are usually roasted to free the kernels which are then consumed. No information on the genetic variability of this crop in PNG.

The Nipa palm (*Nipa fruticans* Wurmn.) occurs naturally along the Papuan coast near mangrove swamps and along the shorelines. The kernel inside the nut is edible and the young shoots are also eaten. Sugar or vinegar can be obtained by collecting sap from the fruit stalk. It is not known if there is any genetic diversity in this crop.

Pangi (*Pangium edule* Reinw.) or locally known as Sis occurs wild in the lowland rainforest areas. The seeds, pulp of the fruits and leaves are eaten after cooking. It is very popular near Madang. Not much is known about its genetic variation.

2.7.3 Genetic Resources of Spice Crops

Unlike the Asian neighbours, people in PNG use very little spice in their food. Almost all spice crops commonly used in the country were introduced many years ago. Only a few indigenous plants are used as herbs or flavourings in some local dishes. There is not much inter or intra-specific diversity existing in these spice crops.

The ginger or kawawar as locally known is a perennial herb with swollen underground rhizomes used in flavouring food. The young shoots are spicy and can also be eaten. The common cultivated species is *Zingiber officinale* Rosc. grown throughout the country. The wild ginger (*Z. zerumbet* L. J.E. Sm) which occurs in the coastal forest areas are also eaten and are used in medicine and magic. Three wild genera of ginger are eaten in PNG, namely Alpinia or locally known as Golgol, *Amomum aculeatum* Roxb and *Horrstedtia scottiana* F.Muell K. Schum. The fruits of these plants are eaten raw or cooked. These plants grow wild in the rainforest habitats most of which are being destroyed because of lumbering activities. The inter and intra-specific diversity of this plant has not been investigated.

The Begonia (*Begonia* spp.) plant is a small herb which occurs wild in the rainforest areas in the highlands. The stalks are eaten and the leaves are used for flavouring food. Leaves of some genotypes are used as ointment on sores. There is genetic variation between and within the species but have not been identified.

The stems of *Coix gigantea* Koenig et Roxb are used for making salt for food flavouring. This plant occurs in swampy places in the highland areas. Not much is known about the genetic diversity of this plant.

Leaves of *Coleus scutellarioides* (L) Bth are used as seasoning in food. This herb occurs wild throughout the country but very little is known about its genetic diversity.

Euodia species, most probably *E. hortensis* Forst., is a shrub that grows wild over a widespread area. It's leaves have a lemon flavour and has been recorded to be used in flavouring food in PNG. Little is known about it's genetic diversity.

The Fennel plant (*Foeniculum vulgare* Mill.) may have been introduced but they grow wild throughout the country in areas over 500 m altitude. The top leaves and the seeds are used as flavouring in food. Not much is known about its genetic variation.

2.8 Genetic Resources of Indigenous Sugarcane Plants

Sugarcane is a member of the grass family, Gramineae, and belongs to the genus *Saccharum*. Species of immediate importance to the Sugarcane Industry are: *Saccharum officinarum* L., *S. robustum* Brandes and Jeswiet et Grassl, *S. spontaneum* L., *S. barberi* Jesw. and *S. sinense* Roxb. Other related genera which are also of interest to the Sugarcane breeders are; *Erianthus*, *Miscanthus*, *Sclerostachva* and *Narenga* (Daniels and Roach 1987). Four species of *Saccharum* are found in PNG namely: *S. officinarum*, *S. robustum*, *S. spontaneum* and

S. eduli. New Guinea is the centre of origin of *S. officinarum*, the 'Noble cane' (Purseglove 1988). It is also the centre of diversity of this species. Many clones of *S. officinarum* have been reported in New Guinea. The Noble canes are cultivated in subsistence gardens in a wide range of environment from the coast to the highland areas and cannot survive in the wild. While *S. robustum* and *S. spontaneum* are highly polymorphic species and do exist in the wild, *Saccharum eduli* is cultivated for its inflorescence which is cooked and eaten as a vegetables.

A number of hybrids between these species have been reported by various collecting expeditions in the past. The earliest collecting expedition of sugarcane was made in 1875. Several collecting trips have been made since and the most recent one was undertaken in 1977. Most of thes expeditions were sponsored by organisations in USA including Hawaii, Australia and the ISSCT. The germplasms collected were sent overseas where some failed to survive, others were established in the World Collections run by USDA/ARS (USA), while the fate of others and in particular those collected in earlier expeditions are unknown.

A total of 206 accessions were collected during the 1977 expedition. No proper records were kept of the composition of this collection. Part of the collection was established at Bubia outside Lae where the collection currently holds 32 accessions of *S. officinarum,* 28 of *S. eduli* and 12 accessions of *S. spontaneum.* There is no documented record to provide a realistic figure on the number of genetic variation of *S. officinarum, S. robustum, S. spontaneum and S. eduli* in PNG. Even if such information were available, the record may only constitute a small percentage of the genetic diversity of these species in the country, because these expeditions could not have thoroughly collected throughout the entire country.

Diverse forms of both *S. robustum* and *S. spontaneum* and their hybrids, exist throughout the coastal regions and low lying inland areas of the country. *Saccharum robustum* prevails in the wetter areas near river systems, while *S. spontaneum* also exists in savannah type environments like parts of the Markham/Ramu plains.

The related genera of *Erianthus* and *Miscanthus* are also found in PNG (Daniels and Roach 1987). *Miscanthus floridulus* (Labill.) Warb occurs in PNG and other parts of the Pacific region. While *Erianthus arendinaceus* occurs in the country around the Fly River area.

The cultivated genotypes of *S. officinarum* could be regarded as landraces or farmer cultivars. Most of these materials have been in cultivation through generations. It is difficult to identify exactly which are traditional landraces and which are not.

2.9 Medicinal Plant Resources

Plants have been used as medicines throughout the world in ancient times and in many countries, including PNG, traditional medicines are still highly valued. PNG has a rich heritage of traditional knowledge of the uses of plants as medicines. It is through a trial and error process that people selected the plants for their medicinal values.

Over 600 medicinal plants have been reported and identified in PNG (Holdsworth 1977), of which 448 have been botanically described. Some 324 plants have been completely identified to the species level which represents 175 different species.

Some of these plant species may have been found to be used for similar ailments in other parts of the world. Papua New Guinea is so diverse in traditions, social norms, customs and the general way of living. The use of medicinal plants and the kind of plant species used also vary from one area to another.

It would be very lengthy to list all medicinal plant species that are used in PNG. The plants used for treating commonly occurring sickness and diseases are listed in Appendix 4.

There are plants for treating snake, scorpion and insect bites, burns, sore throats, toothache, constipation, dysentery and diarrhoea, tropical ulcers, skin rashes and boils. A number of plants are used as contraceptives and some are used to promote easy childbirth and regulate menstruation. Plants such as *Zingiber zerumbet* Sm. can also be used for inducing sterility.

2.10 Genetic Resources of Pastoral Species

The native pasture species of PNG have not been identified or recorded. The research work on pastures in the past was executed by DAL Research Division but on introduced species from Australia and other tropical countries.

Some 500 accessions of native *Desmodium* species were collected by CSIRO personnel throughout the country in 1980 and taken to Australia for research purposes. There was no mention of the deposit of the duplicate collection in PNG.

Currently no work is being done on pasture species in the country. The research Division of DAL does some work on introduced browsing pasture species. The commercial cattle ranges in the country are using introduced pasture species for their pasture improvement programmes. All indigenous pasture species are maintained in their natural stands. There is no record of the diversity and the composition of these genetic materials.

2.11 Ornamental Plant Resources

Papua New Guinea is one of the last frontiers in undiscovered flora and fauna with thousands of ornamental plant species yet to be discovered, identified and documented. The cause of genetic erosion basically comes down to the massive logging operations in this country, that is the main contributor to the destruction of plant genetic resources.

There is no record of any cases of illegal exporting of palms, ferns and shrubs out of the country. However, the Botanical Gardens have encountered exporting of orchid genetic materials out of the country in the past by some foreigners.

2.12 Orchids

The National Botanical Gardens orchid collections could never be completed because of the difficulty in collecting the orchid germplasm due to the diversity of the genetic material and the variability in the climatic requirements for their growth. The ex-situ collections at the National Capital Botanical Gardens has over 500 described species of orchids with about 50 species yet to be described.

This collection of orchids does not contain all orchid species of PNG. It seems that well over 60 percent of the total species of orchids in PNG are yet to be collected, identified and documented.

The Botanical Gardens have encountered illegal exporting of orchids out of the country which will become a major problem if the law is not upheld. The law of the country does not allow any plant material collected from the bush to be taken out of the country. The plant material has to be seed raised or grown in cultivation before it can be taken out. Orchids have been one of those plant materials taken out of the country illegally in the past.

2.13 Ferns and Shrubs

The National Botanical Gardens ex-situ collections have over 15 described species of ferns. This collection does not contain all fern species of PNG because of their different climatic requirements for growth. Well over 50% of the fern and shrub species are yet to be discovered, identified and documented.

2.14 Palms

There are over 39 species of palms held in the ex-situ collections in the Botanical Gardens. These collections are not complete. It seems that over 60% of native palms are still to be

discovered and documented. No palm species in the country has become extinct, but some species in certain areas are in serious danger if conservation programmes are not carried out soon. The main contributor to the destruction of palms as well as other PGR in their own natural habitats is logging, clear felling and the spread of agricultural activities.

3. NATIONAL CONSERVATION ACTIVITIES

3.1 Introduction

As said earlier the genetic diversity in food crops, medicinal plants, ornamentals and timber tree species in PNG is enormous. PNG is a secondary centre of diversity for many of its important staple food crops such as Banana (*Musa* spp.), Sweet potato (*Ipomea batatas*), Yam (*Dioscorea* spp.), Taro (*Colocasia esculenta*), Cassava (*Manihot esculenta*) and Aibika (*Abelmoschus manihot*), a traditional leafy vegetable. Besides the cultivated crops the country also has abundance of relatively unknown food plants that villagers collect from the wild. Among them are fruits and nuts species and edible shrubs and ferns. Many of these species are still in their natural habitats and have received very little research attention.

PNG is covered by about 38 million hectares of forests, all of which is owned by the indigenous people. These forest habitats contain the country's valuable natural wildlife. The indigenous timber tree genera include; the *Araucaria* spp., *Agathis* spp., *Eucalyptus* spp., *Acacia* spp. and some exotic species of *Tectona grandis*, *Gmelina arborea* and *Ochroma lagopus*.

There are over 600 medicinal plants reported to be used in PNG. Most of these plants grow wild in natural habitats and are collected whenever needed.

The forest habitats of the country, particularly the rainforest areas are rich store houses for exotic orchid species and other wild flowers, ornamental shrubs, ferns and palms.

National *ex-situ* collections are maintained for major food crop species, some timber tree species, few fruits and nut trees and ornamental plant species which are maintained in the national botanical gardens.

The *in-situ* conservation of the total plant genetic resources and the current status of *ex-situ* conservation of the major food crops species of the country are discussed.

3.2 Materials and Methods (Conservation Strategies)

The two PGR conservation strategies used throughout the world are the *in situ* and the *ex situ* Conservation. The *in-situ* conservation is referred to as an approach taken to conserve or maintain plant genetic resources mainly the wild relatives or progenitors of the crop species, forest tree species, medicinal plants and ornamental plant species in their natural states and in their own habitats. For the continuation of genetic evolution and integrity, it is important to allow germplasm to be maintained or conserved in their natural states in their own habitats (Ford-Lloyd & Jackson 1986).

The *ex situ* conservation refers to a strategy used in maintaining genetic materials outside their own natural habitats, either in field collections, in seed gene-banks or in *in vitro* storage.

3.2.1 *In Situ* Conservation

3.2.1.1 Natural Parks and Nature Reserves

There are three officially recognised National Parks in the country with numerous Nature Reserves. These areas are owned by the landowners, but the Government through the Department of Environment and Conservation has negotiated with the landowners to maintain them as parks and reserves. The national parks are maintained by Park Rangers who are based on site. The nature reserves are not manned as such, but officers from the Department of Environment and Conservation ensure that these areas are kept free of any agricultural or logging activities.

3.2.1.2 Community Control Land

Land in PNG is owned by the community, clan or the family. There is no individual ownership unless a person is a sole heir to the land or it has been purchased through traditional or legal means. Due to communal ownership of the land, it is very difficult for the Government to carry our any development projects. The land tenure system in the country is very complicated. Under the old colonial system, certain suitable agricultural lands were leased to foreign ownership for 99 years. Almost all these lands have now gone back to the local land owners.

The Government does not own the land. Like others, the Government also has to purchase the land through the Lands Department to carry out any development work. This affects the overall progress, development and advancement in the country.

3.2.2 *Ex Situ* Conservation

The national plant genetic resources collections of the staple food crops, vegetables, fruits and nuts, industrial commodity crops, medicinal, spice and pasture plants in PNG are maintained at different DAL research stations, at various commodity crop institutes and at government-controlled corporations as in the case of sugarcane and coffee. A great majority of the collections are maintained in field gene-banks, some as *in-vitro* materials, reflective of the situation in PNG where the most important crops are vegetatively propagated. A high proportion of the genetic materials conserved in *ex situ* is indigenous to the country. The plant resources that are considered important are the germplasm of root crops, industrial commodity crops (coffee, cocoa, coconut etc.), vegetables, and fruits and nuts.

The introduced seed crops are maintained in short-term storage conditions at various rese-arch stations, using the normal household refrigerators and freezers.

3.3 Results and discussion

3.3.1 In Situ Conservation

3.3.1.1 Natural Parks and Nature Reserves

There is no written record of the germplasm composition of the parks and reserves, but since they are heavily forested, they are likely to contain great diversity of plants and animals. These forested parks and reserves are ideal habitats for some of the unique germplasms of ornamental and timber and non-timber forest products such as orchids, ferns, palms, ratans and bamboos.

3.3.1.2 Community Control Land

The Non-Government Organisations (NGOs) in the country work closely with the landowners in agriculture, livestock and forest projects. The Kandrian Glouster Integrated Development Project (KGIDP) is a good example of an NGO group who worked with the landowners to develop their timber resources. This group received funding from Australian Aid (AusAID), to assist the local landowners in conserving and replanting the indigenous timber tree species. The group is based in Kimbe, West New Britain Province and covers the Kimbe, Kandrian and Glouster areas, some of the richest timber growing areas in the country.

3.3.2 *Ex Situ* Conservation

3.3.2.1 Field Collections

(1) **Sweet potato**. The national lowlands collection of sweet potato (*Ipomoea batatas*) is located at the Lowlands Agriculture Experimental Station, Keravat (LAES), in East New Britain Province. Over the years a total of 1044 accessions were collected and assembled on the station. Characterization of the germplasm has been conducted and as a result, 52 accessions were identified as duplicates. Due to difficulties encountered in the maintenance of the field collection, 669 accessions were lost. The remaining 375 accessions are currently being maintained and are fully characterized using the

IBPGR descriptor lists with some modifications.

The highlands sweet potato germplasm collection is maintained at the Highlands Agriculture Experimental Station in Aiyura. A total of 1453 accessions were collected and assembled on the station, of which 970 are characterized and the information is documented. Out of the total number of accessions, 95 were lost during relocation of the collection in the field, and 149 were identified as duplicates accessions. Of the remaining 1209 accessions, some 19 of the promising are being evaluated at LAES Keravat.

Passport information, characterization and evaluation data of the collections from both research stations are documented in the computer using the DBASE programme.

To complement the field maintenance of the sweet potato germplasm, the collection is gradually being put into *in-vitro* slow-growth conditions at LAES Keravat. The future plan for PGR conservation is to maintain germplasm under *in vitro* slow-growth storage conditions as a complementary conservation strategy to field collections.

(2) **Taro**. The national collection of taro (*Colocasia esculenta*), the second most important root crop in PNG, is located at Bubia Agricultural Research Centre (BARC). Of the original 600 accessions collected and maintained on the station, attrition due to pest and disease infestation and weather conditions has reduced the collection to 437 accessions. These remaining accessions have been partially characterized using the modified IBPGR descriptors and documented using data base (DBASE).

A small collection of 40 taro accessions from the islands of PNG are assembled at LAES Keravat. In addition, 21 farmers' cultivars and land races from the Sepik area were collected and maintained at Saramandi Research Station. Both collections have not been described.

(3) **Yam**. A total of 423 accessions of yams (*Dioscorea* spp.) were collected all over PNG and assembled at Laloki Agricultural Research Station (LARS). Of the total collection, 108 accessions were lost. Part of the remaining 315 accessions have been described for above and below-ground characters using a slightly modified IBPGR descriptors list.

The collection was severely affected in 1995 when the station was cut back on it's financial allocation. Financial difficulties experienced by the Station prevented the replanting of the collection. The whole collection is now lost, only few common cultivars are being maintained by station workers in their backyard gardens.

A small collection of 27 farmers' cultivars and landraces of *D. esculenta* and *D. alata* from the Sepik area is maintained at Saramandi Research Station. In addition, 12 high yielding cultivars of *D. rotundata* from the International Institute of Tropical Agriculture (IITA) were added to the collection for agronomic evaluation.

(4) **Cassava**. A total of 79 landraces of cassava (*Manihot esculenta*) were collected from all over PNG and assembled at LARS, while 36 accessions collected from the islands are maintained at LAES Keravat. All 115 accessions have been characterized using the IBPGR descriptors list and documented in the computer using the DBASE programme.

(5) **Banana.** More than 500 accessions of banana (*Musa* spp.), including the wild indigenous and endemic diploids, were collected all over the country and assembled in the national collection at LARS. Difficulties in field maintenance have reduced the collection to 479 accessions. Of the remaining accessions, 181 have been characterized using a modified IBPGR descriptors list. Both passport information and characterization data are documented in the computer using the DBASE programme.

Part of the original collection is duplicated in the regional banana germplasm collection centre in the Philippines.

A small collection of 17 accessions of edible *Musa* species found in the atoll areas of PNG is maintained at LAES Keravat. This collection has

not been described. Passport information has been entered in the computer.

(6) **Sago**. Some 13 cultivars of sago (*Metroxylon sagu*) found in the Sepik area were collected and maintained at Saramandi Research Station. The collection has neither been described nor evaluated. Incomplete passport information is available in manual form.

(7) **Aibika**. A total of 142 accessions of aibika (*Abelmoschus manihot*) were collected throughout PNG and assembled at LARS. Some 30 accessions are lost, leaving 112 accessions currently in the collection. The materials have been described and evaluated for their yield potential, nutritive components and reaction to common pests and diseases.

Duplicate collections of 67 farmers' varieties found in the island provinces and 23 varieties grown in the Sepik area are maintained at LAES Keravat and Saramandi Research Station, respectively.

(8) **Other traditional leafy vegetables**. A total of 48 accessions of traditional leafy vegetables are held at LAES Keravat and Aiyura. Species in the collection include *Amaranthus* spp., *Ficus* spp., *Gnetum gnemon*, *Polyscias verticillata*, *Rungia klossii*, *Oenanthe javanica*, *Solanum nigrum* and *Setaria palmifolia*.

(9) **Fruits and Nuts.** A germplasm collection of indigenous and introduced fruit and nut species is maintained in field collections at LAES Keravat. The list of species and the number of accessions maintained is shown in Appendix 5.

A small collection of 20 trees of *Canarium indicum* is held at LAES Keravat. A number of *Anacardium occidentale* introductions were made in the 1980s. Record showed that eight varieties were introduced from Bougainville and the other genetic materials are from LAES Keravat, comprising of 6 clones and 17 seedlings.

(10) **Spices, herbs and condiments.** A germplasm collection consisting of 15 species of herbs, spices and condiments is maintained at the LAES Keravat. The collection contains both indigenous and introduced materials. Species that have great potential for export are *Piper mystisticum* and *Vanilla planifolia*. The details of the collections are presented in Appendix 6.

(11) **Coffee.** A total of 70 accessions of *Coffea arabica* and *C. robusta* were introduced to PNG and are maintained in field collection and *in-vitro* storage at the Coffee Research Institute. Most plant materials were introduced from overseas in the form of micro-cuttings. When micropropagation fails the materials can be introduced as bare root seedlings or seeds. New materials introduced as micro-cuttings are multiplied in the tissue culture laboratory prior to field establishment and evaluation.

(12) **Cocoa.** Cocoa (*Theobroma cacao*) was introduced to PNG in the early 1900s. The initial planting material was 'Trinitario' which was introduced from Victoria, Cameron and Samoa. The 'Trinitario' germplasm was the only planting material used in the country until the release of the SG1 hybrid in 1982. Upper Amazonian clones and 'Amelonado' seeds were introduced during the1960s. Additional clones from various sources were introduced in 1981 from Kew Gardens, England.

The Cocoa and Coconut Research Institute (CCRI) maintains clones of cocoa which are components of its two hybrid releases. The clones are grouped into two, based on tree size. No organized conservation programme was undertaken by the Institute until 1994. Beginning 1995, introduction of germplasm from overseas have been intensified. The other thrust will be to collect samples from old 'Trinitario' trees growing in various parts of the country. It is assumed that surviving trees, derived from seedlings could be considered landraces, as they have shown adaptation to the growing conditions and biotic stresses in PNG.

(13) **Coconut.** Coconut is a multipurpose crop, providing copra for export, food, drink, combustible materials, raw materials for making baskets and mats, leaves for thatched roofs for

houses and trunks as posts for houses and fencing. The 1990 National Population Census revealed that over 200,000 families are involved in growing coconuts with more than half these families selling some of their crop.

Coconut is grown in all coastal and lowland inland areas of the country. There is genetic variability in the crop. The local tall varieties are diverse in their nut, petiole and frond colours, the quality of their flesh in terms of the oil content and the size of the nuts. Some ex-situ collections of local coconuts are held in Madang by CCRI.

(14) **Sugarcane.** Around 50 varieties of *S. officinarum* are being introduced annually to Ramu Sugar since 1979. The canes originated from Argentina, Australia, Brazil, Cuba, Fiji, India, Indonesia, Japan, Kenya, Mauritius, Mexico, Philippines, Reunion Islands, South Africa, USA including Hawaii and the West Indies. A total of 500 varieties are held in a museum, as a living collection, planted in small plots. All varieties introduced each year are added to the collection. The materials are not duplicated elsewhere in PNG. Other countries that produced the varieties, maintain their own collection of the clones. In most cases, the clones are held in more than one collection, because of exchange of material between various organizations and countries involved in sugarcane research.

Reliance on a single or few varieties can be risky. Such a problem was experienced in the mid-1980s where more than 90% of the estate was planted to one variety. The susceptibility of this variety to a newly discovered disease, the stunt disease, contributed to major losses in sugarcane production.

(15) **Oil palm**. Oil palm is an introduced germplasm, imported as a cash crop and is now grown by well over 8,000 smallholders and numerous village out-growers in Hoskins, Bialla, Higaturu, Alotau and Poliamba.

The Oil Palm Industry Cooperation (OPIC) through its research arm, the Oil Palm Research Association (OPRA) is currently involved in the maintenance, multiplication and distribution of oil palm genetic materials. The composition of the ex-situ collection is not known, but it would basically be a working collection. The original genetic materials were introduced from overseas gene-banks, which were then evaluated and selected for PNG conditions.

(16) **Tea, Rubber and Pyrethrum.** Tea was first introduced into the Garaina area of Morobe Province and then to the Waghi valley of Western Highlands Province, where it is now grown on commercial scale. Clonal materials and improved varieties were introduced by DAL in the past and tested at Kuk Research station, outside Mt. Hagen. The companies that are growing tea are also responsible for the maintenance of the genetic stock and the multiplication and distribution of seedlings or clonal materials to the growers.

The genetic stock of rubber was introduced to PNG from Malaysia. Some high yielding varieties of rubber were introduced to Cape Rodney and Vanapa areas of the Central Province and the Saramandi/Angoram area of East Sepik Province. Rubber is grown on estates as well as smallholder blocks. The plantations produce and maintain their own seedlings and clonal materials for planting, while the smallholder blocks obtain their planting materials from the DAL nursery blocks located at each rubber growing area.

Pyrethrum grows well at high altitude environments and in PNG it grows mostly in the Enga Province. The extract from the pyrethrum flower has the insecticidinal properties and is the product that is exported. The production of pyrethrum is mainly in the hands of small farmers, so they maintain their own genetic stock for planting.

3.3.2.2 Seed Storage

Seed crops such as rice, maize, peanuts, beans and vegetables are introduced germplasm. Small quantities of these crops are multiplied and seeds are stored under short-medium term storage conditions on various Research Stations

for distribution to small farmers on request. Seeds for distribution are maintained in air conditioned rooms, operating at 15-20 degrees centigrade while those for regeneration purposes are maintained under the normal household refrigeration conditions. The seed crops germplasm regeneration work is carried out by research stations responsible for these crops. The regeneration programme is carried out every year to ensure continuity of viable seeds. Only the "orthodox" seeds are maintained and stored under these conditions. Plants with "recalcitrant" seeds are maintained vegetatively in ex-situ collections or in their own natural habitats as for the case of the indigenous timber tree species.

3.3.2.3 *In Vitro* Storage

In-vitro conservation or maintaining plantlets in tissue culture is still at an embryonic stage in PNG. The Coffee Research Institute is maintaining some coffee genetic materials in *in-vitro* storage. Few genetic materials of sweet potato, taro and vanilla are being conserved in tissue culture at LAES, Keravat.

3.4 Conclusion

All crop germplasm of the country is maintained as living collections in field gene-banks or under in-*situ* conditions, on-farm or in their natural habitats. The crops maintained in *ex-situ* collections are: Banana, Yam, Cassava, Taro, Sweet potato and Aibika. Some indigenous fruits and nuts species plus some introduced germplasm are also maintained in ex-situ collections at LAES Keravat. A small collection of both indigenous and introduced spice crops are also maintained in *ex-situ* collections at Keravat.

The genetic diversity in indigenous forest tree species, ornamental and medicinal plants are still maintained in their natural habitats in the wild. There are areas in the country which are declared as nature reserves and three are officially recognised as national parks. The problem with land ownership in PNG has placed these areas in danger of human interventions. Some of the best forested areas have been declared as nature reserves.

The main commodity crops of PNG are handled by various commodity Boards and Institutions. These Research Institutes maintained the genetic materials of their own crops. Apart from coconut and few sugarcane germplasm, all other genetic materials for the main commodity crops have been introduced to the country many years ago. Genetic materials of these crops are maintained in museum blocks or in working collections at each Research Institute.

In-vitro conservation techniques is recently used in the country. The Coffee Research Institute is maintaining some coffee genetic materials in *in-vitro* storage. Some genetic materials of sweet potato, taro and vanila are being conserved in tissue culture at LAES, Keravat.

Seeds of introduced varieties of beans, coarse grains and vegetables are maintained in short-medium term storages in deep freezers or in common household refrigerators at DAL Research stations.

4. USES OF PLANT GENETIC RESOURCES IN THE COUNTRY

4.1 Use of Forest Genetic Resources

People in rural areas of the country depend entirely on forests for their basic needs. A villager builds his house from the materials he collects from the forest and hunts and gathers bulk of his daily food requirement from the same source. The forest also supplies continuous fuel wood for cooking and warmth.

Papua New Guinea has a rich tradition and the way this tradition is preserved was through arts and crafts. Stories and legends are passed down from generation to generation in carved woods and drawings on woods, rock surfaces and tree barks. The people of the Sepik river are famous for their artifacts. Each carved mask tells a story and it is passed down to new generation in that form. The traditional lifestyle

is very simple but governed by strict rules and regulations. People learn to live with the nature and use the forest resources wisely and in the best way they know of.

Leaves, barks and saps of certain forest trees, shrubs and vines are used individually or in combination as medicine for sores, sickness and diseases. People in the remote areas of the country with no access to health facilities live entirely on these medicinal plants. The Health Department has recognised the values of these medicinal plants and has identified some prominent traditional healers, who are now working side by side with health workers throughout the country.

4.2 Use of Plant Genetic Resource Sources Collections

The utilization of plant genetic resources maintained in the genebanks of PNG is limited to certain species within staple crops, vegetables, and commodity crops. Although many more species are maintained in the genebanks and countless other useful ones can be found in traditional gardens and in their natural forest habitat, the degree by which the germplasm is put to use is dictated by the existence, and to some extent the sophistication of crop improvement programmes that are in place in the country. Also determining the usage of the material is the importance of the species in the nation's economy. It is therefore to be expected that germplasm of the major food and export crops should receive the most attention and would be subjected to greater utilization.

The national breeding programmes for staple crops and vegetables are concerned primarily with the selection of local varieties for wider adoption of farmers in the country. Improvement of the local varieties is not yet an option at the present time, but perhaps will become more important in the future with the growing maturity and sophistication of the crop improvement programmes for these crops.

For commodity crops, specifically coffee, cocoa and sugarcane, the main objective is to adapt imported germplasm to local needs and to select for materials with resistance to pests and diseases prevalent in the country. However, in coconut, selection of local varieties for wider adoption is still the primary option.

4.2.1 Staple Crops

Sweet potato. The accessions of sweet potato maintained in the genebanks were put through preliminary evaluation for their yield performance, reaction to pests and diseases, and consumer acceptability. Some 136 promising accessions were selected and duplicated at Lowlands Agriculture Experimental Station, Keravat. In addition, 19 of the most promising accessions maintained at the Highlands Agricultural Experiment Station are being evaluated at LAES in Keravat.

Taro. Based on the results of the preliminary evaluation of the 437 accessions maintained at the field gene-bank in Bubia Agricultural Research Centre, 30 promising accessions have been selected and are being further tested for their yield potential and eating quality. The collection has also been evaluated for reaction to several pests and diseases prevalent in the Pacific region, most notably taro blight and viruses.

Yam. Out of the 315 accessions characterized and evaluated, 20 accessions of *D. esculenta* and *D. alata* were selected on the basis of their eating quality and yield, and have been put through a varietal assessment trial in several locations.

Banana. Based on the results of the preliminary evaluation of 181 accessions of edible bananas, 10 promising accessions were selected and tested further for their yield potential.

4.2.2 Vegetables

Aibika. Of the 112 accessions evaluated for their yield potential, nutritive components and reaction to common pests and diseases, 12 promising accessions were selected and

evaluated further in variety assessment trials.

4.2.3 Commodity Crops

Coffee. The accessions are used in the varietal improvement programme of the Coffee Research Institute, where hybridization of elite varieties is performed to improve disease resistance and adaptation to different ecotypes whilst maintaining productivity and quality.

Cocoa. A breeding programme was undertaken initially by Lowlands Agricultural Experiment Station, later by the Cocoa and Coconut Research Institute. Initially, clones were selected within the 'Trinitario' germplasm, leading to the selection of 40 clones. Later, polycross hybrids were developed from crosses between 'Trinitario' and upper Amazonian clones. Two hybrids were released as a result, namely SG1 and SG2. Presently, the cocoa breeding programme is concentrating on the development of 'Trinitario' x Amazonian derived polyclonal varieties.

Sugarcane. Commercial hybrids have been introduced annually since 1979 to broaden the selection base and with the ultimate aim of widening and improving commercial variety spectrum for exploitation. More than 50% of imported varieties were discarded due to poor agronomic qualities and problems with pests and diseases. It was for this reason that a breeding programme was undertaken in 1992. The materials used in this work are mainly proven commercial canes used for sugar production else where. Breeding programmes elsewhere also use commercial hybrids, and only the advanced programmes with available resources have the capacity to search for useful traits in the wild or primitive forms of sugarcane, and to attempt to transfer these characters to commercial hybrids. The breeding programme at Ramu does not envi-sage using the available genetic material in PNG for its current breeding programme but could consider this in the future.

4.2.4 Spices, Fruits and Nuts, Condiments and other Crops

Balsa. Experiments to determine the suitability of growing balsa (*Ochroma lagopus*, *O. pyramidalis*) in plantation for the production of wood for export is being undertaken at the Lowlands Agricultural Experiment Station.

Cashew nut. Varietal evaluation of six clones and 17 seedlings of cashew *(Anacardium occidentale*) is presently underway at the Lowlands Agricultural Experiment Station to select genotypes for yield under different environments and management practices.

Japanese mint. Research on identification of superior genotypes of Japanese mint *(Mentha arvensis*) has been undertaken since 1969, and four clones have been identified with superior yields. The clones will be further tested for performance under different environments in PNG.

Kava. Five varieties of kava (*Piper mystisticum*) are presently being evaluated for their performance, and to determine if it could be exported for use in the pharmaceutical industry.

Nutmeg. Germplasm introduction and genotype evaluation on nutmeg *(Myristica fragrans*) has been undergoing and superior nut yielding trees have now been identified.

Vanilla. Research has been carried out to determine the suitability of growing vanilla (*Vanilla planifolia*) as a plantation crop for export. A large block of *V. planifolia* and *V. tahitensis* has been planted in the Lowlands Agricultural Experiment Station for the production of planting materials to be distributed to farmers.

4.3 Benefits derived from the uses of Genetic Resources

The livelihood of the rural people of PNG depends entirely on these plant resources. The forest resources provide all their shelter needs as well as food, clothing and medicine. The kind of benefits the rural people get from these resources can never be measured nor attached

to any monetary values.

The benefits derived from the timber exports is of significant importance to the country and its people. In 1991 the country exported about 4.8 thousand tonne of timber logs, lumbers and woodchips which brought in K69 million in export earnings.

The country has a rich diversity in ornamental plant species especially the orchids, palms and the ferns which are still preserved in their natural habitats in the forests. Some of the exotic species of orchids in the world are found in PNG. Tourists throughout the world visit PNG just to see in reality these exotic orchids and other beautiful flora of the country. Lately, with the help of the PNG Tourist Promotion Authority, tourism activities in the country are expanding rapidly which is of great benefit to the country and its people.

The diversity in taro germplasm has enabled the taro scientists to screen and select genetic materials that are resistant to taro disease complex which will be used in the taro breeding and improvement programme. Taro is the second most important staple root crop in the country and the most important root crop in the South Pacific Region. This crop will develop in a big way in future when the avenues for export markets overseas are explored. The small farmers will benefit directly once the export markets are secured.

The use of sugarcane germplasm "The Noble Canes of New Guinea" in the early days, helped to develop the sugarcane industry of Australia, from which PNG is now tapping on for improved and elite cultivars and breeding lines for the sugarcane breeding programme at Ramu Sugar.

Papua New Guinea artifacts and handcrafts are some of the most renowned in the world. These artifacts and handcrafts have brought in many tourists and visitors to the country. The traditional carvers and artists use the most valuable timber tree species of ebony, rosewood, walnut and the Incia spp. for their artifacts and crafts. The monetary benefits are very good for individual carvers and artists.

4.4 Improving Plant Genetic Resources Utilization

Food crop farmers grow their own cultivars or landraces which they have selected over the years for certain traits. The most important character the subsistence farmer looks for in selecting suitable landraces or cultivars is "taste". Important agronomic characters such as high yielding, pest and disease resistance, early maturity and so forth are of secondary importance to a subsistence farmer. Good tasting cultivars or landraces of staple food crops are often distributed by farmers themselves.

The main varieties of all food crops grown in the country are farmer selected landraces or cultivars. The Breeding programme executed by DAL, Research Division is limited only to few crops at the moment. The Research Division through its Research Stations located throughout the country are responsible for the multiplication and distribution of planting materials of selected food crops to the farmers. The crop improvement programme at the moment is aiming at selection of superior landraces or farmer cultivars suitable for growing under adverse climatic conditions and with good eating qualities.

There is the need to expand on the Breeding Programme for yield improvement and pest and disease resistance for other staple food crops like sweet potato, yam, cassava, banana and aibika. Pests and diseases contribute significant yield reduction in these crops.

For the commodity crops, each Research Institute need to work closely with other international institutions or organisations for the exchange of improved genetic materials.

The Forestry Department has a good re-afforestation programme which is being implemented by the logging companies in areas where timber is being logged. The timber germplasm used in this programme are mostly introduced species which are not as valuable as the

indigenous species that were logged out off the area. The re-afforestation programme in future should aim at promoting the indigenous forest tree species to be planted in place of the ones logged out. The approach taken by the NGO group, the Kandrian Glouster Integrated Development Project (KGIDP) is very appropriate and should be adopted by the Forestry Department's re-afforestation programme in the future.

5. NATIONAL GOALS, POLICIES, PROGRAMMES AND LEGISLATION

5.1 National Programmes

5.1.1 Government Policy on Sustainable Agricultural Development and Plant Genetic Resources

At the 1992 Earth Summit, in Rio de Janeiro, the countries of the North and South accepted a series of challenges crucial to the management of the earth's natural resources. These challenges were defined by AGENDA-21, a comprehensive programme for sustainable development addressing issues vital to the sound management of the worlds environmental wealth. Papua New Guinea's participation at the Summit is recognised globally. The formation of the National Sustainable Development Strategy (NSDS) and its endorsement by the National Executive Council (NEC) of the PNG Government is a direct outcome to activate AGENDA-21 in PNG.

PNG's rapid annual population growth rate of 2.5% demands national attention to food security and other basic needs. Agriculture must become more productive and more sustainable environmentally, economically and socially to meet this growing need. Appropriate policies on sustainable agricultural development at all levels of government (national, provincial an district) are crucial. All development activities need to be sustainable and viable over the long term - sustaining people while not degrading the environment.

The PNG Government's policy implications on sustainable agricultural development as reported in the White Paper on Agriculture (1989) are as follows:

*The Government shall encourage agricultural practices that increase productivity and are environmentally, socially and economically sustainable.

*The Government shall ensure that careful analysis and consideration of all facets of development, whether environmental, economical or social are effectively carried out prior to the implementation of development activities

*The Government shall ensure that development activities are sustainable by designing and implementing activities that meet local needs and participation.

*The Government shall ensure the transformation of smallholder subsistence farming systems to site-specific semi-commercial systems by taking agro-ecological perspective through farming systems development.

The preservation of natural resources and the environment is essential to the future economic and social health of the nation. This is explicitly acknowledged in the fourth objective of the national constitution which states that "PNG's natural resources be conserved and used for all, and to be replenished for the benefit of future generations." Agricultural development should not be the cause of environmental degradation. Sustainable agricultural development would need to be promoted with close monitoring and assessment of environmental impact.

The Government's policy implications on the development and conservation of natural resources and the environment are as follows:

* The Government shall facilitate the assessment of environmental and social impact of agricultural development projects.

* The Government shall promote agricultural practices that are sustainable and environmently sound.

* The Government shall promote conservation, assessment and effective use of genetic diversity of plant and animal species to help maintain and improve agricultural environment.

* The Government shall promote research on development of methods, including biological control, that will reduce the impact of agricultural pests, diseases and weeds.

* The Government shall facilitate the development of institutional capacity to undertake regulatory, monitoring and testing of agro-chemicals and agricultural outputs.

* The Government shall encourage involvement of local people in all aspects of agricultural development and implementation of agricultural projects.

Apart from the general Government policy on Sustainable Agricultural Development and the Preservation of Natural Resources and Environment, there is also a policy in place to protect the native flora and fauna, from being taken out of the country illegally. The Department of Environment and Conservation and Department of Agriculture and Livestock are the implementing agencies in the country for issuing Wildlife Export Permits, Sites Certificates and the Phytosanitary Certificates.

There is no formal documented conservation strategy on Crop Genetic Resources (CGR) as yet. Plans are underway to develop a conservation strategy for the country. The indigenous crop genetic resources of the country are currently being maintained by DAL under the Research Programme of Resource Management with limited internal funding. The DEC has a fomulated strategy on Biodiversity conservation through their programmes on National Parks and Nature Reserves.

The Department of Forests (DOF) also has its strategy on the conservation of the forest tree species of PNG which is executed by the Forest Research Institute (FRI) in Lae. Their main conservation activity is through the Re-afforestation programmes.

5.1.2 Private Companies and Non-Government Organisations Programmes and Policies on Plant Genetic Resources

Any private company utilizing or involved in the use of Forest Resources of the country is governed by the Forestry Act and the Environment and Conservation policy of the country. Their programmes and company polices have to fit into the overall country policy on Forest Resources. There are cases where country polices are not adhered to, like in the case of poor re-afforestation programme in some timber logging areas in the country. These problems will continue and will be amplified in future if nothing is done about them now.

The Non-Government Organisations (NGOs) in the country work with or through the Government departments and the statutory bodies and therefore abide by the policies in place.

The individual farmers in PNG own approximately 97% of the land in the country. In other words they are the owners of any plant genetic resources that are housed on these lands. The fact that most land in PNG is owned by customary landowners, poses a different set of challenges to achieving conservation, to those faced in other developing countries, where conservation areas can be established on alienated land. The conservation focused activities in PNG must adapt to these systems if there is to be any chance for safeguarding PNG's biodiversity endowment in the long term. In other words stable conservation is unlikely to be achieved in PNG, unless landowners perceive that biodiversity conservation is of benefit to them.

5.2 Training

Well over 20 national technical officers underwent some training courses in PGR, especially in areas of Germplasm Collection, Evaluation, Documentation and Conservation. These are mostly short duration courses and were organised by IPGRI in the South East Asian region. One national scientific personnel did a

masters degree in the United Kingdom on Conservation and Utilization of plant genetic resources.

However, at present the number of personnel trained in PGR is inadequate, especially for a country like PNG that has rich diversity in its plant germplasm. There is a definite and urgent need to train more national officers in all the fields of PGR. An awareness programme on conservation of these resources is important and needs to be widely encouraged.

One of the main constraints affecting PGR activities in the country is the lack of formulated strategy or guidelines on PGR conservation. There are Government policies on sustainable agricultural development and preservation of natural environment and resources, but these policies need to be formulated into workable strategies that can be implemented and supported by sufficient Government funding. Lack of adequate internal funding has adversely affected PGR conservation activities in the country, particularly the conservation of the traditional food crop resources. Insufficient technical manpower engaging in PGR activities at present, is another constraint. There is therefore an urgent need to train more technical personnels at various levels of profession (technicians, diplomates, bachelors, masters to doctorates). The high staff turnover is a serious problem in retaining qualified staff in their positions.

Personnel may be sent away for technical training but when they return are either given promotion to higher posts, moved to another jobs or moved into administrative posts. These amount to loss of expertise in the area of germplasm resources.

5.3 National Legislation

There is no formal policy in place on exchange of PGR materials. Arrangements are made informally for the exchange of PGR materials for research purposes between various research institutions in the country and abroad. Papua New Guinea has contributed its banana genetic materials to the international Banana Improvement Programme in Montpellier. A good number of landraces or farmer cultivars of sweet potatoes from PNG are being used in the crop improvement programme under the Pacific Regional Agricultural Programme (PRAP) these are then made available to the other Pacific Island countries. There are no written policies on the exchange or distribution of PGR materials to other countries. To safe guard the invaluable genetic resources from being commercially exploited there is an urgent need to have this policy in place, so as to screen materials properly before they are sent out.

The law that governs the protection of flora in the country does not allow any plant materials collected from the bush to be taken out of the country. The living plant materials have to be seed raised or grown in cultivation for second generation before they can be taken out.

The food crop farmers in the country are mostly subsistence farmers, growing their own landraces or cultivars for their consumption and the surplus is sold in the local markets for a bit of cash. There are no direct government incentives to the subsistence farmers for conservation of traditional cultivars of food crops. The Research Division of DAL has collected and assembled a diversity of crop species in ex-situ collections located at various research stations in the country.

Almost all the staple food crops of PNG are vegetatively propagated. Farmers maintain their own planting materials in old garden sites until the new gardens are made. Sufficient quality planting materials of food crops are multiplied and distributed by DAL on request to farmers at a minimal price. A large quantity of planting materials are exchanged between the farmers themselves.

There is no legislation that governs the sale of planting materials of farmer cultivars or landraces in PNG. Furthermore, the country does not have the Intellectual Property Rights (IPR) legislation. The DAL assists the farmers in multiplying sufficient quality planting materials for distribution

on request. Together with the Department of Environment and Conservation (DEC) the DAL also tries to see that the raw genetic materials of the country are not taken out illegally.

5.4 Other Policies

Agricultural commodity prices are much more volatile than are the prices of most non-farm goods and services. Having appropriate pricing policy in PNG is critical because agriculture contributes a third of the GDP. The government has played significant role in creating stability in agricultural production by sustaining farm incomes through direct and indirect price support schemes. The most direct price support policy are the commodity stabilisation funds which have been depleted due to persistent low international commodity prices. The government has guaranteed bank loans to boost the depleted stabilisation funds and has kept farm prices to reasonable levels. The government policy in the long term is to seek indirect farm price support strategies to make the agricultural sector more efficient and self-sufficient and to replace price subsidies with capital subsidy in the form of infrastructural development.

The rich genetic diversity in traditional food crops of PNG has not yet been tapped for commercial production. The staple root crops (sweet potato, taro, yam and cassava) are abundantly grown in rural areas, but very little is being sold in the urban markets at the moment because of transport difficulties and inaccessibility of the production sites to the urban markets. The government policy on Nutrition should actively carry out the educational awareness programme on consumption of locally grown food crops. Liberal Agricultural credit should be provided to the farmers to grow more crop varieties for local consumption as well as for export.

6. INTERNATIONAL COLLABORATION

6.1 United Nations Initiatives

6.1.1 UNCED and the convention on Biological Diversity

It is through the international collaborations that PNG was commissioned by the United Nations Environment Programme (UNEP) to carry out a study in examining the status of PNG's Biodiversity endowment, particularly the current threats to the *in-situ* preservation of biodiversity international Working Group of Legal and Technical Experts on Biological Diversity was formed and in the 1992 Rio De Janeiro conference, PNG with other 153 countries signed the Convention on Biological Diversity.

The PNG Government through the Department of Environment and Conservation (DEC) with assistance from the Africa Centre for Resources and Environment (ACRE) has put out a book on the Conservation of Biological Diversity in PNG as a follow-up on the signing of the Agenda 21 of the Convention on Biological Diversity. Chapter 14 of this book gives an account of the biodiversity and conservation of the native flora of PNG (Sekhran & Miller 1995).

6.1.2 FAO Global system

Papua New Guinea has not yet signed the Undertaking of the FAO Commission and therefore is not a member of the Commission at the moment.

In the programme level the country is effectively collaborating with FAO through the Regional office of the International Plant Genetic Resources Institute (IPGRI) based in Singapore, on all aspects of plant genetic resources. Direct funds are also made available through the United Nations Development Programme (UNDP) for Non-Government Organisation (NGO) activities in the country.

6.2 International Agricultural Research Centres

6.2.1 CGIAR

Papua New Guinea through DAL has in the past collaborated with CIMMYT, AVRDC and ICRISAT in the introduction of genetic materials of vegetables, coarse grains and food legumes from their gene-banks for research purposes. A number of national research officers have also been trained in technical aspects of crop evaluation and production.

Continuous collaboration is existing between PNG and other CGIAR Centres or Institutes such as IRRI, IITA, INIBAP, ISNAR and IPGRI. Papua New Guinea has greatly benefited from these collaborations in terms of technical manpower training, PGR project funding, exchange of useful and relevant scientific information and access to other international gene-banks for genetic materials for research purposes. International contacts were established between various levels of professionals with the interest in working together to improve the productivity of agriculture throughout the world particularly in developing countries in ways that will enhance nutrition and well-being of the low-income earners.

6.2.2 The International Plant Genetic Resources Institute

The International Plant Genetic Resources Institute (IPGRI) formerly known as the International Board for Plant Genetic Resources (IBPGR), has in the past sponsored number of the major germplasm collecting expeditions in PNG. The country joined the then IBPGR South East Asian Regional programme in the late seventies. Papua New Guinea has a representation on the IBPGR Regional Committee for South East Asia (RECSEA), now known as the Regional Cooperation in South East Asia on Plant Genetic Resources (RECSEA - PGR). Through financial and technical assistance from IPGRI and the other RECSEA member countries, PNG was able to collect and assemble the genetic diversity in traditional food crops throughout the country into *ex-situ* collections. The national PGR collections for the traditional food crops are currently being held at Laloki Agricultural Research Station, outside Port Moresby, with working collections located on other research stations throughout the country.

The IPGRI and DAL co-sponsored two collecting trips on sweet potato and one on traditional food crops, particularly the green leafy vegetables of the country. The Japanese Government and IPGRI co-sponsored two collecting trips in PNG, again collecting traditional food crops, with special interest in taro and yams. Three major banana collecting expeditions were sponsored by IPGRI with technical assistance from Queensland Department of Primary Industry (DPI) and DAL. The main purpose of collecting banana germplasm was to capture and identify genetic materials that have natural resistance against the sigatoka disease complex and those that are showing tolerance to the disease. These collected banana germplasm are being held in *in-vitro* condition at Maroochy Research Station, Nambour, Queensland and the duplicates are at the national collection at Laloki, outside Port Moresby. A small collection of this germplasm showing some tolerance to the sigatoka complex are held by INIBAP at Montpellier, for the crop improvement programme.

More than twenty research personnel from PNG were sponsored by IPGRI on training courses on plant genetic resources. Most of these courses were conducted in member countries within the region. IPGRI also sponsored a research officer to undertake a masters degree programme at Birmingham University, United Kingdom.

An 'internship' arrangement was made by DAL some years ago with IPGRI funding for an experienced PGR scientist who was responsible for the characterization and documentation of the national sweet potato germplasm collection. Last year IPGRI sponsored a banana expert from Queensland DPI to PNG to assist in the identification, characterization and documentation of the banana germplasm, held in the national collection.

Some financial assistance was received from IPGRI for the maintenance of seed crops germplasm and for the improvement of *in-vitro* storage facilities.

6.2.3 Regional Research Centres

Papua New Guinea is collaborating with a number of regional research centres namely; AVRDC in Taiwan, IITA in Nigeria, IRRI in the Philippines, ICRISAT in India, IPGRI Head Office in Rome and the Regional Office in Singapore, CIMMYT in Mexico, the International Network for the Improvement of Banana and Plantain (INIBAP) in Montpellier, France and the International Service for National Agricultural Research (ISNAR) in the Hague, Netherlands.

A number of PNG research officers received technical training on crop improvement and production at AVRDC. Some high yielding experimental lines of tomato and mungbean from the AVRDC programme were introduced to Laloki and Bubia research stations some years ago for performance testing under PNG conditions.

The Research Division of DAL is collaborating with IITA on promising genetic materials of African yams (*Dioscorea rotundata*). A total of ten accessions of *rotundata* were introduced into the East Sepik collection, where they were evaluated and selected for their eating qualities for the local population. Seeds of some promising accessions of cassava with low cyanide (HCN) contents from PNG were sent to IITA for utilization in their breeding programme.

The DA L is working closely with IRRI on testing some of their rice breeding lines under PNG conditions. Number of research officers have also attended short courses on all aspects of rice cultivation and production.

Some collaborative research work on maize was carried out in the past with the Research Division of DAL and CIMMYT and ICRISAT on peanuts and pigeon pea. Both their breeding lines and improved varieties were sent for performance testing under PNG conditions.

Some promising landraces or farmer cultivars of bananas from PNG are held in *in-vitro* storage at INIBAP for crop improvement programme on sigatoka disease resistance. Part of this collection is being maintained at Maroochy Research Station, Nambour. Through this collaboration, the curator of the PNG national banana collection is up-dating the collection documentation on the MUSAID documentation format.

The International Services for National Agriculture Research has been in close collaboration with DAL on re-organisation of research structures and programmes. They were also involved in training of research managers and administrators.

Papua New Guinea, through DAL is working in close collaboration with IPGRI through its Asia-Pacific-Oceania (APO) regional office in Singapore on all aspects of plant genetic resources. Manpower training in PGR has been one of the main benefits to PNG in this collaboration. IPGRI has in the past sponsored and funded number of collecting missions to the country. The current national field gene-bank collections in the country were initially established from these funding. Through this linkage PNG genetic materials (sweet potato and banana) are now being held in international gene-banks and are made available to other gene-banks for crop improvement purposes.

6.3 Non-Government Organisations

There are about eight Non-Government Organisations (NGOs) operating in the country that are involved in agricultural activities. These include the British based Voluntary Services Overseas (VSO), the Australian Volunteers Abroad (AVA), the Japanese International Cooperation Agency (JICA), the Canadian Universities Service Organisation (CUSO), the PEACE CORP of America, the German Development Services (GDS), and the United Nations Development Programme (UNDP). Most of these volunteers are working in small towns and in rural areas on basic agriculture but not specifically on genetic resources.

The Kandrian Glouster Integrated Development Project (KGIDP) was formed two years ago in Kimbe, West New Britain with financial assistance from the Australian Aid (AusAID). The KGIDP is basically involving the local landowners in the timber logging areas of the province to go into replanting of indigenous forest tree species in places of the ones being logged out. The landowners are collecting seedlings of the indigenous timber tree species in the area and are planting them in the areas where logging has taken place. This project is the first of its kind in the country. The Forest Department is carrying out the re-afforestation programme but mostly with the introduced timber species.

6.3.1 Internationals

Papua New Guinea is collaborating with the World Wild-Life Fund (WWF) through the Department of Environment and Conservation (DEC) on number of projects in the country. The integrated conservation development project being carried out in the Kikori river basin of the Gulf province is looking at the conservation of biodiversity in the Kikori river basin. Another projects involve the study on conservation in the Lasanga area of Morobe Province and the awareness programme on literacy and conservation in the East Sepik Province which is being executed by the East Sepik Council of Women (ESCW).

The Global Environment Facility under the United Nations Development Programme (UNDP) is working closely with DEC in another integrated conservation development project on sustainable forest in the Lak area of southern New Ireland. The Department of Environment and Conservation is collaborating with the Wild-life Conservation Society (WCS) in a research project involving the wild-life management area of Crater mountains between the borders of Eastern Highlands, Simbu and Gulf Provinces.

In 1991 the Government of PNG requested the United States Agency for International Development (USAID) to provide technical assistance to DEC under the National Forestry and Conservation Action Plan. This assistance was in the form of a Conservation Needs Assessment (Swartzendruber 1993) study implemented by the Biodiversity Support Programme, a USAID funded consortium of the WWF.

6.4 Regional Inter-Governmental Initiatives

Papua New Guinea joined the IBPGR South East Asian Regional Programme on Plant Genetic Resources, two years after its inception in 1976. The country membership in the region at that time included; Indonesia, Malaysia, Philippines, Thailand and Papua New Guinea. The membership has now extended to Vietnam, Myanmar, Cambodia and Laos.

Since 1992 the member countries decided to finance their own representation at the biannual RECSEA meetings and in 1993 the committee was renamed RECSEA - PGR.

The main objective of this initiative is to promote and enhance the conservation and management of the region's rich and diverse plant genetic resources through collaborative activities that are of benefit to member countries. These initiatives enable the member countries to exchange useful genetic materials and information on PGR utilization for the well-being of the people in the region. Through these initiatives the member countries believe that the sovereign rights and responsibility for indigenous plant genetic resources in-situ and the prior informal consent for the exchange of plant genetic resources will be adhered to. This collaboration will result in a more effective use of available resources in the region.

Under the IBPGR umbrella, number of regional collections on plant genetic resources were established. The regional collection of banana was established at Davao, Philippines. Well over 100 accessions of PNG bananas are maintained in the regional gene-bank in Davao.

Through this collaborative network over 20 research personnel from PNG have received training in PGR from various training centres in the region under IPGRI funding. Number of

experienced PGR scientists from the region have also come to the country and helped the national research officers with their PGR activities.

The most beneficial effect of this collaboration is the linkage or bringing together of PGR personnel in the region who are cohesive in their approach of ensuring that the genetic wealth of the region is effectively utilized for the well-being of the people of the region.

Papua New Guinea is also collaborating in the Pacific Regional Agriculture Programme (PRAP) on sweet potato. The project funded the maintenance of field gene-bank collection which holds over 1,000 accessions at the DAL Lowlands Agriculture Experimental Station, Keravat. The project scientists evaluate and select superior or promising accessions which are sent to the tissue culture laboratory in Western Samoa where they are cleaned free of diseases before distribution to other interest countries in the Pacific region.

6.5 Bilateral Inter-Governmental Initiatives

There are no formal or written agreements in place on Bilateral Inter-Government Initiatives on plant genetic resources. Individual Government Departments, Research Institutes and NGOs involving in the PGR of the country are individually liaising with other international PGR organisations and centres for exchange of useful genetic materials and PGR information.

The most effective Bilateral Initiative is between the research organisations or institutes in the country and abroad. The commodity Research Institutes in PNG are in close collaboration with their sister Institutes internationally for superior genetic materials for their crop improvement programmes.

The DAL through its research stations have in the past introduced number of experimental lines of food legumes (pulses), coarse grain crops (sorghum and maize), rice and introduced vegetables from various gene-banks throughout the world. The food legumes were introduced from CSIRO gene-bank in Brisbane, ICRISAT in India, and the peanut genetic materials from DPI Kingaroy in Queensland, Australia. The genetic materials of coarse grain crops were introduced from DPI Queensland and CIMMYT in Mexico. Some bilateral initiatives were undertaken by the DAL research station, Bubia and IRRI in the Philippines for the genetic materials of rice. Improved breeding lines of rice bred for Asian conditions were introduced to PNG for performance testing.

Over 20 accessions of sweet potatoes from the highlands collection at Aiyura were sent to the international base collection at the Asian Vegetable Research and Development Centre (AVRDC) in Taiwan. These accessions are maintained as seeds in long-term storage conditions.

Technical training in various aspects of PGR activities were made possible through these bilateral initiatives. Number of PNG participants undertook training courses in vegetable improvement and production programmes at AVRDC and maize evaluation and selection programme at CIMMYT. Papua New Guinea has also benefitted from on-the-job attachment training programmes organised through these bilateral initiatives.

The PNG Botanical Gardens do collaborate with international organisations and Botanical Gardens for the exchange of plants and orchid materials which benefits both parties in research and development. The Canberra Botanical Gardens is in collaboration with PNG in setting up a major research and identification project on certain families of orchids in PNG. The PNG Botanical Gardens is working closely with the Singapore Botanical Gardens in the area of technical manpower training.

7 NATIONAL NEEDS AND OPPORTUNITIES

7.1 Background

Papua New Guinea is one of the few countries in the world that still has a good portion of its

forested areas that have not been exposed to human interventions. These untouched areas serve as rich store houses for diversity of species of flora and fauna, some of which are unique to this part of the world.

As a young emerging country, PNG has to develop to advance and with it comes urbanization and development of infrastructure which contributes to the destruction of the natural environment. Foreign investiments in the logging and mining industries have increased drastically in the last fifteen years. These interventions have caused serious disruptions and damages to the environment.

Genetic erosion is already taking effect on the country's food crop diversity due to the processes of social and economic changes that are taking place. Increased population and the quest for monetary gains has seen the gradual encroachment of the forest, the natural habitat of many of these food plants with planting of plantation crops such as coconut, cacao, coffee and oil palm. This has been further exasperated in recent times with increase lumbering and mining operations by large foreign investors. The genetic diversity of the wild progenitors of the food plants in the country are therefore eroding rapidly.

The loss of biological diversity through "global warming" is of great concern throughout the world, especially among the biological scientists. The geographical distribution of different ecosystems and their structure are likely to be altered as temperature and rainfall patterns change as a result of global warming, thus affecting the evolutionary process of the biological diversity (Jackson, *et al.* 1990).

The established crop areas are also threatened with genetic erosion. The change from traditional shifting cultivation towards more semi and intensive farming has caused decline in soil fertility. The build up of pest and diseases has already seen the demise of taro as an important staple in some parts of the country. The increase cash cropping and corresponding decrease in time devoted to food gardens, means that only the most adaptive and productive crops such as sweet potato, taro kongkong and some high yielding varieties of staple food crops are grown. The break down in traditional culture due to western influence has also caused a decline in the use of crops such as taro and yam for ceremonial purposes in some areas and increased preferences for imported food stuffs such as rice and tinned fish in urban areas. This results in the narrowing of genetic variability of the traditional food crops.

7.2 Needs and Opportunities to Safe Guard the Countries Rich Diversity of Plant Resources

7.2.1 Forest Resources

- Forestry Act is currently in place; There is a need to effectively strengthen and implement the Act and closely monitor the forest activities undertaken in the country.

- Re-afforestation Programme; The programme was developed some years ago, but as said earlier, is not being effectively implemented. The Department of Forests (DOF) is currently working on the programme and hopefully it will come into effect by the end of this year. There is an urgent need to monitor the activities of the logging companies and get them to effectively implement the re-afforestation programme once it is enforced.

- The old re-afforestation strategy of planting five timber tree seedlings in place of one tree taken out, needs to be further emphasised in the new programme and closely monitored to ensure that it is effectively executed by all involved in the logging activities.

- The strategy on re-afforestation should place emphasis on effective planting of indigenous forest tree species rather than introduced species only.

- There is a need for research on Seed Technology of forest tree species. Most of the indigenous species of forest trees have "recalcitrant seeds" and can not be easily germinated under

normal conditions.

- There is an urgent need to develop a conservation strategy on other economically important and beneficial forest plant resources such as ratans, bamboos and wild palms which are traditionally used as materials for building houses.

- The DOF through their extension programme and some timber companies, has set up 52,000 ha of planted forest throughout the country. The species planted are all introduced types. At this stage, the planted forest programme or setting up of forest museum blocks should focus on planting of indigenous forest species rather than the introduced species. There is an urgent need to establish museum blocks or ex-situ collections of all indigenous timber tree species before this germplasm is completely lost through heavy logging activities that are currently taking place throughout the country.

- The Department of Environment and Conservation (DEC), needs to develop a clear and implementable strategy on the conservation, maintenance and management of National Parks and Nature Reserves in the country. These parks and reserves should be owned and controlled by the state and not by the landowners. It is very important to ensure that these areas are kept free of human interventions to allow the species biodiversity to continue their genetic evolutionary process. The in-situ conservation through the natural parks and nature reserves, is the ideal model for long-term conservation of forest trees as they are considered as communities in balance within a stable environment.

7.2.2 Genetic Resources of Food Crops

- The greatest and the most urgent need at the moment is to develop a clear national policy on conservation of Plant Genetic Resources of the country. When the policy is in place it has to be supported with sufficient resources in terms of funding and technical manpower.

- The Department of Agriculture and Livestock (DAL) has to develop a workable strategy on all aspects of PGR in the country. This strategy has to be fully supported with sufficient funding and full-time personnels to implement the PGR programmes.

- There is a need for DAL to interact more with other Departments, Institutions and Organisations in the country which are also involved in PGR activities.

- Need to set-up a National Committee on Crop Genetic Resources (NCCGR), which will oversee all activities of crop resources undertaken by various organisations in the country. DAL is the lead agency involved in the crop resources of the country and therefore should have more members in the national committee.

- An urgent need to conserve the farmer's useful varieties or landraces before they are lost through farmer's biased selections to meet the urban market demands. Need to collect as much as possible the farmer varieties and landraces and assemble them in ex-situ field collections.

- As a lead agency involving in the crop resources of the country, DAL needs to take an active role in the conservation of these resources. Full-time personnel should be appointed to look after the current ex-situ field collections maintained at various research stations in the country. Sufficient funding be made available to maintain these collections.

- These ex-situ collections need to be fully characterized, evaluated and information documented in the form that can be easily accessible nationally or internationally.

- The immediate urgent need is to prevent further loses to the germplasm in the current field collections. The DAL through the Agricultural Research Division, is desperately in need of funds to maintain the six major national field gene-banks held at Laloki and Bubia. The genetic erosion taking place in these collections is exceptionally high due to lack of funds to maintain the collections, as said earlier.

- Alternative methods of conserving crop

genetic resources need to be investigated for vegetatively propagated crops. Field gene-banks are in danger of pest and disease outbreaks and the natural disasters such as volcanic eruptions, flood, drought and fire. There is a need to go into in-vitro conservation as duplicate collections to the main ex-situ collections in the fields.

7.2.3 Genetic Resources of Ornamental Plants

- There is a government policy in place protecting orchids from being taken out illegally. The same policy should be extended to include all ornamental plants of PNG, such as the ferns, palms, wild flowers and shrubs. There is a need to closely monitor all live plants from PNG that are going out of the country.

- The Botanical Gardens are the only ex-situ sites where these ornamental plants are conserved and therefore they should receive more assistance from the Government in terms of funds and technical manpower.

- There are 60% of orchids and uncountable numbers of other ornamental plants that are still in the wild, that needs to be collected before they are lost completely through destruction of forest habitats as the result of human interventions.

- There is a need now to carry out the characterization of the ornamental plants maintained in the National Botanical Garden, before new collecting trips are undertaken. Information on these resources are essential and needs to be properly documented for easy access when required.

7.2.4 Genetic Resources of Medicinal Plants

- The urgent national need at the moment is to collect as much as possible the indigenous medicinal plant resources and assemble them in ex-situ collections, either as seeds in cool storage facilities or as living collections in field gene-banks.

- There is a need to botanically and taxonomically identify these resources and characterize them accordingly. These data have to be fully and properly documented for easy access when needed.

- The Department of Health (DOH) should be the lead agency in the utilization of these resources. Before these resources are utilized, they have to be properly evaluated and tested for their medicinal properties. There is a need for collaboration between DOH, DEC and DAL on the conservation, evaluation, documentation and utilization of these medicinal plant resources.

- International collaborations are also essential, particularly for the chemical analysis for the medicinal properties of these resources.

7.2.5 Genetic Resources of the Commodity Crops

- PNG is a home or centre of origin of the "New Guinea Noble Canes" and there are well over 100 accessions of both cultivated and wild sugarcane found in the country. Some of these genetic materials may be useful for Crop Improvement Programmes in future and therefore they need to be collected and conserved before the genetic erosion takes place. Ramu Sugar Company, a sole producer of sugar in the country, should be encouraged to maintain not only introduced breeding lines in the museum block, but also the indigenous species that may become useful in the future.

- The genetic diversity of coconuts in PNG is far greater than is actually recorded. The Cocoa Coconut Research Institute (CCRI) should be encouraged and supported to set up a national germplasm collection of coconuts. With emphasis on planting of hybrid coconuts in the country, the genetic materials of the traditional tall coconuts will eventually die out if nothing is done about the conservation of these materials. There is a need now to collect and assemble the traditional tall coconuts before they are lost.

7.2.6 Genetic Resources o f Pasture Species

- Very little research has been done on the indigenous species of pastures in the country. The domestic consumption of animal products, particularly fresh meat has drastically increased in the last 15 years. There is a national need to identify and do research on the locally available pasture species for the benefit of the expanding Livestock Industry in the country.

7.2.7 National Policies on Plant Genetic Resources Programme

- There is an urgent need to critically look at the fourth National Goal of the country, "Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit for us all, and to be replenished for the benefit of future generations." The number of foreign investors in the logging and mining industries have significantly increased in the last ten years which has placed the forest resources of the country in a very critical situation of genetic erosion. The country needs to review the whole situation and set up new workable policies to safeguard the environment and its resources from being selfishly exploited for monetary gains for the benefit of the minority.

- There is an urgent need in the country to establish a PNG National Committee on Plant Genetic Resources to act as a "watch dog" to ensure that government policies and strategies on sustainable agricultural developments, conservation of the genetic biodiversity and preservation of the environment and it's natural resources is closely monitored and adhered to.
- The country needs to develop an Intellectual Property Rights (IPR) and Prior Informed Consent (PIC) policies to safe guard the indigenous genetic materials from being exploited by foreign interests. The landraces and farmer cultivars have to be protected and should only be given to other countries for research purposes which will also benefit PNG in the end. Farmer's rights have to be observed when dealing with their landraces or cultivars and whatever transactions take place the farmers should also benefit from it.

- The country needs a national policy on indigenous plant genetic resources that are going out of the country. There is an Import Permit for all flora and fauna coming into the country but nothing on materials going out.

7.2.8 Manpower Training in Plant Genetic Resources

- More national officers need to be trained in all aspects of PGR, especially in the fields of conservation, evaluation, characterization, documentation and collecting of the germplasm.

- PGR training should be carried out for all levels of professions, in the doctorate, masters and bachelors levels and not just the technicians.

- The field level officers and the farmers themselves need to be made aware of the importance of conservation of PGR and the advantages of maintaining genetic diversity in their fields.

- The general awareness campaign on the importance of conservation of PGR through preservation of the environment and its natural resources, is essential and long overdue. The general public needs to be made aware of this. The country needs assistance to successfully execute such a country-wide campaign.

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APPENDIX 1. List of Minor Indigenous Green Leaf Vegetables of PNG

Common Names	Scientific Name	Use	Location
Rungia	*Rungia klossii S.Moore*	leaves	Highlands
Chilli	*Capsicum frutescens* L.	leaves & fruits	Throughout
Not known	*Dicliptera papuana Warb.*	leaf tips	Highlands
Kalava	*Ormocarpum orientale* (Spreng.) Merr.	leaf tips	Gazelle & Gulf
Water leaf	*Talinum triangulare* (Jacq.) Willd.	leaves/stems	Coastal areas
Not known	*Adenanthera pavonina* L.	leaves	Lowlands
Ceylon spinach	*Basella alba* L.	shoots/leave	Coastal areas
Asian pennywort	*Centella asiatica* (L.) Urban	whole plant	Coastal areas
Wandering Jew	*Commelina diffusa* Burm.f.	leaf tips	Throughout
Not known	*Desmodium microphyllum* (Thunb.) DC.	young leaves	Highlands
Kongakonga	*Diplocyclos palmatus* (L.) C. Jeffrey	leaves	Gazelle
Indian coral tree	*Erythrina variegata* L.	Young leaves	Sepik
Hibiscus	*Hibiscus rosa-sinensis* L.	leaves	some areas
Nettles	*Laportea interrupta* (L.) chew	young leaves	Gazelle
Not known	*Pipturus argenteus* (Forst.) Wedd.	leaves & barks	Throughout
Comfrey	*Symphytum officinale* L.	young leaves	Throughout
New Zealand spinach	*Tetragonia tetragonoides* (Pall.) Ktze.	leaves	Highlands
Wingbean	*Psophocarpus tetragonolobus* (L) DC	young leaves pods, flower & tubers	Throughout
Gold apple	*Spondias cytherea* Sonnerat	young leaves & fruits	Coastal areas
Mama	*Alocasia lancifolia* Engl.	leaves	Gazelle
	& *A. holrungii* Engl.	leaves	Gazelle
Taro leaf	*Colocasia esculenta* Schott	leaves	Coastal areas

APPENDIX 2. Minor Vegetables and Flavourings

Common Name	Scientific Name	Uses	Location
Cassia	*Cassia* spp.	leaves	Lowlands
Tanget	*Cordyline terminalis* (L) Knuth	young leaves & shoots	Highlands
Leucaena	*Leucaena leucocephala* Dewit	young pods, flowers & shoots	Some areas
Betel pepper	*Piper betle* L.	fruits & leaves (with betel nut)	Lowlands
Sowthistle	*Sonchus oleraceus* L.	shoots & leaves	Some areas
Chickweed	*Stellaria* sp.	whole plant	Some areas
Not known	*Abroma augusta* (L.) Willd.	leaves & roots	Highlands (Chimbu)
Not known	*Ascarina philippinensis* C.E.Rob.	leaves	Highlands (Sinasina)
Not known	*Avicennia officinalis* L.	young leaves	Lowlands (some areas)
Cobbler's pegs	*Bidens pilosa* L.	seeds & leaves	Throughout
Not known	*Blumea riparia* (Bl.) D.C.	leaves	Some areas
Not known	*Boerhavia erecta* L.	young tops	Lowlands (some areas)
Palmyra palm	*Borassus heineana Becc.*	young fruit	Sepik area
Not known	*Calamus* sp. (seeds)	flesh around	Western Province
Bitter cress	*Cardamine* sp.	leaves & flowers	Highlands (Enga)
Not known	*Cassytha filiformis*	fruit	Western Province
Not known	*Cerastium papuanum* Schlechtr.	whole plant	Highlands
Swamp fern	*Ceratopteris thalictroides* (L) Bronin	whole plant	Lowland swampy areas
Not known	*Deeringia amaranthoides* (Lamk.) Merr	leaves	Sepik
Not known	*Elatostema macrophylla* Brongn.	leaves & tips	Highlands (Okapa)
Not known	*Floscapa scandens* Lour.	leaves	Some areas
Not known	*Gymnanthera mitida*	young fruits	Some areas
Not known	*Kleinhofia hospita* L.	young leaves	Some areas
Not known	*Lathyrus tingitanus* L.	pods	Some areas
Not known	*Lysimachia japonica* Thunb.	leaves	Some areas
Not known	*Medusanthera laxiflora* (Miers)	leaves	Some areas
Not known	*Polygonum chinense* L.	leaves as salads	Some areas

APPENDIX 3. Minor Indigenous Fruits and Nuts Species of PNG

Common Name	Scientific Name	Uses	Location
FRUITS			
Bladder cherry	*Physalis angulata* L.	fruit raw & cooked	Throughout
Indian mulberry	*Morinda citrifolia* L.	fruits & leaves	Some lowland areas
Not known	*Horsfieldia sylvestris* (Hout.)	fruit	Western Province
Mangrove nutmeg	*Myristica holrungii* Warb.	fruit	Some lowland areas
Not known	*Madhuca* spp.	fruit	Madang
Not known	*Maesa edulis* White	fruit	Some areas
Not known	Melastoma sp.	fruit	Western Province
Yellow plum	*Ximenia americana* L.	fruit & nut kernels	Some Coastal areas
Not known	*Parinari nonda* F.v.M. ex Bth.	fruit	Some lowland areas
Not known	*Bridelia tomentosa* Bl.	fruit	Western Province
NUTS			
Not known	*Elaeocarpus* spp. *E. pullenis* Weibel, *E. polydactylus* Schltr. & *E. womersleyi* Weibel	seed	Some areas
Not known	*Aceratium oppositifolium* DC	fruit	Some areas
Not known	Omphalea queenslandiae F.M.Bail.	kernels	Some areas
Not known	*Scleropyrum aurantiacum* (Laut.et K.Schum) Pilger	kernels	Some areas
Not known	*Semecarpus* sp.	kernels	Western Province
Not known	*Sloanea tieghemii* (F.Muell) A.C.Sm.	kernels fruit	Highland Some areas
Castor bean	*Ricinus communis* L.	seeds & leaves	Some areas
Not known	*Heritiera littoralis* Dryand	kernels with fish	Some lowland areas
Not known	*Sterculia schumanniana* (Laut.) Mildb.	fruit	Some lowland areas

APPENDIX 4. Plants Used for Treating Common Sickness/Diseases

Family	Scientific Name	Part of plant use
1. Cough		
Papilioniaceae	*Abrus precatorius* L.	leaves
Chloranthaceae	*Chloranthus officinalis* Bl.	leaves
Amarantaceae	*Cyathula prostrata* Bl.	leaves
Magnoliaceae	*Emerrilla papuana* Dandy	bark
Malvaceae	*Hibiscus tiliaceus* L.	roots, leaves & bark
Gramineae	*Polytoca macrophylla* Benth.	juice
2. Fever and Headache		
Araceae	*Alocasia indica* Schott.	young leaves & sap
Apocynaceae	*Alstonia scholaris* R.Br.	leaves
Lauraceae	*Cinnamomum sintoc* Bl.	bark
Liliaceae	*Cordyline terminalis* (L.) Kunth.	leaves
Lauraceae	*Cryptocarya massoy* (Oken) Kosterm.	bark
Leguminosae	*Derris uliginosa* (Roxb.) Benth.	decoction of roots
Himantandraceae	*Galbulimima belgraveana* (F.Muell.) Sprague	bark
Malvaceae	*Hibsicus rosa-sinensis* L.	leaves & roots
Compositae	*Wedelia biflora* (L.) DC.	fruits & leaves
Labiatae	*Hyptis suaveolens* (L.) Poir.	leaves
Vitaceae	*Leea sambucina* Willd.	leaves
Sterculiaceae	*Melochia tomentosa* L.	fruits & leaves
Euphorbiaceae	*Phyllanthus urinaria* L.	decoction
Cyperaceae	*Scleria lithosperma* (L.) Swartz.	leaves
Selaginellaceae	*Selaginella flabellata* Spring	leaves
Zingiberaceae	*Zingiber officinale* Rosc.	roots & stem
Verbenaceae	*Vitex trifolia* L.	leaves & roots
3. Stomach-ache		
Compositae	*Bidens pilosa* L.	roots
Compositae	*Blumea arfakiana* Martelli	leaves & roots
Caricaceae	*Carica papaya* L.	fruit & juice
Lauraceae	*Cinnamomum sintoc* Bl.	bark
Leguminosae	*Inocarpus edulis* Forst.	bark
Gramineae	*Paspalum conjugatum* Berg.	sap
Solanaceae	*Solanum verbascifolium* L.	leaves & whole plant
Verbenaceae	*Stachytarpheta mutabilis* Vahl.	leaves
Zingiberaceae	*Zingiber officinale* Rosc.	roots

4. Sores and Wounds		
Compositae	*Ageratum conyzoides* L.	leaves
Palmae	*Areca catechu* L.	nuts
Lauraceae	*Cinnamomum sintoc* Bl.	bark
Leguminosae	*Derris uliginosa* (Roxb.)	decoction of roots
Aspidiaceae	*Dryopteris milneana* (=D.milnei HK. O. Ktze)	leaves
Magnoliaceae	*Elmerrilla papuana* Dandy	bark
Myrtaceae	*Eucalyptus naudiana* F.Muell.	bark
Urticaceae	*Fleurya aestauans* Gaud.	skin of stem roots
Urticaceae	*Fleurya interrupta* (L.)	flower
Gleicheniaceae	*Gleichenia linearis* Clarke	leaves
Sapotaceae	*Illipe hollrungi* L. Schum.	leaves
Convolvulaceae	*Ipomoea batatas* Poir.	leaves
Convolvulaceae	*Ipomoea pes-caprae* (L.) R.Br.	decoction of leaf
Myrtaceae	*Melaleuca quinquener via* (Car.) S.T.Blake	bark
Rubiaceae	*Nauclea orientalis* (L.) L. (=*Sarcocephalus coadunata* Roxb. ex Smith Druce)	bark
Solanaceae	*Nicotiana tabaccum* L.	whole leaf
Oxalidaceae	*Oxalis corniculata* L.	sap from leaves
Urticaceae	*Pipturus argenteus* Wedd.	juice
Verbenaceae	*Premna integrifolia* L.	leaves
Leguminosae	*Pterocarpus indicus* Willd.	bark
Goodeniaceae	*Scaevola frutescens* Krause	leaf decoction
Combretaceae	*Terminalia catappa* L.	bark & leaves
Dipterocarpaceae	*Vatica papuana* Dyer	bark

APPENDIX 5. Germplasmof Fruits and Nuts Species maintained at Lowlands Agricultural Experimental Station, Keravat

Species	Origin	Importance	No. of Accessions
Anacardium occidentale	introduced	very significant	9
Ananas comosus	introduced	very significant	1
Annona muricata	introduced	minor	1
Artocarpus altilis	indigenous	very significant	2
Barringtonia procera	indigenous	very significant	2
Canarium indicum	indigenous	very significant	3
Carica papaya	introduced	very significant	1
Citrus sp.	introduced	very significant	1
Durio zibethinus	indigenous	very significant	4
Eugenia sp.	indigenous	minor	1
Gnetum gnemon	indigenous	minor	1
Inocarpus fagifer	indigenous	significant	1
Mangifera indica	introduced	very significant	1
Mangifera minor	indigenous	very significant	1
Persea americana	introduced	minor	1
Psidium guajava	introduced	minor	1
Terminalia kaernbachii	indigenous	very significant	1

APPENDIX 6. Herb, Spice and Condiment Species Maintained at the Lowlands Agricultural Experimental Station, Keravat

Species	Origin	Importance	No. of Accessions
Capsicum frutescens	introduced	minor	2
Cinnamomum zeylanicum	introduced	minor	–
Curcuma longa	introduced	significant	2
Cymbopogon citratus	introduced	minor	1
Cymbopogon nardus	introduced	minor	1
Mentha arvensis	introduced	minor	8
Myristica fragrans	introduced	minor	3
Piper nigrum	introduced	minor	4
Piper mystisticum	indigenous	minor	5
Pogostemon cablin	introduced	minor	1
Vanilla tahitiensis	introduced	very significant	1
Vanilla planifolia	introduced	very significant	1
Vetiveria zizanioides	introduced	minor	1
Zingiber officinale	introduced	very significant	5