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Status of Management of Plant and Animal Genetic Resources in Papua New Guinea

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Abstract

PNG has a diverse and rich resource base of plant, livestock and aquaculture genetic resources used for food and agriculture. These resources support livelihoods of the majority of rural population in the country. The safeguarding, maintenance and sustainable use of this genetic diversity is esential for current as well as future livelihood security. The National Agricultural Research Institute (NARI), as per its national manadate, maintains *ex situ* field gene banks as well as *in vitro* storages of major food crops including sweet potato, taro, banana, yam, cassava, taro, sweet potato and Aibika. Some indigenous and introduced fruit and nut crops are also maintained in *ex situ* collections, as are a small collection of both indigenous and introduced spices. NARI also maintains small conservation breeding stocks of sheep, goats, chicken, rabbits and ducks. The sustained use and development of these resources require supportive legislation and policy frameworks, which are still under development. Nevertheless PNG continues to collaborate with regional and international partners in the use and sharing of some of these resources. Currently the key constraints to sustainable utilization of these resources are lack of baseline information about the diversity and status of the resources, limitations in technical and logistical capacity in the design and implementation of appropriate management plans, lack of essential legal frameworks for use, access and transfer of these resources and the preceived continued threats on existing indigenous plant, livestock and aquatic resources from unsustainable utilization, large scale deforestation and expansion of human settlements.

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Introduction

The largely intact and prestine natural forests of Papua New Guinea (PNG), which cover up to 60% of the land mass (of about 462, 860 sq. km) provide natural habitat for a range of indigenous agricultural and forest genetic resources and their wild relatives. The country is also known to have one of the most heterogenous indigenous cultures and traditions with several thousands of separate communities maintaining their own language, customs and traditions for centuries in dense forests, valleys and islands. It is endowed with 3.12 million square kilometers of ocean area, together with 17,000 km of coastline, 4,250 km^2 deltaic plain /lagoon system and 4,180 km coastline around islands and atolls, inhabited by a wide diversity of marine and coastal flora and fauna, with huge potential for sustainable utilization. It also has numerous fast and slow flowing rivers and over 5,000 lakes with an extensive system of marshes located on the north and south parts of the country.

PNG is recognized as a major centre of genetic diversity for some traditional staple root/tuber crops, banana, leafy vegetables, fruits, nuts, and under-utilized crops species and forest trees (Kambuou, 1996). At least three quarters of the rural population in the country secures its livelihoods from the range of local plant, animal and fisheries resources, and hence the genetic diversities in these resources are of direct relevance to food security and livelihoods to the majority of the population.

Currently the National Agricultural Research Institute (NARI) of PNG is the custodian of the country's plant and animal genetic resources, having inherited initial activities and available infrastructure from the Department of Agriculture & Livestock (DAL) in 1996 (NARI, 2006a). NARI now maintains several *ex situ* field gene-banks of the major staple food crop species and two small tissue culture facilities. It also maintains breeding stock of introduced breeds of some livestock species (sheep, goats, rabbits, ducks, chicken). A few commodity-based institutions also maintain germplasm collections of industrial crops, such as coffee, cocoa, coconut and sugarcane (Kambuou, 1996; 2007).

This report reviews the current state of knowledge on the identification, maintenance and utilization of plant, livestock and aquatic genetic resources of PNG and brings out known constraints in the sustainable utilizaton of these resources.

Plant genetic resources for food and agriculture

Kambuou (1996) has provide an extensive review of the known diversity of plant genetic resources in PNG, particularly for the traditional root and tuber crops, bananas and green leafy vegetables, for which PNG is known to be a secondary centre of diversity.

Sweet potato (*Ipomoea batatas* L. Lam) is the main root crop in PNG in terms of production and consumption. It is widely cultuvated from sea level to 2700m with main production in the highlands. Over the years over a thousand accessions of sweet potatoes were collected and assembled in *ex situ* establishments in the country (Kambuou, 1996; 2007); these are mostly landraces, farmers' cultivars and common varieties.

The second most important root crop is taro (*Colocasia esculenta* L. Schott), and is considered as one of the indigenous traditional food crops of PNG. Although it is predominantly grown in the low altitude rainforest areas, it is being grown in highlands of up to 2700m altitude. Over 763 indigenous accessions of mostly landraces and farmers' cultivars were collected and assembled in *ex situ* collections in the country (Kambuou, 1996; 2007).

The yams (*Dioscorea* spp.) are the third most important root crop of the country, and up to 400 accessions of yams were collected and asembled in *ex situ* collections. Cassava is not native to PNG but is the main staple crop in coastal areas. Up to 115 accessions, mostly landraces and farmers' cultuvars, have been collected and assembled in *ex situ* collections.

Over 40 species of edible green leaf vegetables in PNG had been collected. The most popular species include Aibika (*Abelmoscuhus manihot* L. Medik), *Amaranthus* spp., Tulip (*Gnetum gnemon* L.), Rugia (*Rugia klossil* S. Moore), water dropwort (*Oenanthe javanica* D.C.), Blackberried nightshade (*Solanum nigrum* L.), Kumu mosong (*Ficus* spp.), Kangkong (*Ipomoea aquatica* Forskal), Watercress (*Nasturium spp*.) Valangular (*Polyscias spp*.), Kumu grass (*Callipteris prolifera* Lam. Bory), Choko tips (*Sechium edule* Jacquin Swartz) and Pumpkin tips (*Cucurbita moschata* Duch et Lam), all of which are either cultivated in the gardens or grown in the wild. Some of these species have great intra-specific variations. For example, over 140 Aibika accessions of landraces and farmers' cultivars had been collected from all over the country (Kambuou, 1996; 2007).

PNG is an important centre of distribution of wild banana, and has the greatest genetic diversity of botanically primitive diploid cultigens amongst large numbers of cultivars. Bananas are grown all over the country and they are important staple food crops in the

coasal low altitide areas. According to Argent (1976; cf. Kambuou, 1996), two genera of family Muaceae are found in PNG - genus Ensete, represented by one species, *Ensete glaucum,* and genus Musa, represented by nine species. Kambuou (1996) reported that some 800 accessions of both cultivated and wild bananas from PNG were collected and assembled; but only about a quarter of this number are in national field collections. Fruit species native to PNG include wild mangoes (*Mangifera* spp.), bukbuk (*Burckella obovata* Forst Pierre), a native fruit of the Atolls of PNG, Marita (*Pandanus conoideus* Lamarck), taun (*Pometia pinnata*), golden plum (*Spondias cytherea* Sonnerat), the tree cucumber or Bilimbi (*Averrhoa bilimbi* L.) and a number of introduced citrus species.

Coconut is a widely occuring and cultivated nut species consumed throughout the country. It is also an imprtant cash crop. The same is true about Betel nut (*Areca* spp). Six *Pandanus* species, four edible *Canarium* species (also known as Galip nut), and five edible *Terminalia* species (Okari) are reported in the country. Another popular nut tree species is Pao (*Barringtonia novae herbernae* Laut). Others are the PNG oak or Castanopis chestnut, the finschia nut, the tahitian chestnut, the candle nut (*Aleurites moluccana* L. Wild), the Nipa palm (*Nipa fruticans* Wurmn) and Pangi (*Pangium edule* Reinw), also locally known as Sis (Kambuou, 1996).

Unlike the Asian neighbours people in PNG use very little spice in their food, and almost all spices commonly used in their food are introduced species. Only a few indigenous species are used as herbs or flavourings in some local dishes. Some of these are the ginger, the Begonia (*Begonia* spp), *Coix gigantea* Koenig et Roxb, *Coleus scutellarioides*, *Euodis* spp and the Fennel plant (*Foeniculum vulgare* Mill).

PNG is the centre of origin of the ‘Noble cane’ (*Saccharum officinarum*). There is also substantial diversity of this species being cultivated in subsistent gardens in a wide range of environments from the coast to the highland areas; more notably it cannot survive in the wild. Kambuou (1996) reported that a total of 206 accessions were collected during the 1977 expedition, but little was documented about the composition of this collection.

Reported research work on pasture and forages focused on introduced species; the native pasture species of PNG are yet to be identified or recorded. In 1980 some 500 accessions of Desmodium species were collected by CSIRO researchers and transferred to Australia without duplicate collections being maintained in PNG. There is no current work on indigenous pasture and forage species.

Management of plant genetic resources

Through financial and technical assistance from the former International Plant Genetic Resources Institute (IPGRI) and bilateral regional support, PNG has undertaken series of projects for the collection of germplasm in traditional food crops throughout the country and established *ex situ* gene banks at research stations of initially the Department of Agriculture and Livestock (DAL), and since 1996 the NARI. The NARI has subsequently developed a genetic resources program to coordinate management of genetic resources at national level (NARI, 2006 a,b). The national plant genetic resource (PGR) collections for the traditional food crops are currently being held at Laloki, Aiyura and Kerevat research stations representing the three major agroecological zones of the country – the dry lowlands, the mainland highlands and the low lying wet islands regions, respectively. Working collections of these germplasm are also maintained at these and other research stations of NARI. It is expected that these collections are regularly replanted to regenerate new and healthy materials and are also checked for mixtures to avoid contamination of materials in the field (NARI, 2006b), but these have not been consistently implemented as noted from reports of losses and admixtures. The current national collections include 1209 accessions of sweet potato, 763 accessions of taro, 221 accessions of banana, 234 accessions of yam, 95 accessions of cassava and 49 accessions of Aibika (Table 1). In addition, a range of fruit, nut and spice species and varieties, including the rambutan, mangosteen, durian, guava, taun, galip nut, nutmeg, pepper and kava are maintained in field gene banks.

While these are maintained as *ex situ* collections, most of the landraces and farmer cultivars are assumed to continue to survive under *in situ* conditions with farmers or exist in the wild along with their wild progenitors, but this will need to be verified. For instance, out of over 300 accessions of taro identified in the early 1980s in the coastal Huon Gulf district of Morobe Province, only a limited number of more marketable common cultivars are maintained by many farmers at the expense of the wide range of taros that they once maintained (Kambuou, 1996). Similarly Apa (2006) reported that a 2005 survey of Gabadi-Mekeo area of Central Province revealed that farmers maintained only eight of the 15 common banana cultivars recorded some nine years earlier.

Table 1: The numbers of accessions currently held in national core and working collections by NARI (Kambuou, 2007)

Crop	Scientific name	National	Working	
		(Field)	Field	Tissue
Sweet potato	*Ipomea batatas*	1209	80	72
Banana	*Musa spp*	221	107	23
Taro	*Colocasia esculenta*	763	101	5
Yam	*Dioscorea spp*	234	9	
Cassava	*Manihot esculenta*	95	87	
Aibika	*Abelmoschus manihot*	49	60	
Irish potato	*Solanum tuberosum*		41	59
Chinese Taro	*Xanthosoma sigatifolium*		3	
Swamp taro	*Cyrtosperma chamissionis*		2	
Andean tubers			3	
Various traditional vegetables			22	

Even among the registered collections, a good number of accessions of the major crops have been reported as lost due to technical and logistical constraints. An economic assessment of the costs and benefits of field germplasm maintenance activities of major food crops conducted in 2001 (Wells and Eldridge, 2001) not only established the case for continued resource allocations on this activity at national level, but also affirmed the need for regional collaboration in germplasm management both to facilitate sharing of resources and reduce maintenance costs for germplasm collections.

In terms of *in situ* conservation, three officially recognized national parks with a number of nature reserves in them are being maintained. These are owned by land owners and government employed park rangers maintain them on site, and ensure that these areas are kept free of any agricultural or logging activities (Kambuou, 1996).

Livestock genetic resources

A comprehensive survey or census of livestock genetic resources of PNG is yet to be undertaken. Only crude estimates of livestock populations were made in 1982, 1993 and in 2002 (Table 2).

Table 2. Important livestock species, known breeds and their population estimates

Species	Breeds	Important features	Population estimates (Quartermain, 2002)
Pigs	Native	Tolerance to fibrous feeds, internal parasites	1.8 million in 2002
	Large White, Landrace, Saddle Back, Duroc, Tamworth	Variable attributes	32,000, all in commercial herds
Chicken	Native chicken	Scavenging, broody, tolerant to parasites, with high mortality losses and low production	1.5 million
	Australorps	Dual purpose meat and egg type, adaptable to scavenging	Onle several hundred known purebred populations currently maintained by NARI and OKTedi.
	Ross strain broilers	Commercial inbred broilers	Parent stocks maintained by commercial companies
	Shaver Brown	Commercial inbred layers	Parent stocks maintained by a commercial company (Zenag)
Cattle	Javanese Zebu	Hardy; tolerant to tick and screw work infestation; adapted to poor pasture; have short calving interval; found only in the Sepik plains	400~600; perhaps decreasing in size; down from an estimate of 2000 in 1982. Breed status may be endangered.
	Brahman, Droughtmaster, Santa Gertrudis, Aberdeen Angus, Hereford	Comemrcial beef breeds	In large and small commercial herds; no reliable population estimates available
	Friesian Jersey	Commercial dairy breeds	In large and small commercial herds; no reliable population estimates available
Sheep	Highlands Halfbred		About 15,000 and increasing
	Priangan	High incidence of multiple births	
Goats	Mixed breed	High incidence of multiple births	20, 000~25, 000
Ducks	Muscovy	Dual purpose and versatile	10,000 flocks
	White Campbell, Khaki Campbell, Indian Runner Rouen	Mainly egg type, hardy	3000
Rabbits	New Zealand White	Suited to highlands	20,000
	Canberra Halflop	Suited to lowlands	
Swamp buffalo		Mainly found in the Sepik plains as feral populations; but also in Madang, Morobe and East New Britain Provinces as draught animals.	4000

In PNG, indigenous pigs appear to be the most important livestock species to smallholder livestock keepers, be it in terms of population size and distribution, contribution to livelihoods or socio-cultural significance. They also have a much longer evolutionary history than other livestock species. But their genetic diversity is largely unknown. With several hundred different ethnic groups and languages and numerous isolated traditional communities that exist in the country, the pig genetic diversity may have particular relevance for detailed genetic studies (Ayalew, 2007).

The indigenous chicken populations in the mainland as well as major islands appear to have been subjected to extensive genetic admixture from introduced improver breeds such as Australorps which have been promoted indiscreminately over the last several decades. However, as the Australorp chicken are not broody, replacement of pure breeding stock has always been a problem to smallholder farmers. Thus the Australorp chicken of smallholder farmers were either not sustainably maintained in pure stock in the villages, or are often kept together with village chicken, leading inevitably to continual uncontrolled crossing and interbreeding. Detailed genetic studies are needed not only to quantify the existing genetic diversity in the native village populations but also to gauge the level of genetic introgressions from introduced genotypes (Ayalew, 2007). On the other hand, the commercial broiler and egg industries which use commercial inbred lines of exotic genotypes, are very strong in PNG, engaging up to 55 thousand smallholder farmers in a grow-out model for contractual broiler production (Glatz, 2007).

The existing sheep and goat populations in PNG evolved from interbreeding of exotic breeds introduced into the country mainly during the colonial and post-colonial period in the past 100 or so years (Quartermain, 2002). No indigenous populations are known to exist in the country. The Priangan and Highland halfbred that exist today must have evolved as composites of these breeds at various proportions. It is therefore hypothesized that the existing sheep populations have a narrow genetic base. Similarly, the existing goat populations are believed to have evolved from remnants of a variety of dairy-type goats introduced during the early colonial period (Quartermain, 2002). More recently some feral goat populations from Australia and New Zealand were introduced to genetically reinforce the village goat flocks. Mainly goats but also sheep are becoming increasingly popular livestock species for smallholder farmers in the high and mid altitude areas of the country (Ayalew, 2007).

There is no native cattle breed in the country; the Javanese zebu was introduced from Indonesia and Australia, and their numbers are very low and hence recognized as endangered. The surviving population is presumed restricted in the Sepic plains in the northern mainland of the country, some of them reportedly surviving as feral herds. Several other exotic commercial beef breeds introduced from Australia are mainly kept by commercial ranches (MoA&L, 2004).

Management of genetic resources

PNG has a national coordinator for farm animal genetic resources appointed from the Ministry of Agriculture and Livestock to coordinate core activities. However, the coordination activity has been rather weak, and researchers from other institutions (NARI, Unitech and NAQIA) have taken up such activities as the preparation of the Country Report to the State of the World's Animal Genetic Resources for Food and Agriculture (MoA&L, 2004) and networking. The national farm animal management strategy proposed in the Country Report did not proceed to implementation stage. Generally the development and sustainable utilization of farm animal genetic resources have not been a priority development activity in PNG. One possible reason is lack of qualified manpower in this area.

As per its national mandate, NARI currently maintains *ex situ* conservation flocks in its research stations mainly as a source of selected breeding animals to supply smallholder farmers. These include some 250 breeding ewes of Highland Halfbred sheep at Tambul, 30 breeding ewe of Priangan sheep at Labu; 70 breeding does of goats; 50 rabbit does; 50 Australorp laying hens; 30 native village chicken, 70 breeding Muscovy ducks and 70 layer true ducks. The goat, Australorp and rabbit flocks are currently maintained in duplicate *ex situ* conservation breeding flocks. A growing number of smallholder farmers are raising goats, sheep, Muscovy ducks and rabbits; however, except occasional exchanges and sales of breeding stock, these flocks do not have formalised functional relationships with the breeding flocks maintained in the research stations to manage risks of loss of genetic diversity. The conservation flocks are therefore vulnerabe to natural and man-made disasters that can lead to sudden loss of whole breeding flocks. For livestock genetic resource, the most effective strategy to conservation is to sustainably utilize the resources in their natural habitat by encouraging and supporting the traditional livestock keepers.

There are no facilities for the collection and storage of cryopreserved genetic material (semen, ova, embryos) for purposes of genetic improvement or conservation. Facilities to carry out molecular studies are not available in the country.

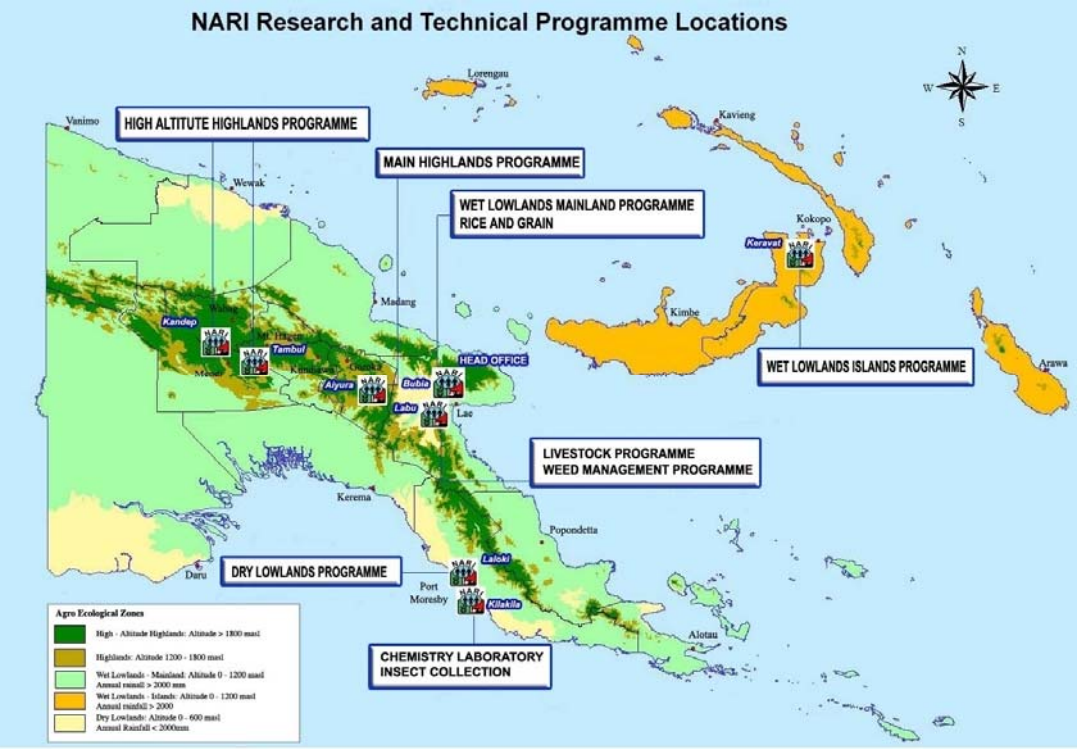

Figure 1. Political map of Papua New Guinea showing the location of research stations of NARI involved in *ex situ* maintenace of germplasm collections

Aquatic genetic resources

As stated above, PNG has an extensive resource base for marine fisheries. The abundant rainfall and fertile soils also make inland aquaculture a viable option for rural communities in most parts of the country. Located in the tropics, PNG is home to most of the important tropical aquaculture species: barramundi (*Lates calcarifier*), freshwater prawns (*Macrobrachium rosenberghii* and other *Macrobrachium* spp), freshwater crayfish (*Cherax albertsii*), tropical seaweeds, sea cucumber (*Holothuria* spp), tropical sponges and corals, groupers, marine prawns (*Penaeus* spp), mud crabs (*Scylla* spp), giant clam and pearl oysters (FAO, 2002; Smith *et al.,* 2007). It also has a great diversity of freshwater and marine

environment for aquaculture. There is a tremendous potential in inland aquaculture given that captured fisheries has become increasingly commercially unsustainable.

Unlike developments in other island countries in Asia, aquaculture in PNG is a recent activity as compared to agriculture and animal husbandry, but with well coordinated awareness and training, it can play an important role in improving food security and contribute to sustainable rural development (NFA, 2004).

In an effort to increase local fish stocks, numerous exotic fish species were introduced into PNG. The introductions of fish species before 1990 were either illegal or planned without proper quarantine procedures, but after 1990, import protocols were established and enforced (Coates, 1989; Kolkolo, 1996). In total, about 200 fish species have been introduced to PNG in an attempt to improve wild fish and aquaculture production, recreational fishery and aquarium (Smith *et al,.* 2007). Based on preliminary indications, it is hypothesized that some introduced species have led to undesirable changes in the composition of native fish stocks in some water bodies.

Relevant national legislation

A draft bill on access and benefit as well as modalities for material transfer agreements on genetic resources is currently under discussion and it is hoped that the bill will be enacted very soon. PNG has strong quarantine protocols for import of any germplasm and materials that are deems risky for the maintenance of native genetic resources in the country. Currently, there are no formal national legal frameworks for transfer of plant, animal or aquatic genetic resources out of PNG; informal arrangements between concerned international parties are being used to transfer genetic materials even for research purposes. It is recognized that genetic materials transfererd without a proper MTA prorocol are not safeguarded from unauthorized commercial uses.

PNG has an operational national aquaculture policy that identifies the major constraints to fisheries and aquaculture development in the country as well as the strategies for nation-wide development of aquaculture (NFA, 2004). But the policy does not cover the management of native fisheries genetic resources of the country. Facilities for quarantine and conservation of fisheries genetic resources are yet to be established.

PNG does not have any direct or indirect public incentive to farmers for their continued maintenance and conservation of indigenous crop, livestock or fisheries genetic resources.

Collaboration and networking

PNG is taking active part in various regional and international collaborative projects and networks related to the management of germplasm, including the Pacific Agriculture Plant Genetic Resources Network (PAPGREN). It also collaborates with the Centre for Pacific Tree and Crops (CePaCT), the Banana-Asia Pacific Network (BAPNET) and the Bioversity International in the sharing and maintenace of plant genetic resources. National networks relevant to the management of germplasm are the Papua New Guinea Biodiversity Network (PNGBioNET), the National Biotechnology & Biosafety Network and the National Biodiversity Strategy and Action Plan (NBSAP) under the Department of Environment & Conservation (DEC).

PNG is also taking part in regional initiatives for the characterization and documentation of existing farm animal genetic resources of the South Pacific Region. The South Pacific Community, to which PNG is also a member, provides technical and financial support as part of regional initiatives in the management of genetic resources.

Major constraints in the management of GR

1. Incomplete, or lack of, baseline information on the identity, diversity, distribution, utilization and current status of plant, animal and aquatic genetic resources. At least all the *ex situ* collections need to be fully characterized and documented in the form that can be easily accesible nationally and internationally.
2. Limited technical and logistic capacity in the design and operationalization of appropriate programs for the management of genetic resources, that encompass and, as appropriate, combine complementary *in situ* as well as *ex situ* modes of conservation. Numerous accessions from collections have been lost over time due to limitaions of maintaining *ex situ* collections; others have been identified later as duplicates. Uncontrolled contaminations have also been reported.
3. Lack of necessary national ABS and MTA protocols to formalize transfer of genetic materials across borders.
4. Absence of national management plans for at least the major plant, animal and aquatic genetic resources with direct relevance to food and agriculture. Contingency plans are yet to be developed to avert disasterous losses of genetic resources in the event of

major natural and man-made catastrophes. For instance, a whole collection of 423 yam accessions were lost from the Laloki research station in 1995 when budgetary allocations were cut back and no replanting was done subsequently.

5. Perceived continued threats to the maintenance of genetic resources from large scale deforestation due to logging, expansion of human settlements into hitherto uninhabited natural forests and unsustainable utilization of native plant, animal and aquaculture getetic resources.

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