The State of Plant Genetic Resources for Food and Agriculture in Lao PDR

Country Report

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CONTENT

List of Acronyms and Abbreviations

ACIAR	Australian Centre for International Agriculture Research
ARC	Agriculture Research Centre
AusAID	Australian Aids for International Developments
AVRDC	The World Vegetable Centre
BUCAP	Biodiversity Use and Conservation in Asia Program
CIAT	International Centre for Tropical Agriculture
DED	German Development Service
FAO	Food and Agriculture Organization for United Nations
FNPP	FAO – Netherlands Partnership Program
FRC	Forest Research Centre
GDP	Gross Domestic Product
GPA	Global Plan of Action for the conservation and sustainable use of PGRFA
HHRC	Haddokkeo Horticulture Research Centre
IRRI	International Rice Research Institute
IUCN	The World Conservation Union
Lao PDR	Lao People's Democratic Republic
LRC	Livestock Research Centre
LSP	Livelihood Support Program
MAF	Ministry of Agriculture and Forestry
NAFES	National Agriculture and Forestry Extension Service
NAFRI	National Agriculture and Forestry Research Institute
NISM	National Information Sharing Mechanism on PGRFA
NGO	Non Governmental Organizations
NTFP	Non Timber Forest Products
PGR	Plant Genetic Resources
PGRFA	Plant Genetic Resources for Food and Agriculture
RF	Rockefeller Foundation
SDC	Swiss Agency for Development and Cooperation
SNV	Netherlands Development Organization

Section I
Executive Summary

Diversity of plant genetic resources in Lao PDR is vast and its products are closely associated with the livelihoods of rural communities.

Since the early 1990s, the changing socio-economic situation in the country has increasingly put pressure on plant genetic resources (PGR), in some cases leading to a severe erosion of their diversity. For this reason, most vulnerable areas at risk of genetic erosion have been demarcated and protected by forest law and regulations. However, law enforcement in most of the protected areas has not been as effective as expected. Therefore some improvements in this regard urgently need to be considered.

The government of Lao PDR has developed a number of important policies to support the sustainable use of agricultural biodiversity. The overall strategy for plant genetic resources aims to establish sustainable food security systems and to alleviate poverty in the rural sector, while protecting the biodiversity of its plant genetic resources. Policies are currently being revised for the further protection of plant genetic resources and the rural economic development through a sustainable management of these resources.

There is a significant threat and risk of erosion for important plant genetic material from their natural habitats. While there are no new programs directly related to surveying and inventorying PGRFA in Lao PDR, little attention is being paid to continuing *in situ* management of many plant genetic resources for food and agriculture. In fact, some programs have given limited priorities to conduct more research on *in situ* management for their respective genetic resources. The main reasons for this weakness are: staff limitations, financial restrictions, poor knowledge and lack of training for ground staff, insufficient knowledge on plant genetic erosion and the absence of an early warning system to alert when loss of genetic resources occurs. Thus, it is vital to upgrade inventories available for any *in situ* and on-farm conservation activities and to conduct new surveys in rapidly eroding areas. Indigenous knowledge (IK) on *in situ* conservation has been documented for few crops. However, further research on the efficiency and accuracy of these methods is necessary.

The current *ex situ* conservation measures for most important crop genetic resources is overall satisfactory. However, the two genebanks at the ARC and HHRC require more attention as they are operating at their full capacities. An efficient response mechanism for emergencies should be established, in particular for those related to refrigeration failure. One solution for this type of emergency is to have a service contract agreement with the refrigeration service provider in Vientiane to take immediate action when such an event occurs. It is also necessary to organize temporary cold storage facilities during inevitable lengthy power interruptions. *Ex situ* conservation is needed for material collected from rapidly degrading areas and seed storage or field genebanks are necessary to maintain this material. At present, genetic material from rice, vegetables and fruit crops can be processed and stored immediately after collection, but there is no such assurance for most of the other genetic resources available in Lao PDR. Therefore, a centralized genebank under the national system of plant genetic resources is required.

PGR evaluation is a fairly slow process in Lao PDR. The ARC and HHRC have commenced crop research programs to screen a large number of species under specific environment conditions. However, field screening involves large amounts of resources, personnel and time hence requires significant funding for the continued evaluation of most

of other genetic materials available in Lao PDR. Utilization of PGRFA in crop improvement programs has made significant progress for rice and some vegetables. Direct adaptation of genetic resources outside *in situ* conservation areas has been successful for rice, vegetables and some non timber forest products (NTFP). Few aromatic and glutinous rice landraces identified from rice genebank have been distributed to farmers in other areas. A number of rice breeding programs have been initiated at the ARC addressing rice quality, drought and cold tolerance, and pest resistance. By screening around 300 rice accessions, promising lines for these attributes were identified. Populations from crosses between these donor lines and a few popular lines are available at the ARC for field selection. The national rice program will provide funds for further field experiments. A major limitation in the utilization of PGR for plant improvement program in Lao PDR is the lack of trained staff. There are currently only a few breeders and agronomists working on few crops and external projects provide financial assistance for the evaluation of genetic resources.

The models developed for PGRFA utilization need to be tested in other communities that are heavily depended on subsistence farming systems. Main constraints in adopting such models are the social differences, desire and readiness to accept changes to their habits and the distance to markets for diverse products. Better collaboration between existing extension systems and NGO programs may be required to resource these programs.

The current national legislation on the protection of biodiversity is inadequate. There should be a mechanism of financial incentives for the rural farmers who contribute to the conservation of the forest. The country also needs stronger quarantine laws to check for contamination of plant genetic resources with imported material. Training programs are essential for protecting and managing biodiversity particularly, in areas of surveying, inventorying and identifying *in situ* locations for PGR conservation. On-site group training programs or on-the-job training is useful for field staff, whereas postgraduate training is required for research staff for better planning in the future.

In March 2006, Lao PDR has become part of the International Treaty on PGRFA. Three months later national representatives participated to the 1st meeting of its Governing Body, which took a number of important decisions for the Treaty's implementation, including (i) the adoption of the Standard Material Transfer Agreement for exchanging materials under the Multilateral System of PGRFA access and benefit sharing, and (ii) the definition of priorities under the Treaty's Funding Strategy. Although in its very early stages of implementation, the Treaty is expected to traduce the political will into a mobilization of human and financial resources essential for the achievement of its objectives. Through international and regional cooperation, technical and financial support for the national PGRFA programs is needed. Emphasis also should be put on human resources' development to counter most of the future challenges on biodiversity conservation and management. Given the magnitude of challenges that Lao PDR faces today, the country has to find more resourceful and balanced solutions for the conservation and utilization of PGRFA while moving towards a market-oriented economy for effective engagement in economic affairs with the international community. Thus, Lao PDR evidently needs future foreign assistance to complement national efforts for protecting biodiversity and developing sustainable programs for PGRFA.

Section II
Introduction

Lao People's Democratic Republic (Lao PDR) is one of the countries with a large proportion of land covered with undisturbed forest in South East Asia. The capital and largest city of Lao PDR is Vientiane, and other major cities include Luang Prabang, Pakse and Savannakhet. It has a land area of 236,800 square km, and a population of around 5.6 million. The topography of Lao PDR is largely mountainous, with elevations above 180 meters typically characterized by steep terrain, narrow river valleys, and low agricultural potential. The country is rich with natural resources such as forestry, minerals and hydro-electric power. However, the development is hindered by the lack of efficient communications in the heavily rugged mountainous landscape. This complicated ecological environment has formed a big basket of very diverse crop genetic resource.

1. Trend in Population Development

After independence, the first countrywide census was conducted in 1985 and recorded as 3.6 million. Since then, census and population statistics have been collected every 10 years. In 1995, second population census was conducted and reported as 4.5 million, indicating an annual population growth of 2.5% from 1985 to 1995. The annual population growth for the last ten years was 2.44% indicating a growth of about -0.06%. The gender and sex ratio estimated in 2005 showed that female population (2.81 million) is slightly higher than the male population (2.79 million). Based on the population growth (2.45%) during last two decades, a population of 7.8 million is predicted in 2020. Current population density is around 24 per km^2. However, the highest population density of 177 per km^2 is present in the capital[1].

2. Geographical Information

Lao PDR is located between latitude 14^o 10' N to 20^o 10' N and longitudes 100^o 20' to 107^o 50'E in South East Asia. It is a landlocked country bordered by Thailand, Myanmar, China, Vietnam and Cambodia. Most of the western border to Thailand is demarcated by the Mekong River, which forms the main river system in South East Asia. The Annamite Mountains extend approximately 2130 kilometers forming the eastern border with Vietnam. Lao PDR shares its southern border (approx 541 kilometers) with Cambodia. Most of the northern part of the country is bounded by a mountainous border with China and shares the 235km. Mekong River border with Burma.

The main features of the country are its predominant mountainous landscape to the north and the Mekong River valley. Only about 4% of the total land area is arable and rice cultivation is the predominant agriculture system. Due to commercial logging and expanded swidden, or slash-and-burn, and farming, the forested land area has declined. The government policy is to ban slash-and-burn system, settle them on the cleared land, and provide lands in lowland areas for agriculture and other farming activities.

3. Diversity in Climate

Lao PDR has a monsoon climate with a distinct dry and wet season. The dry season lasts from November to May with the cooler period in December and January. The monsoon season produces severe rain that lasts for short periods in the year from September to

[1]Preliminary Report, 2005. Steering Committee of Population Census, National Statistic Centre

October. The wet months vary according to location; in Vientiane, from May to September, in Luang Prabang, August is far wetter than any other month and rainfall varies according to altitude. Annual rainfall distribution varies across the northern, central and southern agricultural regions of Lao PDR. Provinces in the northern region generally receive less rainfall than the central and southern regions, with small variations (1566 ± 247 mm annum^{-1}) across provinces. The northern provinces of Sayabouly and Luang Prabang have the lowest mean annual rainfall, with 1284 and 1406 mm, respectively. Provinces in the southern region receive the highest annual rainfall (2237 ± 426 mm annum^{-1}), with a higher variation across provinces within this region. Saysomboun Special Zone and Bolikhamxay receive the highest annual rainfall with 3231 and 3107mm respectively. Temperatures are as low as 13^{o}C at higher altitudes in the coldest period of its wet season and as high as 35^{o}C in the hottest period, between March and May, of the dry season.

4. Pre-dominant Farming Systems, Major Crops and Seasons

The rice based farming system is the pre-dominant subsistence farming system in Lao PDR. Rice cultivation accounts for more than 80% of the cultivable land. The wet-season lowland rice production is the most important production system, which in 2005 accounted for about 75% (575520 ha) of the total rice area (770325 ha) and 78% (1.98 tons) of total production (2.53 tons).The rice production systems in Lao PDR can be classified into three broad ecosystems; Irrigated Lowland, Rainfed Lowland and Upland (Table 1)[2]. The terms "Upland" and "Lowland", as used in describing rice production ecosystems are not related to the elevation or topography where the rice is grown. Lowland rice fields are found at over 1000m elevation in Xieng Khouang Province. Lowland rice grows in bunded fields and the soil is flooded for at least part of the crop season. Upland rice fields can be on flat fields at low elevations, such as those grown in Vientiane Municipality. Lowland rice production is common in the mountainous northern region and along the eastern border with Vietnam. This system is referred to as "Montane" lowland. It is distinguished as rice grown in the mountains in small valley bottoms or on terraced hillsides. While it is lowland rice by definition, the management practices in this system are different.

Cassava, vegetables, corn and tuber crop cultivation are mostly found in dry season in upland areas. Wet season vegetable cultivation is limited mainly due to high rainfall, resource limitation and small work force. However, the land under vegetable cultivation is relatively low and often farmers use their paddy fields for vegetable cultivation during dry season.

The average farm-size holding in Lao PDR is about 1.62ha. However, the largest farms in Champassak are about 2.02 ha, and the smallest farms found in Phongsaly are 0.85ha. At present, the emerging smallholders (small-scale contract farmers) and concession based commercial farming systems (contract and land allocation for large farms) influence changes in subsistence agriculture system in some areas in Lao PDR

[2] Linquist, B. et al. 2006. Rice Production System of Lao PDR. In "Rice in Lao PDR". Eds. J.M.Schiller, MB Chanphengxay, B. Linquist and Appa Rao, IRRI publication.

Table 1. Terminology for rice growing environments found in Lao PDR

Ecosystem	Description
Irrigated Lowland (paddy)	Rice grown in bunded fields and fields are flooded for at least part of the season. Irrigation water is used.
Rainfed Lowland (paddy)	Rice grown in bunded fields and fields are flooded for at least part of the season. Rain water is used.
Upland	Rice is grown in unbunded fields and rain water is used. Typically grown on sloping fields associated with 'slash-burn'.

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5. Economy Based on Agricultural Products

Agriculture, mainly subsistence rice farming, dominates the economy, employing an estimated 85% of the population and producing 47% of gross domestic product (GDP). Rice, livestock and non-timber forest products (NTFP) largely contribute to the household income of the rural farmer (Figure 1).

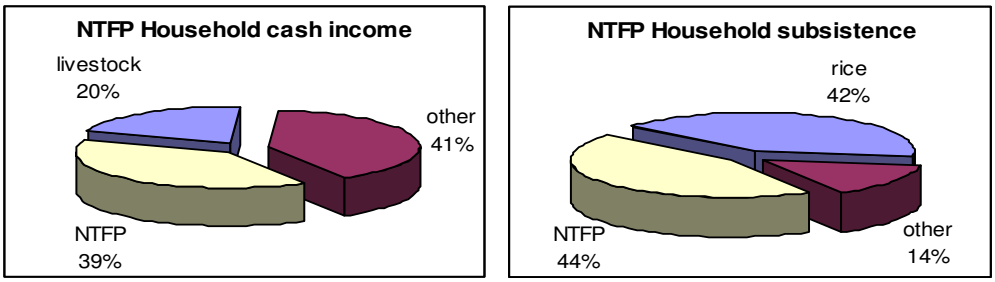


Figure 1. Rural family non-cash and cash income from farm and non-farm products as compared to rice and livestock income (adopted from NTFP in Lao PDR; a manual to 100 commercial and local products, 2007).

Low domestic savings cause Lao PDR to rely heavily on foreign assistance and loans as investment sources for agriculture and economic development. In 2004, for example, foreign grants toward agriculture and forestry accounted for more than US$ 75.7 million. This amount is about 7.3% of total foreign investment on projects in Lao PDR in 2004[3].

6. Food Security and Future Trend

Demand for food in Lao PDR is increasing, due to the 2.44% annual population growth. Rice is the most important agricultural production for securing food, and the level of production varies according to population density across the country. However, the limitation in food product mobilization and marketing causes seasonal food shortages in some areas.

The government has identified 47 districts as poor areas due to seasonal food shortages. The national priority and policies are directed towards alleviating poverty in these communities by 2010. The major food crop production in Lao PDR as recorded in 2005 statistics is shown in Table 2. Farmers living in villages closer to forest area harvest their daily vegetables and fruits from the wild. The value of these NTFP consumed by rural Lao

[3] Statistics. 2005. Committee for Planning and Investment, National Statistics Centre, Vientiane Capital

people is estimated as $280 per capita/year (per capita/year income is $400). It accounted for $224 million nation-wide, 20% of the GDP[4].

Table 2. Main crops, cultivation area and the production as indicated in 2005/2006 statistics in Lao PDR (World Bank Economic analysis, Lao PDR, 2005-2006).

Crop	Land area (ha)	Production (tons)
Rice	575520	1,976,000
Maize	67,500	203,500
Root crops (starch)	23,908	175,228
Vegetables and beans	107,150	670,500
Peanut	14,605	12,404
Soybean	5,620	4,720
Mungbean	2,415	2,135

7. Recent Trends in Agriculture Sector in Lao PDR

Because of the growing agricultural economy (around 4.7%)[5] and open market systems, there is a trend towards quality food and food diversity. In addition, with increasing investments in the industrial private sector, the demand for land is growing. With these recent economic developments and the government policy for a market economy, changes are taking place in the farming sector.

These changes include semi-mechanization of crop cultivation with small-scale tractors and harvesters, labor migration from the agriculture sector to the industrial development sector, changes in land utilization system such as shifting subsistence farming to a near commercialized system, changing food habits in urban cities and importing of agricultural products from neighboring countries.

Local indigenous knowledge about NTFP is mostly within the older generations and is at risk of being degraded or lost due to out migration and lifestyle changes of younger people. With socio-economic development, forest dependency decreases and the people skills on manufacturing handicrafts or traditional knowledge of NTFP use for medicine is diminishing. Young generation in Vientiane, as for any other city, is out of touch of nature and often has little knowledge on NTFP.

NTFP, such as wildlife or orchids, are rare in markets except in the province or along major provincial roads heading to Vientiane where they have become exotic items. Outside pressures through increased market values for forest products, restricted access to previously used areas are a few of the threats mentioned before, which induce inappropriate use of natural resources. Inevitably, this intensive competition for limited resources has resulted in conflicts of interest within and between communities, thus traditional rules and practices are increasingly being ignored. This breakdown of traditional village systems is consequently increasing poverty.

[4] NAFRI, NUoL, SNV 2007. Non-timber forest products in Lao PDR. a manual of 100 commercial and traditional products. NAFRI Vientiane, Lao PDR.

[5] Lao PDR: Rural and Agriculture Sector Issue Paper, World Bank report on RDNRSU East Asia

Section III

Chapter 1
The State of Diversity

1. Introduction

The biodiversity in Lao PDR is tremendous where the natural habitat has been undisturbed and less affected by human activities. Similarly, there is a rich and complex agro-biodiversity system involving cultivated and non-cultivated agricultural products. In order to provide legal protection for the biodiversity, the Lao Government established the Forest Law in 2002. Figure 2 shows the protected forest areas under this biodiversity conservation law. Lao PDR acceded to the Convention on Biological Diversity in 1996, to the Cartagena Protocol on Biosafety in 2004, and to the International Treaty on Plant Genetic Resources for Food and Agriculture in 2006.

1.1. The Main Values of Plant Genetic Resources

Virtually, every plant in the biodiversity has some value to Lao people. Those plants are important as staple food, vegetables, fruits, medicinal herbs, oil and perfume, ornaments, decorations, shelters and for small cottage industry. Direct and indirect contribution of plant genetic resources accounted more than 49% of the GDP in 2001.

Rice is the most important crop for Lao people. It is not only the quantity of rice but also the quality, which is highly important in their diet. Lao people are the world largest consumer of high glutinous sticky rice. The center of origin of glutinous rice is Lao PDR. A large number of glutinous rice varieties with different fragrant and eating qualities are cultivated, and their distribution across Lao PDR is related to the distribution of different ethnic communities.

Vegetables are the second most important food crops in Lao PDR and are the main sources of dietary nutrients for the rural communities. Farmers grow more than 45 vegetable species in their home gardens (per. comm. DED). A number of non-cultivated vegetables and fruits directly harvested from the forest complement these.

1.2. Diversity Within and Between Crops

A number of crops are grown in Lao PDR. Rice and vegetables are the major crops while fruits, corn, tubers, cereal crops, legume spices, and pasture are considered as minor crops. Sugarcane, coffee, rubber, cotton and tea are the dominant high-valued industrial crops. Multipurpose timber trees, medicinal plants, pasture, fodder legumes, and semi-wood crops belong to economically important non-cultivated, non-timber forest products.

Farmers are adopting modern varieties of crops due to their higher yield potential over local landrace material. There are also locally improved and imported varieties of rice, vegetables and fruits species. Farmers are still nurturing their traditional varieties because of their locally appreciated characteristics and quality, better adaptation to different farming conditions, low input requirement and resistance to pests and diseases.

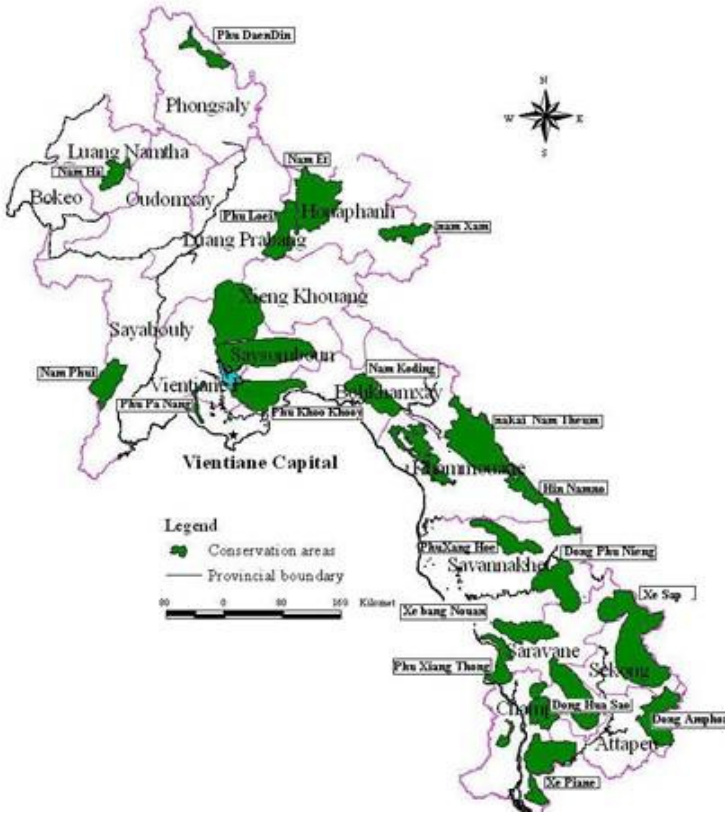


Figure 2. National biodiversity conservation areas in Lao PDR (NAFRI-GIS Unit, 2006).

1.2.1. The State of Diversity in Major Crops

NAFRI in collaboration with international organizations have taken measures to identify and conserve the biodiversity to preserve valuable genetic material for future use. With the aid of international funding organizations, the NAFRI has initiated several biodiversity programs for several crops and their varieties. The Rice Biodiversity Project for Collection of Rice Gene Pool funded by the SDC, and Conservation and Sustainable Utilization of Agro Biodiversity Project for Vegetables funded by the German Development Service (DED) are two projects through which useful information on diversity of plant genetic resources of rice and vegetables have been collected from as many as 15,000 accessions.

Rice in Lao PDR

Lao PDR lies within the primary center of origin and domestication of rice (*Oryza sativa* L.). Farmers traditionally grow glutinous and photoperiod sensitive varieties in rainfed environments. They often grow a handful of varieties with different maturity to enable harvesting at different times. Rice varieties grown in three ecosystems are different in terms of morphological, physiological, agronomical and nutritional attributes. Traditional lowland varieties are more uniform than upland varieties. In the past, traditional farmers used small plots in the same field to grow several local varieties.

After the introduction of modern cultivars in 1993, more than 70% of the area, in provinces along Mekong River, has been cultivated with improved varieties. Since 1993, the rice production in rainfed lowland ecosystem has increased with the introduction of foreign genetic resources via the Lao-IRRI program. The popular TDK varieties are the most common modern rice varieties available in Lao PDR.

The rainfed upland ecosystem is mostly under slash-and-burn system and has heavy slopes with gradients of 15-60% in attitudes from 300 to 600m. Only 10 to 11 traditional varieties with wide variation in many attributes, including maturity and height, are grown in this ecosystem. Upland rice is always grown with other grains and vegetable crops as a mixed culture.

Traditional rice varieties in both rainfed upland and lowland ecosystems differ in crop duration and plant characteristics such as height, tillering, color, panicle shape and size, grain shape and size, and (mostly) cooking and eating quality. A large number of aromatic rice among local indigenous varieties is grown in both lowland and upland ecosystems. These local cultivars have a high economic value for export market. Most of the traditional varieties (85%) are glutinous rice. However, under current economic situation in Lao PDR, glutinous varieties may gradually disappear unless modern glutinous varieties with high yield become available for cultivation.

Vegetables in Lao PDR

Vegetables are an important crop group for food security in Lao PDR. Laotians mostly consume locally grown and wild vegetables. There is a wide range of local traditional vegetables that are grown in upland conditions in the dry season. They are mainly from *Leguminosae, Cruciferae, Solanaceae* (Figure 3)*, Cucurbitaceae* and *Amaranthaceae* families.

Figure 3: Diversity within indigenous eggplant species and seeds of different beans and spices in Lao PDR (Courtesy of DED project at HHRC).

The demand for vegetables is high during the wet season as well as in the dry season, however, most of the vegetable varieties grown in wet season are susceptible to rain damage, water lodging and diseases. This reduces the supply of vegetables and pushes up their price in the market during this period of the year (Figure 4). The agro biodiversity project at the HHRC addressed this issue and identified a small number of genetic resources suitable for cultivation during the wet season.

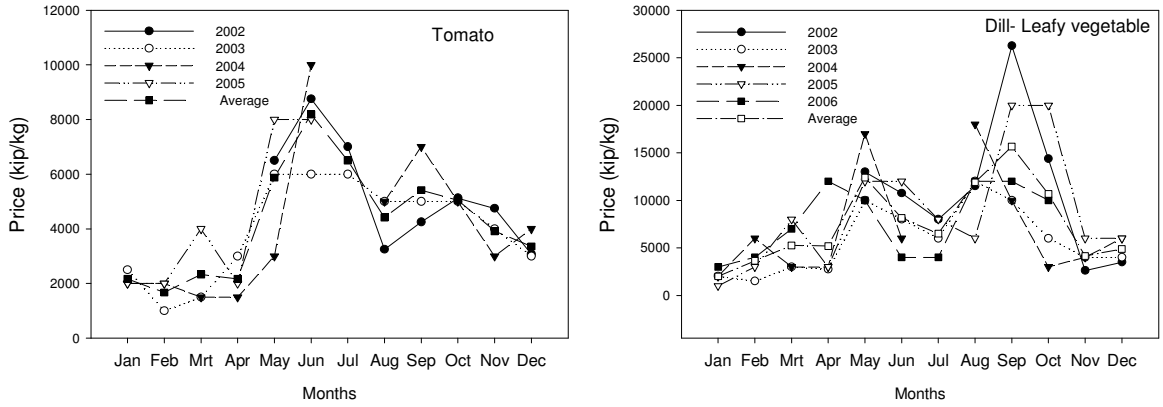


Figure 4. Seasonal variation in price of tomato and dill during the last 5 years (2002 to 2006) in Vientiane Capital (Courtesy of HHRC).

Non-cultivated vegetables are harvested from the forest and wetland areas closer to farms. They are from families of *Gramineae* (*Paspalum* sp.), *Amaranthaceae* (wild amaranth), *Solanaceae* (wild eggplant). It is reported that over 700 species of wild plants are utilized for food and other uses[6].

Diversity among local vegetable genetic resources

Table 3. A list of vegetables commonly consumed in Lao PDR

Allium fistulosum (Multiplier onion)	*Ipomoea aquatica* (Water convolvulus)
Allium fistulosum (Shallots)	*Lablab purpureus* (Lablab bean)
Allium sativum (Garlic)	*Lactuca sativa* (Lettuce)
Allium sepa (Onion)	*Luffa acutangula* (Angled loofah)
Amaranthus dubius (Amaranth)	*Luffa cylindrical* (Smooth loofah)
Amaranthus spinosus (Phak hom nam)	*Luffa* spp. (Marbouwk)
Anethum graveolens (Dill)	*Lycopersicon esculentum* (Tomato)
Apium graveolens (Celery)	*Mentha cordifolia* (Mint)
Bambusa arundinacea (Bamboo shoot)	*Momordica charantia* (Bitter gourd)
Brassica juncea var *foliosa* (Chinese mustard)	*Ocimum sanctum* (Basil)
Brassica oleracea (Cauliflower)	*Raphanus sativum* (Radish)
Brassica oleracea (Chinese kale)	*Sechium edule* (Chayote)
Brassica rapa (Cabbage)	*Solanum tuberosum* (Potatoes)
Brassica rapa var chinensis (Phak choi)	*Solanum melongena* (Eggplant green)
Capsicum annuum (Hot pepper)	*Solanum melongena* (Eggplant pink)
Capsicum frutescens (Sweet pepper)	*Passiflora foetida* (Phak bouang)
Carica papaya (Papaya)	*Phaseolus vulgaris* (French beans)
Coriandrum sativum (Coriander)	*Pisum sativum* (Pea)
Cucumis pepo (Pumpkin)	*Trichosanthes anguina* (Snake gourd)
Cucumis sativus (Cucumber)	*Vigna sesquipedalis* (Yard long beans)
Daucus carota (Carrots)	*Zea mays* (Sweet corn)

There are more than 45 farm grown vegetable species consumed in Lao PDR. The most important local vegetables for food security are shown in Table 3. Among them Chinese

[6] Kirjavainen, L.M, 2004. Symposium on biodiversity for food security. Proceedings, 14 October, MAF

mustard, phak choi, yard long bean, cucumber, eggplant, tomato and chilli are grown widely in home gardens. There are two different types of indigenous vegetables (landraces). They include crop varieties selected by farmers which have evolved in farmed fields known as "Farmer's Vegetables" and the varieties that are primitive, mostly non-cultivated and have adapted to different local environmental conditions are known as "wild vegetables" (per.comm. DED).

1.2.2. The State of Diversity in Minor and Underutilized Crops

Diversity among local fruit crops and plantation crops

The biodiversity of fruits and berries is a valuable asset for food security and nutrition values in Lao PDR. The diversity of local fruit species has not changed significantly in last 10 years. In recent years, Lao PDR has imported a large quantity of fruits from neighboring countries; therefore, the demand for local fruits has severely dropped. This change could influence the market of local fruits and nuts in the future. While these changes have affected the choice of foods in urban communities, rural farmers are still enjoying their local fruits. There is some evidence that several landraces are left behind while the cropped area of introduced varieties is increasing.

A number of local landraces including papaya (*Carica papaya*), banana (*Musa sapientum*), mango (*Mangifera indica*), orange (*Citrus sinensis*), pineapple (*Ananas comosus*), water melon (*Citrullus lanatus*) and passion fruits (*Passiflora edulis*) are at risk of disappearing from urban areas. There are only a few surveys and inventories available on indigenous fruits such as Burmese grape (Mak fai) (*Baccaurea ramiflora* Lour.), chestnut (*Castanopsis indica* Roxb.), wild mango (*Spondias pinnata*), raspberry (*Rubus multibracteatus* Lév.). These indigenous fruit species have both nutritive and medicinal values and their collection and conservation is an urgent requirement for preserving biodiversity in Lao PDR.

Industrial crops like coffee (*Coffea arabica, Coffea robusta*, *Coffea canephora*), cotton (*Gossypium hirsutum*), tea (*Thea sinensis*), sugar (*Saccharum officinarum*), rubber (*Hevea brasiliensis*) and paper mulberry (*Bryonia alba*) are growing in different parts of Lao PDR in small scale. During last 10 years, rubber and coffee cultivation in Lao PDR has been increased.

1.2.3. The State of Diversity in Wild Plants for Food

Diversity Among Non Timber Forest Products

About 80% of the population lives in rural areas and nearly 50% of their income is from a wide range of non-timber forest products (NTFP) (Annexure i). These non-cultivated products are as important as major crops to Lao people. These products are vegetables, nuts, fruits, spices, medicinal herbs, ornamentals, flowers and species providing raw material for small cottage industry. Some of these genetic resources are used for multiple purposes such as food and medicine.

Mushrooms, bamboo shoots and other various leafy vegetables are among the non-cultivated vegetables in Lao PDR. Due to the abundance of wild vegetables, farmers are able to make use of this diversity throughout the year. Rural farmers are custodians of a rich Indigenous Knowledge (IK) on conservation of this genetic material. Identification of crops, time of harvest, and management of other forest crops to provide sustainable growth for wild vegetables are some aspects of the IK important for sustainability.

Cardamom, lemongrass, broom grass and rattans became commercially useful in Lao PDR during last few years. Farmers harvest these crops mostly from the forest. In recent years, new plantations have been established in Lao PDR with these crops (Annexure ii).

1.2.4. The Diversity Changes in Modern Varieties and Landraces

Improved varieties and popular landrace materials were developed/selected for yield, food quality, and tolerance/resistance to biotic and abiotic stress conditions. This has occurred particularly for rice. Better landraces were selected from the vegetable germplasm and distributed to different regions. Selected materials are popular in urban commercial farms while traditional varieties are still grown in rural farms and back yards. Figure 5 shows the distribution of improved cultivars and selected landraces in recent years.

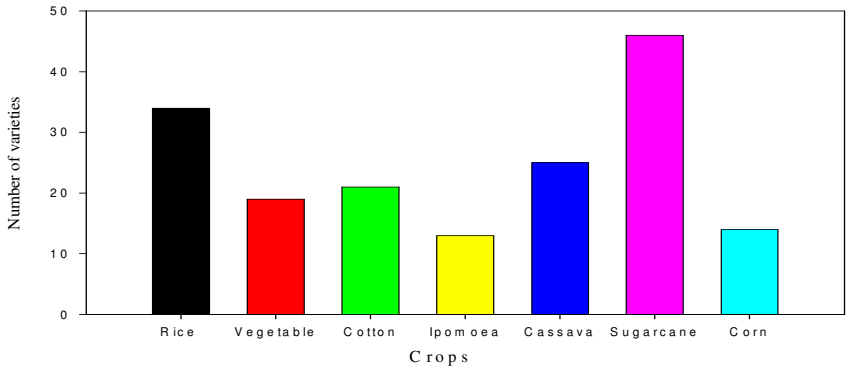


Figure 5. Number of improved varieties (modern) and selected landraces made available for different crops during last 10 years in Lao PDR.

1.3. Factors Influencing the State of Plant Genetic Diversity

1.3.1. Changing Consumer Preference for Food

Unlike consumers in most developed countries, Laotians enjoy food in a specific manner. Patterns of food consumption are different between people living in rural and urban areas. Urban dwellers mostly buy their food products from markets, whereas the rural community grows their own food products in their farms or backyards during the wet and dry seasons. When food is scarce, villagers use non-cultivated food crops as supplements. Therefore, the cultivated and non-cultivated food crops are equally important for food security in the rural community.

Traditional dietary habits have not changed much with the changes in the economy. There are some changes in supply of food products to the market. During the last few years, the urban community consumed more imported fruits than the local fruit varieties, as new exotic fruit species such as apple, pear, mango and rambutan have been introduced to the market. However, some local fruits and vegetables are still popular in the urban and rural markets. There are small differences in selection of vegetables for cultivation in central and southern Laos. The high demand for value-added vegetable crops in some seasons force farmers to grow short duration crops in southern Laos while traditional vegetables are commonly grown in central Laos.

1.3.2. Factors Creating Genetic Erosion in Lao PDR

In this section, the genetic erosion refers to the loss of varieties from the crop and crop-associated biodiversity. Improvement of landrace material through breeding programs could cause genetic erosion at gene or allele level. Though such programs have been started in recent years, breeders have also taken measures to conserve genetic material for future use.

Economic, social and cultural factors increasing vulnerability or inducing erosion of crop and crop-associated biodiversity in Lao PDR are listed below:

- Rapid trend towards the introduction of modern varieties for increase productivity in the rural agriculture sector resulting in the displacement or disappearance of local landrace cultivars from their origin (eg. the role of modern rice varieties in rural sector)
- Less interest on local landraces, especially local fruits and some vegetables, due to their poor yielding ability and quality
- Less attention on utilizing some PGRFA (local fruits and wild flower) because of low impact on the current market economy
- Shifting from traditional agriculture to market-oriented agriculture (crops with high seasonal or periodic demand)
- High production (yield) targets under moderate to low input management (eg. by 2010 the government is aiming at 3.2 million tons of rice production in Lao PDR)
- Rapid exploitation of some genetic material to meet the emerging and inconsistent demand for genetic material from conservation areas (eg. rapid declining of wild orchid species from the forest area in the south)
- Land clearing
- Poor communication between conservation groups and the timber industry in order to protect the genetic resources from human activities
- Lack of resources and training for monitoring genetic resources
- Floods, droughts, pest and disease outbreaks
- Lack of an early warning system to protect biodiversity in Lao PDR

1.4. Future Needs and Priorities for Increasing Awareness of PGRFA

FAO, through the FNPP, has assisted Lao PDR to improve the awareness of the contribution of non-wood forest products and agricultural biodiversity to food security, nutrition and sustainable livelihoods. This has been done through improved understanding and development of market opportunities to improve rural livelihood. The current public awareness on the importance of PGRFA and conservation is generally poor. The public media should be used to convey the message that conservation of PGRFA is a national obligation and an important requirement for food security. Public involvement in genetic conservation programs such as tree planting can be introduced. Student involvements in genetic conservation programs such as herbarium collection, tree planting, class excursions are necessary to increase their enthusiasm. University level curricula in the fields of Botany, Taxonomy, Plant Ecology, Population Dynamics, Evolutionary Genetics and Forestry are necessary to encourage young graduates to work in PGRFA programs. Urgent consideration is needed to establish an early warning system to prevent sudden erosion of biodiversity in protected areas. A systematic study and documentation of Indigenous Knowledge (IK) is also important.

1.5. Priority for Capacity Building Needs

Broad based plant genetic conservation training programs are required for staff at all levels including scientists, technical staff, forest management, law enforcement staff, voluntary conservation groups, forest guards and people involved in the timber industry. It is necessary to develop links between international organizations to learn and share appropriate knowledge on PGR erosion and conservation. The local expert knowledge on rice biodiversity programs in Lao PDR is valuable for developing new projects on other crops such as fruits, flowers and small industrial crops.

1.6. Priorities for Better Understanding the Role and Value of PGR in Lao PDR

Economic:

The identification and development of alternative markets for diverse products is important. For instance, aromatic-organic rice and aromatic-black rice are prime contenders for export and tourism industry. International support is needed to maintain high standards of new products. Improved technology is required to maintain high nutritive and medicinal values of products made from local fruits and vegetables. The variety of flowers in Lao PDR is an excellent resource for interior and exterior decorations, mainly for festivals and tourism industry. Research is needed to promote cut flowers and leaves (ornament plants) industry in the export market (eg. croton). Opportunities for increased utilization of pasture, fodder, semi-wood tree crops and legumes in animal production system should be explored.

Social & Cultural:

Promotion of local landrace cultivars and adoption of sustainable cropping systems with new knowledge on crop production will lead to improve yields in farms. Also indigenous knowledge (IK) can be transferred to other rural areas where appropriate and necessary. Seed production and storage, seed drying, cultivar selection and plant protection are some of the practices where local knowledge is useful in improving yields in rural farms.

***Ecological*:**

The ecological value of plant genetic resources is demonstrated by their wider adaptability across agro ecosystems, survival from pest and disease outbreaks, multiple uses (eg. nutritional and medicinal), diverse tastes, color, shape and smell of products, naturally occurring secondary products (eg. bee honey and wax), and their contribution to the environment.

1.7. Priorities for Improved Monitoring of Genetic Resources

The top most priority should be the completion of the database on PGRFA in the NISM. This database provides an overall view of PGRFA available in Lao PDR and their current status. Future priorities for improved monitoring system of PGRFA are (i) the allocation of more resources, (ii) the coordination of existing PGRFA monitoring systems, (iii) the development of a common awareness among different groups regarding threats that could cause erosion of genetic resources in different locations, (iv) capacity building and (v) the establishment of a network between national, regional and international stakeholders.

Chapter 2
The State of *In Situ* Management

2. Introduction

There are different approaches for conservation of PGR. *In situ*, on-farm and *ex situ* conservation approaches have been well applied in many countries[7]. Information on conservation methods are used to minimize the erosion of PGR from potential environmental hazards and human interferences. With regard to *in situ* conservation, genetic resources remain directly in the hands of the primary users. Traditional and primitive indigenous knowledge (IK) plays a vital role in conservation of PGR. *In situ* conservation allows plant genetic resources or different plant species to be maintained in their natural ecosystems or agro ecosystems. This helps to continue the evolutionary process in the plant kingdom.

In the rural agricultural sector, on-farm conservation evolves landrace material because of natural selection as well as directional selection for specific characters in the plant population. This selection process creates some negative effects on diversity of genetic resources, because some old genetic material could easily be discarded due to lack of distinct functional attributes.

2.1. Surveys and Inventories of PGRFA

The NAFRI, and its research centers (ARC, HHRC, FRC and LRC), international institutes and the National University of Lao PDR, have conducted a number of surveys, on rice, vegetables, fruits, medicinal plants and non timber products. Several surveys and reports are available on few other crops as well. As a result, a large quantity of information is available for rice, vegetables, trees and NTFP in Lao PDR. Different formats of information recording are available for most of the crops surveyed. In many cases, surveys offered an opportunity for collecting germplasm to be stored *ex situ*. At present, surveying activities are restricted due to financial resource and staff limitations. In addition, lack of skilled staff to continue botanical and taxonomic studies hinder the progress of most of the biodiversity projects in Lao PDR.

A number of systematic surveys were conducted during last 12 years, mainly for rice and vegetable in Lao PDR. For the current country report, most of the information was collected from the rice biodiversity projects and vegetable agro biodiversity project conducted at NAFRI with the technical and financial assistance from the Lao-IRRI and DED projects, respectively.

2.1.1. Rice

Inventories and Surveys Prior to 1995

Several agencies have collected more than 3,000 accessions of cultivated landrace material between 1970 and 1990. Unfortunately, most of the information from this period is missing and the PGR have disappeared due to lack of documentation and proper *ex situ* conservation practices. Some information is available from a survey conducted on wild rice (*Oryza rufipogon, Oryza granulate* and *Oryza nivara*) by the MAF and IRRI in 1989, but the passport information on PGR during this period is limited.

The plant improvement units at the NAFRI and IRRI germplasm collection based in Lao

[7] The State of the World's Plant genetic Resources for Food and Agriculture, Rome 1997

PDR have been involved in a series of surveys covering rice PGR. Passport information was collected for (1) traditional cultivars (landraces) grown by farmers for generations, (2) varieties developed through mass selection from popular landraces (*Ta khiet, Dolay, Nang nuan, Homnang nuan* and *Sampathong*), (3) weedy intermediate rice; hybrids between wild and cultivated varieties and (4) wild rice from outside farms. The locations of these surveys are presented in Figure 6.

Inventories and Surveys (1995-2000)

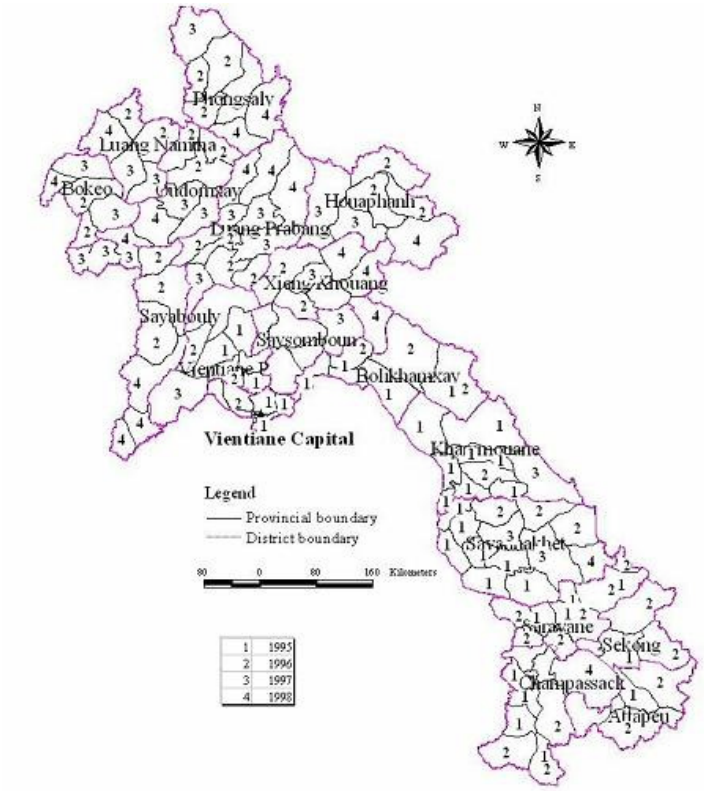
In 1995, three surveys were conducted in five central and four southern provinces. Two to five districts were selected from each province covering 51 districts. Large environmental variations were observed across these locations. The first survey was able to document information on 2145 accessions from these districts. Most of the accessions were glutinous rice. There were 72 wild rice samples from *Oryza rufipogon* and *Oryza nivara*, and also some hybrids between cultivated rice and wild rice.

Four surveys conducted in 1996 covered 80 districts in 18 provinces. On-farm surveys were conducted for both rainfed upland and lowland ecosystems. Local varieties used for transplanting were collected from Oudomxay, Luang Namtha and Phongsaly. The varieties collected from these locations are specific for cold conditions. Xieng Khouang and Phongsaly often experience cold weather during rice establishment in wet season. Several wild rice types were collected from Champassak (*Oryza ridleyi*), Khammouane (*Oryza officinalis*), Luang Prabang and Oudomxay (*Oryza granulate*). *Oryza nivara* and *Oryza rufipogon* were also collected from other districts. The total number documented was 4223 accessions.

The 1997 survey commenced in September 1997 and continued until February 1998. A total of 3846 accessions were documented from 94 districts in 17 provinces. There were 39 accessions of wild rice and wild hybrids from *Oryza officinalis*, *Oryza rufipogon, Oryza granulate* and *Oryza nivara.* In the dry season of 1998, 570 accessions were documented from farms where the seeds were stored as mixed seed. These mixtures were physically separated before *ex situ* conservation.

Two surveys conducted from September to December 1998 covered 17 provinces. As a result, 2392 accessions of genetic materials were documented. During September 1998, mainly central and southern regions were surveyed and 142 accessions with early maturing attributes were documented. New areas in the northern districts were surveyed between September and October and 583 accessions with early and medium maturing attributes were documented. In November-December, the survey was extended to areas which were not surveyed during previous expeditions. About 800 late maturing accessions were documented from farmers' threshing floors and stores.

The local extension staff conducted the 1999-2000 survey after obtaining intensive training on germplasm collection. They documented 586 accessions of cultivated local rice



and one wild rice accession. Areas previously unobserved due to very poor road accessibility were covered in this survey. However, 39 samples were documented from Thathom district in Xaisomboune Special region during the 1999 survey.

Figure 6. Districts identified for rice genetic resource collection during 1995-1998[7]

Table 4. The details of 12 surveys[8] conducted for the exploration of rice genetic resources in Lao PDR since 1995

Surveying and inventorying	Number of surveys			No of accessions documented	Percentage
	Province	Districts	Number of Surveys		
August- December 1995	9	51	3	2145	16.3
October 1996- February 1997	18	80	4	4223	32.0
September 1997- February 1998	17	94	1	3846	29.2
September 1998- December 1998	17	69	3	2392	18.1
October 1999-April 2000	12	21	1	586	4.4
Total	18	136	12	13196	100

There were also 362 upland rice accessions and 224 lowland accessions recorded, and among them 499 accessions were glutinous and the rest nonglutinous. However, some passport information of this collection was incomplete. The summary of the rice genetic resource surveys is presented in Table 4.

[8] Appa Rao et al., 2001[a].Collecion, classification and conservation of cultivated and wild rice of the Lao PDR, Genetic Resources and Crop Evolution 49: 75-81.

2.1.2. Vegetables

There is limited information available on surveys of vegetable genetic resources prior to 2002. Mainly forest areas were surveyed for plant species, thus some information on wild and cultivated vegetables is available under a NTFP survey in 1998. Between 2002 and 2006, with the financial assistance of the DED, scientists from the NAFRI and HHRC conducted a comprehensive survey in 14 provinces on vegetable genetic resources in Lao PDR. The area and number of visits are presented in Figure 7. During the period of this survey, 9 visits were made to 17 provinces and 1 Special Zone. The total surveyed area covered 76 districts and 281 villages. The number of accessions documented from different agro-ecological zones is shown in Figure 7. The most common vegetables in different locations are given in Table 5.

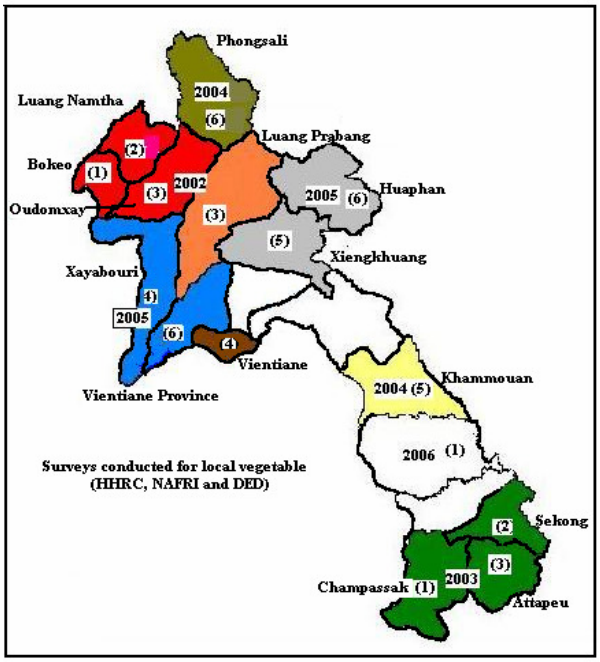


Figure 7. The area (provinces) surveyed for the exploration of local germplasm for vegetables by the HHRC, NAFRI and DED since 2002. The number of visits for each location is shown within brackets (per comm. DED project).

Prior to 2002, only one survey on non-cultivated vegetable species was carried out in forest ecosystems in Lao PDR. Records identifying those areas for *in situ* conservation are available and information have been documented. Systematic data recording (passport information) is necessary for follow-up surveys in order to initiate early warning system and minimize erosion of these genetic resources.

A number of cultivated, traditional and non-traditional plants were found in rural agro-ecological systems including slash-and-burn ecosystem. Rural farmers grow vegetables in home backyards, highland areas along with cereals, along paddy field bunds, or even in small pots. Few farmers also use parts of their paddy fields for vegetable cultivation in dry season. A majority of vegetable seeds in the villages are produced by farmers and stored in small containers for cultivation in the next season. Seed exchange is also a common practice in many villages. There is a traditional system of seed production and sharing of local vegetable seed among villagers in most of the surveyed areas. The farmers use their traditional knowledge to select seed material from their crops for the next season.

Table 5. Popular vegetables grown in different agro-ecological regions in Lao PDR (2006)

Region	Vegetable crops	Number of accessions
Northern Highland	Chilli, Legumes, Cucumber, Phak choi, Eggplant	357
Northern Lowland	Legumes, Phak choi, Loofah, Chilli, Cucumber	800
Vientiane Plain	Tomato, Lettuce, Phak choi, Chilli, Eggplant	156
Mekong Corridor	Legumes, Loofah, Phak choi, Chilli, Corn	443
Central & Southern Highland	Legumes, Eggplant, Loofah, Chilli, Corn	210
Boloven Plateau	Chilli, Eggplant, Corn, Phak choi, Legumes	103
	Total*	2069

* 2007, collection total is 2140

2.1.3. Other Annual and Perennial Crops

The ARC conducted few other surveys on maize, cassava, sweet potato, and sugarcane. Most of these surveys were conducted in households in the Vientiane municipality, Vientiane province, Luang Namtha, Xieng Khouang, Huapanh and Luang Prabang provinces. The ARC conducted 3 surveys in 2003, 2005 and 2006 for maize accessions. It also conducted a survey on crop genetic resources of cassava. Though cassava is an introduced crop, it has been grown in Lao PDR for many years. The genetic material of cassava is mainly from Thailand, Vietnam, Indonesia and China. A survey was conducted in three provinces; Xieng Khouang, Vientiane Province and Oudomxay, however, passport information was not documented for any of those accessions. As per forage species no surveys have ever been conducted.

2.1.4. Non Timber Forest Product (NTFP)

Descriptive information is available for a large number of NTFP found in Lao PDR, but the passport information was not available for *in situ* conservation. There are no reports available from successive surveys conducted to gather more information on these crops. A list of NTFP available in Lao PDR is given in Annexure i. The FRC undertakes management projects on NTFP, however, the human and financial resources are inadequate for conducting surveys and monitoring the extent of erosion of genetic materials from their natural habitat.

Limited information is available on *in situ* conservation of biodiversity for other crops such as cassava, sweet potato, sugarcane, non timber products, flowers and medicinal plants. Monitoring the progress of *in situ* conservation is lacking for most crops.

2.1.5. Medicinal Plants

A field survey[9] on commonly used medicinal plants in Pakse and Bolikhamxay provinces identified 55 species from 31 families (49 genera) of vascular plants. The survey was conducted with 600 villagers using the two-stage stratified sampling procedure. The focus group discussion (FGD) was conducted amongst health officials and villagers in the same district. The local names of these plants, target sickness or purpose and preparation method of local medicine were recorded. These genetic materials are either planted in household backyards or collected from the forest area. The native doctors grow most of these rare genetic resources in their home gardens (*in situ* conservation) and continue to use for medicinal purposes. Almost 77% of households use these plants as herbal medicine

[9] Kongmany Sydara, 2005. Use of Traditional Medicine in Lao PDR. Complementary Therapies in Medicine.p1-7.

and for sauna, massage and acupuncture. Systematic documentation of surveyed data on medicinal PGR is essential. No records are available on follow-up surveys. Due to lack of resources and trained staff, the conservation and documentation was weakened. However, the National University of Lao PDR is keen in continuing the program on *in situ* conservation of natural medicinal plants.

2.2. On-farm Management and Improvement of PGRFA

The Lao government has set priorities for on-farm management of rice. The rice breeding and variety testing programs at the NAFRI and regional research centers encourage farmers to grow local landraces in their farms where there are limited resources of high inputs such as fertilizer and pesticides. Some farmers have introduced few popular local landraces from different locations in Lao PDR. The identified landraces were multiplied and distributed among villagers by the respective farmer. Such information has been recorded for 10 landraces identified from different locations[10].

Information documented from surveys is used in characterizing genetic resources. The surveys also assist in identifying the distribution of rice genetic resources in relation to various ethnic groups in Lao PDR. The Bolikhans ethnic group prefers rice varieties with long peduncle because they harvest only panicles using sharp blade. The Phouthai ethnic group in Xepon district in Savannakhet collects seeds by hand striping and prefers cultivars with few upright panicles carrying large number of seeds. These community preferences will help on-farm conservation of most indigenous rice genetic resources.

During the past decade, provincial agricultural research and extension centers have been established in main agricultural areas. Researchers have developed crop research programs to improve the productivity of crops in local farms. Rice is one of the main crops that research and extension workers are working together in order to help farmers. Recently, the NAFRI and ARC introduced the participatory variety selection program for rice and anticipate to carry out further training programs for farmers and extension workers in the future.

Rice and vegetable projects on PGRFA have encouraged farmers to conserve their landraces in their farms and provided new genetic material to diversify their genetic resources for better productivity. The re-introduction of local aromatic and glutinous rice cultivars from the rice germplasm at the ARC to rural and urban farmers and the distribution of vegetable seed by the HHRC are aimed at improving on-farm conservation of genetic resources.

2.3. Restoring Agriculture Systems after Disasters

Floods and droughts are the major natural disasters in Lao PDR. Natural plant genetic resources in mountainous areas are frequently destroyed by forest fire due to slash-and–burn agriculture system. Until this problem is fully addressed, training programs covering the basic practices in forest fire prevention, management, suppression and restoration for guards, forest workers and local communities can play a vital role in handling such circumstances. The current government policy aims to discourage slash-and-burn and settle farmers permanently on cleared land. The government supports farmers to grow pasture, cover crops, trees and fruit crops on the land and train them to use non-tillage practices for crop establishment to minimize erosion. In addition, the government provides cultivable land from lowland areas for paddy cultivation.

[10] Appa Rao et al., 2006. In "Rice in Lao PDR" Eds. J.M.Schiller, MB Chanphengxay, B. Linquist and Appa Rao, IRRI publication

During the wet season, flooding is common in lowlands along the Mekong River in central and southern Laos. The natural habitats in the region are able to rejuvenate after the waters recede. Information is available on the impact of floods on cultivated crops in the region. Flooding has occurred in the central region in 22 years of the last 35 years.[11] The floods and drought regularly destroy rice crops in this region. Facilities available for *ex situ* conservation of rice in Lao PDR play a key role in restoring popular variety spectrum in the respective rural areas.

Human interference is another means of diminishing forest genetic resources. There is evidence of illegal removal of important PGR from their natural habitat by organized groups of people. Regeneration of endemic species currently being illicitly removed from these forests would be a substantial cost to the country. For example, the wild orchid populations in the southern forest are more vulnerable to genetic erosion caused by human interference. Therefore, it is necessary to develop and enforce laws and other protection measures to ensure that utilization of forest resources is only undertaken in a legitimate and controlled manner. This includes conducting appropriate awareness and education programs on conservation of the biodiversity among communities living within or near forest areas. It may also involve sharing of responsibilities and benefits with local people.

2.4. Non-cultivated Forest Product for Food Security in Lao PDR

In general, the farming community mostly consumes cultivated crops and any surplus is available for marketing. The cash flow from selling crops other than rice is an additional income to the household. Farmers also utilize non-cultivated traditional crops from forest ecosystems. The dynamic *in situ* management of forest biodiversity is important in the current changing economic environment. The Lao Government has committed to conducting public awareness programs on *in situ* conservation of NTFP for food and biodiversity. In conjunction with the FAO, IUCN and SNV, the NAFRI has developed several projects on conservation and sustainable utilization of NTFP to increase public awareness and reduce threat of their extinction from the biodiversity.

The TCP project "Non wood forest products (NWFP) community-based enterprise development: a way for livelihood improvement in Lao PDR" (NAFRI, FAO and SNV) provide important guidance to support rural farmers to make the transition from subsistence farming to market-oriented agriculture. For example, the project in Savannakhet in the Central Laos assists 45 farmers to grow mushrooms for their consumption and to develop small market for fresh mushrooms. The sale of mushrooms provides supplementary revenue to the household in addition to the income from upland cultivation. Similar work is carried out in Champassak and Luang Prabang provinces, which assist farmers to develop sustainable management programs for several NWFP.

The bitter bamboo shoot management in Oudomxay province in north is another *in situ* conservation project that assists farmers to increase their food security using wild genetic resources. This project aims to supply bitter bamboo shoot to Yunnan Province of China. Under this project around 50 families are able to manage an area of 550ha of bitter bamboo.

Thus the genetic resources are well conserved in their habitats while a substantial income is earned from the forest. Farmers keep 10% of the product for their consumption and earn about 49% of their family income by selling the rest. There are other non-cultivated forest

[11] Schiller et al, 2000. Increased lowland rice production in the Mekong Region. ACIAR proceedings, 101, pp327.

products managed by rural farmers in Lao PDR. These crops include cardamom, rattan, paper mulberry, broom grass and some leafy vegetables. In addition, many other wild crops and some important wild fruit species under the threat of extinction are also being utilized by rural farmers.

2.5. Priorities and Needs for Improvement of *In Situ* Management

There is limited awareness within communities with reference to the policies and regulations on *in situ* conservation of PGR outside the highly protected forest areas. Several surveys and expeditions were conducted to identify areas with rich biodiversity in these forests. However, systematic inventory and passport information is available only for a small number of crops. Therefore, priority should be given to collate all available data into the national inventory of PGRFA in the NISM.

In situ management has been reported for rice, vegetables and few other products. The management programs could be extended for other crops such as fruits, medicinal plants, non-wood forest products and tuber crops. Currently, limited information is available on those crops to identify their original habitats. Further surveys should be conducted to conserve genetic resources at risk of erosion. Most of the surveying activities initially utilized small samples of the village populations to introduce *in situ* or on-farm PGR management systems at village basis. However, the success of any activity mainly depends upon the level of enthusiasm of the village community. Considering the diversity of the population's cultural and ethnic beliefs and their willingness to accept changes, the level of ultimate success of any program will need to be re-assessed countrywide.

Developing interrelationships is pivotal among institutes of genetic resource management (ARC, HHRC, FRC, LRC, CRC and Universities) and organizations with developing interest on the conservation of biodiversity. The knowledge of disciplines such as Socio-economics, Taxonomy, Conservation Biology, Forest Ecology, Information Technology, Farming System and Agronomy, Evolutionary Genetics and Breeding needs to be shared when ever required.

Funds should be made available to train staff to initiate research and development plans on effective *in situ* management system. Currently, few staff members have enrolled in postgraduate training programs on *in situ* management and indigenous knowledge (IK) on rice and vegetable on-farm conservation. However, it is important to train more scientists to build an adequate work force for crop genetic resource management.

The ARC in NAFRI recently initiated a farmer participatory selection program for advanced lines including landraces. Rice breeders at ARC recommended farmer selections to the same rice ecosystems and encouraged the provincial seed production systems to use them for multiplication. The farmers maintain few local landraces in their rice ecosystem. Such activities should be expanded for other crops.

2.6. The Major Constraints Identified for *In Situ* Management

Reduced budgets are the main constraints which restrict the continuation of broad surveys of PGR and conservation. Most activities are funded by external projects and are at risk of discontinuing after the committed period. There is also an acute shortage of trained staff to employ in PGRFA. This shortage extends from field workers to scientists, socio economists to information technologists. Though there are staff engaged in postgraduate level training programs in overseas universities, their number is limited.

There is some confusion among villagers regarding the boundaries of the national conservation forest and the accessible forest areas for NTFP. This is due to the land allocation, which has proven to be problematic in these areas.

There is no mechanism or research methodology to quantify the erosion of PGRFA in Lao PDR. This is a real threat for the survival of PGR in areas where genetic erosion is rapid due to urbanization, establishment of plantations, and migration from subsistence to commercial agriculture. With the financial and technical assistance from regional and international organizations, an effective disaster warning system within Lao PDR can be established. Routine surveys should be conducted. This effective warning system would prevent or minimize erosion of the plant genetic material in Lao PDR, while being a dynamic mechanism to foster information exchange among countries. However, database management and timely updating of information are important for an early warning system.

Although many NTFP in *in situ* conservation are of considerable commercial importance, Lao PDR is losing much needed foreign earnings by allowing NTFP to pass borders unprocessed, illegally and un-documented. China is the dominant world trader of NTFP, with Thailand as a major supplier to the world market. However, knowing the state of resources in both these countries and Vietnam and the uncontrolled border trade from Lao PDR, it may well be that part of the trade originates from Lao PDR.

Chapter 3
The State of *Ex Situ* Management

3. Introduction

Lao PDR is proud to own one of the biggest rice gene banks in Asia. In an attempt to conserve the diversity of rice and other crops, Lao PDR has used static *ex situ* conservation methods such as field managements, seedbanks and material duplication internationally and locally. The state of *ex situ* conservation and management of PGR is satisfactory for some crops like rice and vegetables, but needs more attention for most of the other genetic resources which are currently under threat of genetic erosion.

3.1. Sustaining and Expanding *Ex Situ* Collections

Ex situ conservation allows plant genetic resources or different plant species to be maintained outside their natural ecosystems or agricultural habitat. This process augments the *in situ* conservation of genetic resources. Unlike *in situ* conservation, genetic evolution cannot be expected under *ex situ* conservation. This is a process of storing genetic diversity for long-term conservation and facilitating exploitation of the desirable genetic variation for securing food for future generations.

3.1.1. Main Ex Situ Collections

There are several *ex situ* genetic resource collections for different crops in Lao PDR (Table 6). The NAFRI (ARC, HHRC, FRC, LRC), national (University of Lao PDR) and international (IRRI, DED, SIDA) institutions have established *ex situ* conservation facilities of PGRFA particularly for rice, vegetables, fruits and non timber products. Seedbanks and field genebanks are the currently available facilities in the country. Seedbank facilities are available for rice and vegetables but are only able to maintain seed collections only for short to medium terms. Over a total of 15000 accessions are available in several *ex situ* collections at NAFRI's research centers. The research personnel at respective crop research centers maintain these genebanks. Field genebanks are in place for rice, vegetable, cassava, sugarcane, sweet potato, corn, pasture and fodder grasses and NTFP such as rattan and cardamom, broom grass and lemon grass.

Existing storage facilities are basic and the subsequent risk of loss is high due to various reasons, including inconsistent power supply and the lack of back-up power system, air-conditioning system, inadequate maintenance facilities, inadequate security and protection from natural hazards and lack of temporary storage facilities during emergencies. The limited availability and quality of instruments such as dryers, humidifiers, accurate moisture testing equipment and auto-climate recorders also affect the quality of seed storage in the seedbanks. These basic storage conditions have placed much of the valuable material in many *ex situ* collections at some risk of loss.

3.1.2. National Genebanks in Lao PDR

Though several systematic surveys have been conducted during the last 12 years, most of the conserved genetic material (seeds) is merely from rice and vegetables. There is limited detail available on *ex situ* conservation of genetic material from other crops such as cassava, sweet potato, sugarcane, non timber products, ornamental plants and medicinal plants. Clonally propagated crops and crops that rarely produce seeds are managed mainly in field genebanks.

Table 6. Stakeholders and programs on *ex situ* conservation of PGRFA in Lao PDR

Stakeholder	*Ex situ* conservation Program	Type of genebank	Number of accessions
Agricultural Research Centre	Lao traditional Rice Conservation	Seed genebank (medium term collections); Field genebank	13291
Agricultural Research Centre (NAFRI)	Corn introduction Project	Seed genebank (short term collections); Field genebank	44
Agricultural Research Centre (NAFRI)	Sugarcane genotype management	Field genebank	36
Agricultural Research Centre (NAFRI)	Wild Rice Conservation	Seed genebank (short term collections); Field genebank	16
Agricultural Research Centre (NAFRI)	Cassava Research Project	Field genebank	99
Forestry Research Centre (NAFRI)	Aquilaria crassna provenance trial	Botanical garden	
Forestry Research Centre (NAFRI)	Lao Tree seed project	Seed multiplication	50
Forestry Research Centre (NAFRI)	Rattan genetic resource	Field genebank	
Haddokkeo Horticulture Research Centre (NAFRI)	Agro-biodiversity Vegetable Seed production	Seed genebank (medium term collections); Seed genebank (short term collections)	2130

Rice Genebank

There is no material from surveys prior to 1995 for *ex situ* conservation, except for a few reports available on the collections. The medium-term seed storage facility was established for rice in 1997 at the ARC through the new biodiversity project for rice in Lao PDR.

Seed collection before 1995

In 1989, the MAF and IRRI conducted a survey on wild rice (*Oryza rufipogon, Oryza granulate* and *Oryza nivara*) and collected seeds for *ex situ* conservation at the ARC. However, this material was used for genetic evaluation and no indication of conservation is present though some have been used in breeding programs.

Seed collection 1995-2000

The number of seed samples collected and stored from North, Central and South Lao PDR after 1995 is 5,919 (44.8%), 4,625 (35.1%) and 2,652 (20.1%), respectively. Samples were separated for upland (55.9%) and lowland (44.1%) rice ecosystems. Within each ecosystem, accessions were identified as glutinous and non-glutinous. Among all, 85% carried glutinous endosperm (Table 7).

The rice collection is conserved under medium- and long-term storage conditions. Samples, 20 g in size, are stored in sealed plastic cans at 5^{o}C and 50% relative humidity, and in freezers at -18^{o}C and 8-12% seed moisture content. Though the ARC had taken proper safety measures for the smooth functioning of rice *ex situ* conservation facility, there were losses due to power failure. To avoid such situations, the entire germplasm was duplicated in long-term storage at the IRRI under an agreement signed by the Ministry of Agriculture and Forestry and the IRRI.

Table 7. Classification of rice accessions in *ex situ* conservation based on ecosystems and endosperm types

Region	Ecosystem				Endosperm type				Total Accesions
	Lowland		Upland		Glutinous		Nonglutinous		
	Accessions	%	Accessions	%	Accessions	%	Accessions	%	
Central	2868	49.3	1757	23.8	4102	36.4	523	27.3	4625
Northern	1332	22.9	4583	62.2	5037	44.7	878	45.9	5915
Southern	1621	27.8	1037	14.0	2140	19.0	512	26.8	2652
Total	5821		7371		11279		1913		13192

3.1.3. Vegetable Genebank at HHRC

The genetic conservation and utilization project for vegetables at the HHRC is a classic example to demonstrate the importance of local landrace material for food security in Lao PDR. The chain of activities was carefully tailored and a simple model was developed to address the vegetable shortage in the country.

The vegetable seedbank was established at the HHRC in 2002 with the assistance of the DED. The project aimed to collect and conserve seeds from all the available indigenous vegetable varieties under medium-term storage. It also aimed to develop research programs to identify most suitable vegetables for different regions. As a result, now more than 2140 accessions are conserved in the *ex situ* collection. Conservation facilities are equipped with two air conditioning units (one back-up), four fridges, equipment for seed drying, processing and packing, computers and glasshouse space.

Seed accessions from 13 vegetable species are stored in these seedbanks and the number of accessions varies from 15 to 320 for different vegetable species. More than 200 accessions are available from legumes, chilli, and mustard (Figure 8).

3.1.4. Ex Situ Conservation of Other Annual and Perennial Crops

Most of the stakeholders listed in Table 6 have field genebanks or seed gardens at their stations or elswhere. The ARC maintains field genebanks for maize, cassava, sweet potato, cotton and sugarcane. A total of 280 accessions, namely 94 maize (*Zea mays*), 99 cassava (*Manihot esculenta*), *27* sweet potato (*Ipomea batatas*), 36 sugarcane (*Saccharum officinarum*), and 21 cotton (*Gossypium* spp) are conserved in the field genebank at the ARC in Vientiane. The institute maintains this genetic material by propagation of seeds or clones every year.

Field genebanks for pasture and fodder grasses is located at the Livestock Research Centre (LRC) in the Naxaythong district. Evaluation and seed production of *Brachiaria* spp and S*tylosanthes* spp are carried out in these field genebanks. In addition there is a multiplication program for cassava at the LRC.

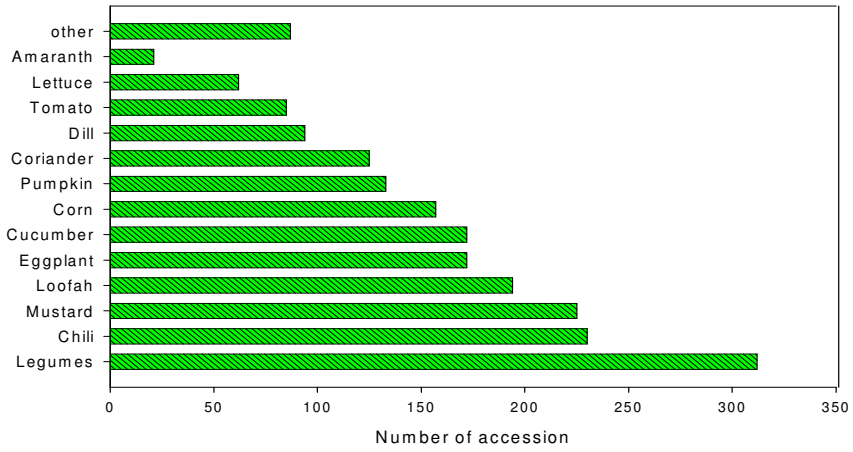


Figure 8. Number of accessions stored from each vegetable species at the HHRC. (Personal communication, Dr. Matthias Plewa, DED, HHRC).

Genetic resources of rattan, cardamom, broom grass and cinnamon are maintained in the field genebank at the FRC in the Naxaythong district. These accessions were collected from surveys and propagated in the research field. Several *ex situ* conservation fields for NTFP were established recently in nine provinces (Annexure ii).

The Coffee Research Centre (CRC) at Champassak Province maintains a field genebank of coffee with several *Coffea arabica*, *C. indica* and *C. robusta* species. These species were introduced to Lao PDR during French colonization.

Today, *ex situ* conservation plays an integral part of the biodiversity conservation in Lao PDR. Rapid changes in forest utilization and the exploitation of forest product, changing agriculture systems in mountainous areas, commercialized market-oriented agriculture and the emergence of large commercial plantations, lack of community awareness of biodiversity, and lack of trained technical staff in area of *in situ* and *ex situ* conservation, have accelerated the degradation and erosion of biodiversity. Projects such as "Participatory National Biodiversity Conservation Area Management" provide enormous social and economic opportunities for farmers living in areas vulnerable to the erosion of biodiversity. Correspondingly, indigenous knowledge on resource management can be integrated to the sustainable management of forest.

A large amount of plant species (*taxa*) still remains in the forests under the protection of sustainability projects in Lao PDR. Once identified and secured under *ex situ* conservation these may represent an economic opportunity in the future. *Ex situ* conservation is an essential element of a conservation strategy that minimizes the risk of genetic erosion and provides for the sustainable utilization of these resources. Resources, expertise (trained professionals) and research are needed for implementing a long term conservation strategy. Staff training on advanced interdisciplinary themes and managerial subjects can be a way of building capacity to meet the future demand for conservation.

3.1.5. Documentation and Characterization of Ex Situ Conservation

Plant genetic resource documentation is a slow process in Lao PDR, which needs careful attention. Significant effort is required to assemble, document and maintain the national database system of PGRFA. The rice and vegetable databases are partially digitalized, however, further information is required to complete and use it as the NISM of PGRFA. The rice germplasm was characterized based on the growing ecosystem, endosperm

characters and phenology. Therefore, accessions are available for early, mid and late maturity for both glutinous and non glutinous rice that could grow under lowland or upland conditions. Sub samples of the genetic material were further characterized for aroma, seed color and seed size. Data is also available on the province and district of collection and provide important information on geographical distribution of different rice accessions and naming of different landraces in Lao PDR[12].

The family, sub family and species of vegetable germplasm have been identified and recorded. The information on geographical distribution of different vegetables has also been recorded. The experimental information was used to characterize the disease resistance of the accessions in *Solanum melongena L.* and seasonal adaptability (wet season and dry season) of the accessions in *Cucumis sativus L.*

The database of timber and non timber products, including medicinal crops, provide a wide range of information. Nevertheless the quality, reliability and the method of documentation has to be improved. Better resources and personnel involvement are necessary for systematic recording of the whole PGRFA in Lao PDR.

The contribution of the *Royal Botanical Garden of Edinburgh* is well acknowledged in providing training programs for technical and scientific staff on taxonomic studies of wild flora in Lao PDR.

3.1.6. Germplasm Movement within Lao PDR

The entire rice germplasm is duplicated at the genebank in the IRRI. The breeders and agronomists in Lao PDR duplicated subsets (1000 accessions) of the genetic resources (seed) in four locations (2 in North and 2 in South). These materials are grown under different environments and are evaluated for biotic (pest and disease) and abiotic stress tolerance, persistency of aromatic and seed colour characteristics.

The Cassava germplasm at the ARC has been duplicated at the field genebank at the LRC in Vientiane. These accessions were evaluated to obtain suitable material for cattle feed. Two populations of corn (*Zea mays*) genetic resources collected by the ARC and HHRC were partially characterized for waxyness. Further characterization and documentation is yet to be done.

Future plans for expansion of *ex situ* conservation are based on the government policy on biodiversity conservation for the next 10 years. However, urgent consideration should be given for the establishment of a National Genebank and Seed Testing Facilities in Lao PDR. Alternatively, immediate action should be taken to seek assistance from international genebanks (such as AVDRC) for long-term storage of vegetable and fruit crop seed material.

3.2. Planned and Targeted Collecting

During last ten years, active germplasm collection, evaluation, conservation and utilization programs have been conducted for rice and vegetables. Few programs for other genetic resources conservation have been identified. External funds and technical cooperation is expected by the ARC for a cassava (forage) evaluation program. The CIAT will introduce a cassava genetic population for selection under Lao conditions, however, there are no

[12] Appa Rao, S., C. Bounphanousay, J.M. Schiller, A.P. Alcantara and M.T. Jackson. 2002b. Naming of traditional rice varieties by farmers
in the Lao PDR. Genetic Resources and Crop Evolution 49: 83-88

plans to conduct surveys and collect genetic materials for biodiversity conservation. There are many areas with rich biodiversity yet to be surveyed.

3.3. Assessment of *Ex situ* Need

The strategic directions for e*x situ* conservation must be identified. At present, cost of *ex situ* conservation (multiplication) is substantially high and most programs are unable to continue, as there is no budget allocation for field genebanks. The genetic material of medicinal plants is mainly conserved in backyard gardens of villagers. Surveying, inventorying and monitoring of those PGR is urgently needed. The two seedbanks available in Lao PDR are operating at full capacity and pose a significant risk of loss should a malfunction occur. Regional collaboration may be required to identify alternative locations for *ex situ* conservation of vegetables and some fruit genetic resources. Further research is necessary to explore low cost conservation methods with the use of indigenous knowledge. The establishment of a well-equipped central genebank facility with properly trained staff is a priority for the long term *ex situ* conservation strategy of Lao PDR. There are many other plant genetic materials to be surveyed, collected and conserved in the near future. Conservation *in situ* and on-farm of PGRFA is more difficult during the transition period of farming systems. Other forms of plant tissues conservation (cryo-preservation) could also be explored in the future genetic conservation strategy.

Chapter 4
The State of Utilization

4. Introduction

An environment friendly and sustainable use of PGR for food has been inherent practice in Lao agriculture since early in their history. The rich biodiversity present today, is an excellent proof of the sustainable management of the environment by the traditional custodians in rural areas. Prior to the introduction of modern varieties and pre-green revolution era, biodiversity was the only way to create genetic variation for selecting crops and species for sustainable agriculture. Today, in Lao PDR, crop yields are well above the yields of traditional varieties grown in those environments. However, PGR are still the focus of any variety improvement for biotic or abiotic stress conditions under the cloud of radical environmental changes in Lao PDR and in the world as a whole.

4.1. Distribution of Plant Genetic Resources

There is no legislated and centrally controlled system for the distribution of PGR among various users within the country. However, research centers under the NAFRI have proposed programs and are seeking approval for the effective use of those resources for various programs. The rice improvement program is a typical example for the distribution and utilization of genetic material for various agronomic objectives. This material is available in limited quantities from *ex situ* conservation facilities at the ARC with the approval of the Director of the ARC. In 2006, 1000 accessions were distributed by the genebank at the ARC to four provincial centers for propagation and utilization programs. Theoretically, both sending and receiving stations need to maintain records on movement of genetic resources across locations.

HHRC has released upon request more than 40% of conserved vegetable genetic resources to other agricultural projects and vegetable growers in different districts. The seed genetic material is maintained in farms which are key elements of the e*x situ* conservation strategy. *Brachiaria*, *Stylosanthes* and Cassava species were released from the LRC in Vientiane and were grown in several grazing lands in the North. The genetic material is being used for adaptability tests as well as some animal nutrition programs.

4.2. Utilization and Enhancing the Use of Plant Genetic Resources

4.2.1. Action Taken to Improve the Use of PGRFA

The Lao PDR Government has taken initiatives to improve the use of PGRFA by developing bilateral and multilateral agreements with international organizations and projects for sustainable use of genetic resources. The ultimate aim was to improving livelihood of rural communities. Large amount of funds has been invested for PGRFA projects, and foreign experts and technical staff have trained local scientists. These projects supported by FAO, SNV, SDC, DED and BUCAP have improved the sustainable utilization of PGRFA among rural communities, and consequently the awareness of their importance. The government also encouraged the development of local programs to transfer the sustainable management systems to other areas where necessary.

The introduction of market economy and free trading across neighboring countries has encouraged local farmers to develop value-added products from the local PGRFA. The new markets have improved the utilization of genetic resources in rural Lao PDR.

The germplasm collection programs in Lao PDR have broadened the knowledge and awareness of the diversity of crop genetic resources for food and agriculture and its importance for the livelihood of rural communities. Historically, the farmers in rural areas utilised most of the PGRFA and the indigenous knowledge on utilization of those materials is paramount. Farmers had a fair knowledge on manipulating phenology and photoperiod sensitivity in rice to avoid drought and other seasonal stress conditions, variety selection for wet and dry seasons, plant protection by mix variety culture, application of green manure for retaining quality of rice and so on. However, these traditional technologies were practiced in isolation and passed from one generation to another. Actions have been taken to understand and appreciate the indigenous knowledge on protection and utilisation of PGRFA, and introduce those technologies and PGR to other rural farmers to reap the benefit of them. An example is the broadening of aromatic and glutinous rice variety spectrum in rural areas.

Few crop improvement programs and rural development programs are utilizing genetic resources identified from the PGRFA programs. The most effective of these is the vegetable seed production program at the HHRC, where a large number of local landraces were collected and used to develop systems for *ex situ*, on-farm and *in situ* conservation. Several market surveys were conducted to identify the demand and price fluctuations across seasons (see Chapter 1). Results suggested that highest prices and lowest supply occur during the wet season when it is more difficult to produce vegetables. The agronomic constraints including rain and flood damages, water-logging situations, and social constraints such as high labor demand for rice cultivation, limited cash flow due to heavy investment on rice cultivation are the driving forces of this seasonal demand. The germplasm was evaluated to identify cultivars better suited for the wet season. As a result, vegetable seeds of local landrace material adapted for cultivation during the wet season are now available in the market. Similarly, field selection was conducted for popular vegetable accessions and seed production program was initiated.

Several local landraces of aromatic rice were identified and released for multiplication. Hom nan nuang and Kai Noi are two of the popular aromatic varieties selected and re-introduced from the rice germplasm at the ARC. Muang Nga and Mak Gny are two local landraces with high gall midge resistance. The Rockefeller foundation provided funds to screen local landrace rice materials for drought tolerance. Out of 130 accessions screened in the ARC, few local accessions, including Chao Deng and Chao America, demonstrated better adaptation to water limited conditions. These varieties were included in the breeding program and the farmer participatory variety selection program conducted by the NAFRI in 2007. Other genetic material from *ex situ* collections are being tested for adaptation to different locations.

Adaptability trials of *Stylosanthes* and *Brachiaria* accessions from *ex situ* collections of LRC are being conducted in grazing lands at different locations. The crop institutions in Lao PDR have different capacities to enhance utilization of genetic resources. External funding and technical support is critical to implement such programs. However, some institutes are able to launch small-scale activities to encourage farmers to use local genetic material for crop stability. For example, the LRC implemented a program to introduce cassava in cattle feed which encouraged farmers to grow local cassava varieties.

A rich biodiversity can be seen among cultivated and non-cultivated NTFP. The FRC, SNV and SIDA jointly implemented a bitter bamboo shoot project in an *in situ*

conservation area in the north. The farmers in the project area managed bamboo plantations and harvested the product for consumption and sale. Similarly, the FAO, NAFRI and SNV implemented a project on marketing and small enterprises development for poverty alleviation in few provinces. Mushroom, paper mulberry, broom grass and rattan were used to develop small industries in villages in the Savannakhet, Luang Prabang, Champassak and Oudomxay provinces. Projects with such benefits would also encourage greater farmer involvement in genetic resource conservations.

4.2.2. Characterization and Evaluation of PGRFA

Most of the genetic resources available in the rice and vegetable germplasm were partially characterized and evaluated for agronomic performances following some guidelines of IBPGR (phenology, yield, morphological and plant characteristics). About 3000 rice lines with distinct names were identified. Further research are needed to identify the rest. However, complete characterization is necessary for all of those collections. Incomplete records on biochemical and physiological evaluation of seed particularly related to cooking quality, and field evaluation on biotic and abiotic stress conditions are available for some rice landraces. Some records on characterisation of tree crops and medicinal plants are available; however, more information is needed to formulate programs for the utilization of genetic material.

The institutions need skilled staff, substantial facilities and capital for genetic resource evaluation. Some projects were funded by international donors (eg. vegetable program at the HHRC by DED) while most of the others have no budget allocations. Postgraduate training programs and Lao Agriculture Research Funds are also financed by various international organizations (eg. the IRRI and ACIAR). The budget and resources are allocated only for 2-3 year research projects and Lao scientists use local germplasm for their genetics or agronomy experiments. Funds should be made available to continue these programs in the future.

4.2.3. Utilization of Genetic Material for Breeding Programs and Food Security

Rice is the most important agricultural product in Lao PDR. With the significant contribution of national and international germplasm, substantial progress has been made in raising the productivity of rice during the past decade. However, to meet the internal demand in 2010 rice production should increase up to 3.2 million tons, almost an additional 1.0 million tons to current production. Therefore, crop improvement is a high priority in rice industry while seeking alternative markets for rice products has been given secondary consideration.

The traditional breeding can still play a major role in rice improvement. The genetic resources in the rice genebank are important to stabilize the yield in low production environments. Priority has been given for the evaluation of local genetic material under low input management where modern varieties do not achieve high yields. Recent genetic evaluation programs with landraces in the ARC showed positive results on drought adaptation and high yielding aromatic rice. Kai noi rice in Xieng Khouang and Houaphanh is a classic example of utilizing local genetic material for innovative industry.

Current breeding activities in national rice program

The main objective of the National Rice Breeding Program (NRBP) in Lao PDR is to provide farmers with a range of varieties with increased yield potential and broad adaptability to local conditions. Other specific objectives include; (a) intermediate to late maturing and photoperiod insensitive varieties, (b) grain with glutinous endosperm and

acceptable quality, (c) yield stability under drought, flood and other abiotic stresses, (d) resistance to major pest and diseases and (e) improving plant types – semi dwarf to intermediate plant type with long grain.

The three main rice breeding programs in ARC are for:
(1) drought prone areas
(2) drought and submerge tolerance
(3) lower topo-sequence

Until recently, the NRBP and Lao-IRRI program implemented a progeny introduction (F_2 crosses) program from the Thai-IRRI program. Selections were carried out at three research centers in Vientiane, Savannakhet and Champassak. This program was terminated in early 2000, however, a large number of varieties were released from this program.

The breeding program for variety development for drought prone areas in rainfed lowland was started in 1995 as an ACIAR project; "Plant breeding strategies for rainfed lowland rice in NE Thailand and Lao PDR". Large number of local landraces and introductions were tested in multi-location trials at Vientiane, Champassak and Savannakhet provinces. The objective was to identify varieties with broad adaptation and desirable parent lines for breeding programs targeting these rainfed environments. A number of varieties including IR57514-PMI-5-b-1-2 and IR68102-TDK-b-b-31-3 were selected and later used for cultivation and as donors for the national breeding program.

Identification of drought resistance sources from the local PGR started in 2002 with the assistance from the Rockefeller project; "Improving drought resistance in rainfed lowland rice for the Mekong region: use of new conventional approaches and molecular tools". Nine lines including seven local landraces (Ang Do, Chao America, Chao Deng1 Chao Deng2, Hom , Kham1, Kham19) were identified as donor parents and were used to develop Single Seed Descent (SSD) populations for both molecular and field selections. The program developed 23 SSD populations (F_3- F_6), and developed markers for QTL for elite parents.

Another pedigree-breeding program with local landraces (aromatic) to improve quality and yield of existing commercial varieties was started recently at ARC. The farmer participatory variety selection program (PVS) is used for the selection of lines for farmer's acceptance. Some traditional landraces are also included in the PVS trials.

The selection for submerge tolerance was started recently at ARC, and the variety introduction has commenced as a part of the program. Generally, pedigree, bulk, modified bulk and SSD method are used in ARC for breeding and selection[13].

An introduction of cold tolerant varieties from the INGER gene pool at the IRRI and other countries (China, Australia, India and Korea) was started in 2002. The adaptability for cold conditions was tested at higher elevation (>500m) at Luang Namtha and Xieng Khouang.

[13] Boualaphanh, C et al., 2000. Rice improvement method for Laos. ACIAR Proceedings, No 101, pp229

The germplasm evaluation is a continuous process at the ARC. These rice accessions are evaluated on the aromatic, glutinous and non glutinous characteristics, and physiological characteristics such as biotic and abiotic stresses. The selections are used as donor parents in the crossing programs. As a result, the ARC has successfully developed several populations carrying traits for aromatic rice, drought resistance, seed color and glutinous and cooking quality (softness). More resources and manpower is needed for further evaluation of these populations.

In the 1990s, better performing lines from the Thai- IRRI introductions were selected and the excess genetic material from each population was discarded without any further testing. This led to the loss of important genetic material already imported to Lao PDR. However, genetic material from the Thai-IRRI breeding program contributed to significant increases in rice yield in Lao PDR during last 10 years.

During the surveys in 1995-1998 of rice genetic resources, collectors found 10 local landraces selected by farmers from different areas. These farmers have used pure line selection for characters such as single culms, culm thickness and panicle size. Currently, these varieties are popular among villagers in those areas.

Breeding and selection activities for other crop improvement programs in Lao PDR

Evaluating 99 accessions available in the corn germplasm at the ARC resulted in identifying varieties with high and low waxy endosperm. With the existing corn improvement program, breeders aim to improve the yield and agronomic characters of non waxy varieties to use in animal feed. Currently, pure line selection program is implemented by the ARC for non waxy germplasn. The ARC is receiving a corn population (F_1) from CYMMIT and cassava population (F_2) from CIAT for the development of new corn and cassava varieties. The ARC also implemented a soybean breeding program in which several crosses were made with locally available material and introductions.

The vegetable seed development program at the HHRC mainly concentrated on few vegetables such as eggplant, pumpkin and tomato. The pure line selection programs for wet season and dry season vegetables are highly successful. The AVDRC selection criteria for different vegetables are used for the selection of better performing vegetables.

As a result of rapid phase of urbanization and the migration from rural to industrial areas, one could expect a significant drop in consumption of NTFP in the future. Currently, NTFP consumption contributes significantly to the Lao economy by reducing import substitution. With the rapid degradation and genetic erosion of consumable forest products in Lao PDR, there will be a shortage of vegetables and some major food products in the future. The government policy on crop diversification in low productive land would allow introduction of NTFP as cultivated crops in the future. Some results of pilot projects have shown the potential value of NTFP as food crops in Lao PDR and in the region.

4.3. Opportunities for Improvement of Market for PGRFA

The government policy on promotion of agricultural products for new market allows farmers to change their traditional cultivation systems. The several projects conducted in rural areas assisted farmers to identify potential crops for export market. Mostly, there is a high demand for NTFP in China and Vietnam. Rural farmers have taken this opportunity and changed their habits in forest product utilization. Farmers exposed to market-oriented agriculture have a strong preference for new and improved crop varieties, which have

higher quality, productivity, stability and uniformity within the population. This has a positive impact on poverty alleviation in the rural communities, but a real threat for conservation of biodiversity.

4.3.1. Promotion of Marketing Products from PGRFA

The business sector is involved in developing market for PGRFA, and the Government provides assistance to promote activities. Private sector was able to produce environmentally friendly organic aromatic rice (Kai noi) for the western market in France. However, it is difficult to develop international markets for some local products, as there is no regulatory mechanism to monitor and certify the product. Hence, Lao PDR need strong international cooperation to develop market in order to reap any long-term economic benefits from its useful biodiversity.

Local fruit production is another area, which has high potential for export market and needs more attention. Imported fruits are common in urban fruit markets, while local fruit varieties are available mostly in rural markets. The market value of local fruits is quite low, but quality can be improved by adapting similar approach used for vegetables in Lao PDR.

A centralized marketing system and efficient modes of product transportation is required to support rural farmers. The local demand for some Lao agricultural product is limited and the price of a product depends upon the economic situation of the local community. A middle man is involved in marketing and setting prices of those products. Farmers are unable to provide fresh produce to urban markets due to lack of a centralized marketing system and efficient modes of product transportation. Also, the perception of product quality in villagers is different to the expectations of urban market. A pilot project conducted in the north has attempted to find resolution to this inherent problem. The bitter bamboo and mushroom genetic resource management and marketing projects attempted to demonstrate to the community that supply of quality products and sustainable forest management could improve their livelihoods.

The bamboo weaving is a tradition that was in danger of being lost. Thongdeuane Keomany[14], an expert in bamboo craft for more than a decade, provided the basics of bamboo weaving to the women in the village of Ban Lak 62. These crafts were used to attract international markets, and with the help of the FAO, the women established links with national and regional markets which ultimately resulted in a 40-50% increase in their household income. Another positive outcome was the increased awareness on conservation of their bamboo natural resource.

4.4. Seed Supply System and Role of Market

Rice and vegetable seed production is organized better than other crops under conservation in Lao PDR. Once the National Science Council formally releases a rice variety, breeders at the ARC produce breeders seeds in small quantities (300-500 panicles). The foundation (R1) seeds are produced from breeder seeds at the research centers, and uniformity and purity is carefully checked. Foundation seeds are planted in rows in large plots and registered seeds (R2) are produced following the guidelines of seed certification standards (not with all ISTA standards). The contract farmers finally produced certified seeds (R3) from registered seeds under the supervision of provincial seed production centers (PSPC). Currently, there are four PSPC for rice at Vientiane (ARC), Savannakhet (Tassano Seed Production Centre), Champassak (Phongnam

14 http://www.fao.org/forestry/newsroom/en/news/110909/highlight_110995en.html

Agriculture Research Centre) and Luang Namtha (Agriculture Research Centre). Provincial and district level coordination is needed to estimate the total requirement of seed for each season. The PSPC provides seeds and financial assistance for the contract farmers to grow certified seed. At harvest, the PSPC buys seeds from the contract farmers and processes it for storage. There is a second group of farmers around the centre, who has access to seed during emergencies. The marketing is partly controlled by the PSPC. The actual seed supply is not well documented as more than 80% seed are produced by farmers themselves. However, the seed production in 1999-2000 was 290 tons and in 2001-2002 increased to 710 tons[15]. The seed production plan is decided by the MAF through a committee in which departments, institutes and seed multiplication stations are represented. The estimated seed production (R3) for 2008 is 60,000 tons and the provincial seed requirement for northern, central and southern provinces are shown in Table 8[16]. In 2006, the ARC has produced 25 tons R1 seeds from several varieties to be planted for R2 seeds in 400 ha in wet season 2007. Eleven provincial agricultural service centers and research centers in Lao PDR and cooperators around the centers will be involved in the production of R2 and R3 seeds. Seed production program is partly supported by ADB, BUCAP and other NGO programs.

Table 8. Summary of seed production target to achieve 60,000 tons of R3 seeds for 2008 planting

Region/province	Area and seed production (R2) in wet season 2007					R3 seed production for wet season 2008	
	Area for R2 seed	PSPC produce 10% (R2)		Cooperate farmers produce 90% (R2)			
	Area (ha)	Area (ha)	tons	Area (ha)	tons	Area (ha)	(tons)
Northern (16%)	64	6	18	58	174	3200	9600
Central (56%)	224	23	69	201	603	11200	33600
Southern (28%)	112	11	33	101	303	5600	16800
Total	400	40	120	360	1080	20000	60000

There is no organized private investment except the involvement of corporate farmers for rice seed production and marketing in Lao PDR.

The vegetable seed production system has been developed by the HHRC with the assistance of the DED. The farmer network in Vientiane province conducts vegetable seed production. There are about 23 farmers from 11 villages in the network. Currently, they are producing seeds from 18 crops developed by the research centre. The HHRC farm produces small quantity of seeds, and supports the marketing process. The processed seed are packed, labeled, and sold in the market under the label of the HHRC. There are about 44 contacts (seed sellers) for marketing seeds (23% of products) in the province. Agricultural projects in Lao PDR purchase about 44% of the seeds while 13% by farmers. The HHRC involved in monthly follow up and annual evaluation meetings, establishment of a seed fund for financing, quality testing of seeds at the HHRC and farmer training for seed production in Northern Provinces. There is no accurate information on the seed requirement for vegetable production in Lao PDR. However, there are shortages of seed production for some vegetables while surplus productions for others. The seed production by the network at the HHRC for few popular vegetables during 2002-2006 are shown in Figure 9.

[15] Lathvilayvong, P. 2004. Rice seed processing in the Lao PDR. Ministry of Agriculture and Forestry, Lao PDR

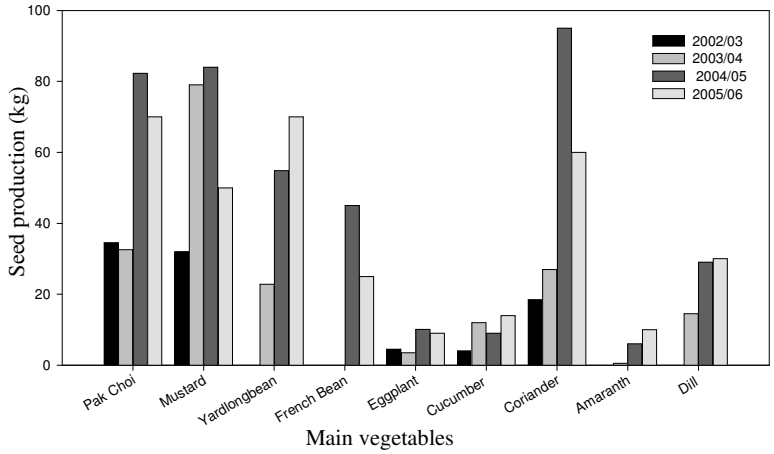
[16] Seed Production Program for 2006-2010, National Rice Program

Figure. 9. Vegetable seed production during dry seasons (2002-2005) at Vientiane.

There is no central seed laboratory to monitor the seed quality of any crop, and imported seeds from Thailand, China and Vietnam are available in the market. There are standard regulation and guidelines for seed and plant material importation. However, the borders without any proper quarantine checks allow seed and plant materials cross over. This is a potential threat for local PGR, because imported material could introduce foreign pathogens and pests to Lao crops. A LSP program conducted by the FAO[17] indicated that the demand for seed is high in areas where rapid transitions in agriculture systems are happening. It also highlighted that the current seed production system needs to be accelerated to meet the increasing demand.

The National Science Council does the variety recommendation and release of new varieties of rice. In this Council 7-9 members are from MAF and Ministry of Science and Technology. Once a year, breeders prepare a list of varieties with their agronomic and other characters for the examination and approval by this Council, for formal release.

Private sector involvement is necessary to inject more resources for the future



development of seed regulatory system in Lao PDR. It is important to develop a Central Seed Laboratory and Plant Quarantine System to protect the biodiversity in Lao PDR.

4.5 Future Needs for Utilization of PGRFA.

Significant effort has been made to collect and conserve PGRFA in Lao PDR. Utilization of genetic resources has led to important results in rice, vegetable and some NTFP. Rice improvement program in the NAFRI developed a strategy for effective utilization of rice gene pool at the ARC. However, there are more opportunities to enhance the utilization of these resources. Evaluation of the germplasm for important traits need to be continued. There are limitations such as funds, human resources, equipments, skilled staff and supporting services that affect the progress of evaluation of germplasm at the ARC. Resource mobilization and skilled staff are required to continue current activities.

Diversified rice based products represent one of the emerging opportunities for market-oriented economy. Variation within the wide genetic base of Lao PDR rice collection and cultivated materials provides for the development of a large range of different products

[17].Sescon, J.T and Salazar, R. 2007.access to seeds and plant genetic resources for food and agriculture. Their role in improving rural livelihoods in Lao PDR. LSP working paper 42.

including for processed rice export market, alternative rice products, fermentation and energy saving products. All these deserve timely investigation.

Farmers' knowledge on utilization of genetic resources can be very useful during crop improvement. The participatory variety selection program has improved both farmers' involvement and acceptance of selected materials. Systematic documentation and analysis of these results is essential for future planning and development of farmer participatory programs.

Rice breeding program has developed from landraces several populations valuable in terms of yield and quality attributes, which are now in various stages of selections at the ARC and other agriculture centers. Staff shortages have severely affected progress of the breeding and selection program. Continuation of the selection of these populations should be given a high priority.

Small number of vegetable germplasm has been evaluated and utilized. The pure line selection for other vegetables should be continued. Breeding programs are necessary for long-term crop improvement for most of the popular varieties. However, immediate requirement is to utilize the available genetic resources and exploit the variation among accessions to identify better performing landraces.

Though there is a vast range in the taste of local fruits in Lao PDR, limited research has been conducted to utilize wild and local fruit crops in plant improvement programs. There are programs for new fruit crop introductions in some areas. Perennial fruit crops in *in situ* conservation areas can be utilized in pure line selection programs.

Domestication of commercially important NTFP would be another important area for future planning of PGRFA utilization. The FRC has already begun programs with the assistance of other organizations. However, systematic research components are needed to investigate agronomic and social constraints on adaptation of those crops in other environments. This has shown some positive results in areas where slash-and-burn has been practiced early.

Well-planned short-term and long-term research programs are essential for effective utilization of available genetic resources. The NAFRI and its centers are involved in many programs aimed at sustainable utilization of PGRFA. Those programs are supported by external funds and technical expertise. However, Lao PDR needs gradual development of its own skills and resources for continuation of such programs in the future.

Chapter 5
The State of National Programs, Training and Legislation

5. Introduction

Plant genetic resources activities are centrally administered by the NAFRI, which makes budgetary provisions for local institutions to collect, characterize and conserve local landraces and wild relatives of crops in the country. The main objectives are to increase productivity of crops through improvement programs and with the technical and financial collaboration of international organizations. The government develops legislations to protect the biodiversity and its custodians while targeting poverty alleviation and sustainable agriculture development in the country. Training and capacity building among participants in biodiversity programs is becoming more important with the radical changes observed in the Lao economy and environment.

5.1. National Program for Plant Genetic Resources (NPPGR)

NAFRI is the national centre responsible for strategic planning of PGRFA in Lao PDR as well as for activities implementation and monitoring, including all 20 priority activity areas of the *Global Plan of Action* (*GPA*) for the conservation and sustainable use of PGRFA in Lao PDR. NAFRI has recently established a National Information Sharing Mechanism on PGRFA to strengthen partnerships among key national stakeholders, to hold the historical memory of and to monitor what has been and is being done in the country on PGRFA conservation and use. The Information Service unit at NAFRI, jointly with other national stakeholders, have populated a national database under the Mechanism with information on PGRFA in Lao PDR since 1996. NAFRI centers are among the major stakeholders providing and sharing information within the Mechanism. In addition to them, the National University of Lao PDR has also expressed interest in taking part in this information sharing process.

During the past decade, the research programs developed for conservation and utilization of biodiversity has all been evaluated and approved by the NAFRI. The ARC and LRC jointly implemented an integrated program on the utilization of cassava species for animal feed in Vientiane. The national program for PGR targets mainly the common crop species available in rural agriculture and forestry system. Assistance from international organizations through multi-disciplinary approaches is essential for successful implementation of national programs.

During the past decade, biodiversity programs in Lao PDR were funded by international organizations (FAO, IRRI, SIDA, SNA, DED, CIAT, DANIDA and CIP). Continuation of these programs after the completion of the foreign funding period is challenging. Some institutes (ARC, rice) are adequately funded by the government and are able to attract external financial assistance to continue key programs. Simultaneously, there is a negative trend in government funding for national biodiversity programs in Lao PDR. The main activity areas identified for future funding are;

- Identify regions and locations for *in situ* conservation of biodiversity, particularly, areas where rapid development is occurring (plantations, industries etc).
- Improve *ex situ* conservation (genebanks) and develop a centralised national genebank for biodiversity conservation. The current level of degrading PGR is

alarming, thus, surveying, seed and plant genetic material collection and conservation needs urgent attention. Any success of conserving genetic material depends upon the facilities for efficient *ex situ* conservation.

- Initiate programs for germplasm evaluation and utilization on crop improvement.
- Conduct further studies on indigenous knowledge and identify crop species that could be conserved safely with local knowledge.
- Develop legislative mechanism for biodiversity conservation and farmer's Indigenous knowledge protection.
- Establish an early warning system to minimize the rate of erosion of biodiversity. For this, accurate database management under NISM is important.
- Improve database management system by providing more training and resources.
- Provide funds for continuation of surveys of PGRFA.

5.2. Network

The International organizations such as FAO, IRRI, AVRDC, CIAT, CIMMYT, ACIAR, IUCN, DED, SNV and NGOs have links with local stakeholders and provide information and technical support for sustainable management of PGRFA.

In collaboration with Chiang Mai University, Thailand, the ARC is planning to conduct a project to evaluate the rice germplasm in terms of iron nutritional value. Similarly, NAFRI, ARC, RF and ACIAR have developed a joint project network with Kasetsart University to screen rice genetic material using quantitative trait loci (QTL) analysis, targeting drought resistance. CIAT together with ARC and LRC has developed a network to screen genetic resources of cassava for local adaptation in Lao PDR. There are several other programs, which extended the local network with international institutions. Moreover, there is indirect involvement with several international organizations such as universities, research organizations and private entrepreneurs for further screening activities.

5.3. Education and Training

Undoubtedly, one of the most important components of any development program in Lao PDR is education and training. There is a relatively small number of qualified personnel currently working on biodiversity conservation programs. Certainly, they acquire on-the-job training on different types of field activities. However, solid academic training is essential to form a cadre of professionals that can play a leadership role in biodiversity conservation and utilization in Lao PDR. Faculties of the National University are working together to build up their knowledge on biodiversity conservation and should strengthen partnership programs with foreign universities to improve local curricula and training opportunities, taking into account that a multi-disciplinary approach is important to understand and fully utilize the complex biodiversity in Lao PDR.

It is interesting to notice that NAFRI has signed a memorandum of understanding with the *Royal Botanical Garden of Edinburgh* to train more scientists at the National University of Lao PDR on taxonomic studies and conduct more surveys on PGR.

5.3.1. Programs for Staff Development

Staff development is a national priority and an important part of policy on conservation of PGR. The National University of Lao PDR is the only university in the country which offers B.Sc level degree courses for Science, Agriculture and Forestry. The curriculum for science and agriculture is basic and needs further improvement in the future. However, the university works closely with international institutes and crop research institutes, and

provides opportunities for young students to understand biodiversity and the importance of PGRFA for food security and poverty alleviation in rural communities.

Short and long-term staff training courses can play a vital role in the conservation and sustainable utilization of biodiversity. Training must be not only on the life sciences such as Botany, Climatology, Seed Science and Technology, Taxonomy, Ecology, Population genetics, Earth management and Geographical Information, but also on all the fields of Social Sciences as Anthropology, Sociology, Economics and National Conservation Law and policy.

Several Postgraduate training programs addressing PGRFA conservation and utilisation are being attended by Lao Scientists, mainly in Vietnam, Thailand, Japan and the Philippines. The NAFRI organizes short-term on-the-job or in-service training programs for farmers and stakeholders with the support from international projects. During the last 10 years more than 100 people have been trained on various aspects of biodiversity.

5.3.2. Obstacles for Training and Education

Limited staff and heavy workload restricts the number of personnel that could be trained at a time. Insufficient laboratory facilities, limited access to books and literature, inadequate skill in information technology also affect the quality of education at the University. The current trend in education among young generation is the deviation from traditional fieldwork-related disciplines (agriculture and environmental sciences) to modern service-related disciplines such as management and information technology. This transition may cause difficulty in attracting young talented students for science and agriculture-based subjects. However, in the future, this attitude has to be changed by providing more incentives, including social and economic benefits to the services related to agriculture and conservation of biodiversity.

It is important to continue providing proper overseas training opportunities to national research and technical staff in the field of biodiversity. However, fluency in English is one of the main obstacles for them to qualify for such training in western countries. Because of limited finance for overseas training and rising cost of education in western countries, Lao scientists are compelled to select regional universities for postgraduate training.

5.4. National Legislation

There are number of laws to protect PGR and forest, and regulate land use in Lao PDR, however, there are many other areas yet to be protected by law and hence the development of a strong legislative mechanism is vital.

Some of the laws are:

- Promulgation of Land Law, Presidential Decree Law on (No. 33/PO, 1997) 20 areas for National Biodiversity Conservation Act.
- 1996 Forest Law passed by the national assembly.
- Land Law, Prime Minister Decree 164, 1993 - 18 national biodiversity conservation areas identified.
- Logging Ban, Decree on (PM Decree No. 67/PM, 1991) protecting trees by logging.
- Tropical Forestry Program, Decision on Adoption of (PM Decree No. 66/PM, 1991) forest conservation.
- Forests and Forested Land, Decree on Management and Use (COM Decree No. 117/CCM, 1989).
- Seed and plant protection regulation**:** Seed material import regulation (quarantine

regulation) controls importation of plant material. The general regulation is to provide a phyto-sanitary certificate with the plant material.

In addition to the above-mentioned legal framework, there are other laws, which have a bearing on environmental management, namely the Water Resources, the Mining and the Land Law.

To emphasize the legal and constitutional pledge to protect the national biodiversity in the highly protected areas, a land law (Land Law No. 01/97, 1997) was introduced to the national assembly in 1997. The law clearly states that the fauna and flora in the forests is under the control of the Government and the nominated authorities could develop regulations for the protection of biodiversity. The other laws regulate the process of using forest and land for sustainable economic development in Lao PDR. However, well formulated resource management and environmental conservation policies are yet to be developed. Currently, national and international consultative committees actively engage in this area.

The tasks entrusted from the legislation to the Ministry of Agriculture and Forestry are:

- Study strategic plans, policies, laws and regulations pertaining to forestry, wood industry and environment in view of submitting them for the approval of the Council of Ministers.
- Develop provisions, recommendations, and elaborate regulations for the implementation of the above mentioned strategic plans, policies and regulations.
- Organize, supervise and control the implementation of the strategic plans, policies and regulations pertaining to forestry, wood industry and environment at the national level.
- Monitor and grasp the periodical changes occurring in forest resources.
- Organize and direct the system of forestry and environment management network at the national level.
- Study and approve the establishment of forestry enterprises, wood and forestry product processing plants and other factories using wooden raw materials as energy generators in the center and localities throughout the nation.
- Nominate directors of forestry in provinces and prefectures, and directors of wood industry enterprises dependent on the Ministry.
- Coordinate the provinces and prefecture in the nomination of forestry directors at the level of districts and directors of wood industry dependent on the localities.
- Coordinate with the localities and relevant sectors to propagate and educate all Lao citizens to love nature and assume their responsibilities in safeguarding, regeneration, plantation and use of forest resources with high efficiency and in conformity with the state regulations.
- Entertain foreign relations and cooperation in the field of science-techniques on forestry, wood industry and environment.
- Train and refresh cadres working in the field of forestry, wood industry and environment.

The Government assigns the management responsibilities to relevant Ministries; Ministry of Agriculture and Forestry, Ministry of Industry and Handicraft, Ministry of Communication, Transport, Post and Construction, Ministry of Information and Culture, Ministry of National Defence, Ministry of Interior, and Ministry of Finance. These ministries are accountable for the centralized management through land registration, land titling, land leasing based on the National Socio-economic Development Plan, and to ensure a direct management of construction land.

5.5. Information System

NAFRI has established an information management system, the National Information Sharing Mechanism on PGRFA (NISM) with technical assistance of FAO and has collected mostly scattered information on PGRFA in Lao PDR. The main stakeholders currently involved in the NISM are ARC, HHRC, LRC and FRC. The information available on rice, corn, sweet potato, cassava, vegetable, fruit crops, pasture, NTFP and other agricultural crops is systematically entered to the database by these stakeholders. They have computer facilities and number of trained staff to compile and digitize the available information on PGRFA. Most of the digitized information is available electronically at NAFRI and it now being made publicly accessible through the Mechanism's web portal and CDs. Further work is needed to complete the available information and to maintain updated the Mechanism's database.

In addition to the National Information Sharing Mechanism on PGRFA, NAFRI has set up other information services and databases, including a library database and the Lao Agriculture and Forestry Database (LAD) covering publications on agriculture.

An important aspect of information management is the one dedicated to the documentation of *ex situ* conserved germplasm and to its conservation, regeneration and distribution. In this regard no information system per se is being used. The information is recorded on generic database management software and spreadsheets.

Information on rice genetic resources is currently being used in the varietal development programs (Breeding) at ARC. The unavailability of sufficient resources has hampered the progress of the evaluation of these PGR on agronomic, physiological and quality characteristics for future breeding purposes. Information in the vegetable crop database is also useful for the development of breeding and selection programs. The current strategies of vegetable selection at the HHRC showed that such information could effectively be used in future varietal development programs. However, the information available on other crops needs to be updated in the NISM. In addition, an information management system for PGRFA accessions conserved *ex situ* is necessary for facilitating crop improvement programs in Lao PDR. Regular training and monitoring is needed for staff recruited for data entry and processing.

PGR information on medicinal plants and NTFP available at NAFRI needs to be incorporated into the NISM. Compilation of all the available information is vital for the development of strategic plans on the utilization of PGRFA for successful agro-biodiversity conservation in Lao PDR.

5.6. Public Awareness

Public awareness is the key to protect biodiversity in Lao PDR. FAO through the FNPP, assisted to increase awareness of importance of agro biodiversity to food security, nutrition and sustainable livelihoods.

There are legislation and control mechanisms in all levels of governance. Nevertheless, the PGR are under severe threat particularly in regions under rapid development. At present, the media plays a mediocre role in publicizing the activities related to the protection of biodiversity. However, public media can be a more efficient means of improving public awareness on the danger of eroding biodiversity in the country. Some volunteer organizations are campaigning against illegal activities such as forest logging,

transportation of protected and endanger plant material across borders, and supporting farmer's rights, conservation of rural biodiversity from industrial agriculture and exploitation of biodiversity.

As far as educating the public on biodiversity and its protection is concerned, primary, secondary and tertiary level education should equally show interest in developing training material in their curricula on environment and natural resource management. However, as agricultural sciences in higher education programs gets less and less priority among young students, the opportunities for educating the next generation on biodiversity and its sustainability becomes more challenging. Innovative education on biodiversity and related subjects is important from the grassroots level. Similarly, the contents must be presented as an interesting subject in terms of business ventures, cultural identity as a proud nation retaining world-class biodiversity, eco-tourism, plant taxonomy and rejuvenation of traditional herbal medicine and environment engineering.

Development of networks to link biodiversity programs to the tertiary education programs is necessary to improve awareness among young graduates on practical implication of research on national objectives. The use of modern information technology for creating awareness of biodiversity in Lao PDR is satisfactory. International projects publish their results and information in their respective web sites. With the modern internet search facilities, the young generation can research any information on the biodiversity in Lao PDR in the World Wide Web. A variety of classified and unclassified information is available in the internet on this subject. A typical example for unclassified information on utilization of genetic resources in Lao PDR is the article published by Harris[18] on Agar wood industry in Lao PDR. This article provided a daunting conclusion and it reads as "In conclusion, the world of agar wood is not a world of easy, pat answers. For every seemingly conclusive piece of data flagged, others will pop up to challenge it. Are our forests burning? Are we destroying our world? Yes, and yes. Should agar wood be monitored, and protected? Yes, and yes. Can we still incorporate this lovely tree, this exquisite oil, this divine perfume, into our lives? Yes, oh yes". Generally, there is a lack of understanding among urban communities about the value of agro biodiversity in Lao PDR and less appreciation of the attempts made by rural custodians to protect the biodiversity. On the other hand, there is also a poor understanding among rural communities on the protective mechanisms implemented by the government through legislations and their key roles in protecting biodiversity for their livelihood.

Education, mass media, cinema, internet, books, journals, newspapers and billboards will help improve awareness of biodiversity among urban community. Participatory workshops, farmer education programs on laws and regulation, small leaflets with more graphic based explanations on various aspects of PGR conservation, and, in particular, rural development projects on the protection and sustainable use of PGR will help to raise awareness among rural people and facilitate the implementation of a nationally agreed conservation strategy.

5.7. Economic Evaluation of the PGR for the Country Economy

Value-added agricultural products have contributed about US$ 45 million to the country economy in 2005. The contribution of PGRFA towards economy has been estimated in terms of their contribution to GDP. For example, proportion of NTFP contribution to the economy is about 40% of the rural income in 2005. Though the national income has been

[18] http://www.enfleurage.com/ac-agarwood-2.html

estimated through export market of PGRFA such as cardamom, coffee, NTFP and timber products, there is no direct method to evaluate the actual economic and social benefit generated for the rural communities. This has to be looked at as direct export, import substitution and indirect contribution to the social development in rural Lao PDR. In future, formulation of financial incentives to rural farmers needs also to be addressed in the light of their contributions on protecting biodiversity.

Chapter 6

The State of Regional and International Collaboration

6. Introduction

The conservation and utilization of biodiversity in Lao PDR was a hot topic among regional and international conservation organizations during last 10 years. This is clearly proven with their involvement in conservation programs in Lao PDR. The Government of Lao PDR has received financial assistance through collaborative projects with Switzerland, Netherlands, Germany, United Kingdom, United States of America, Russia, Japan, China, India, Thailand, Vietnam, Korea and Taiwan. While United Nations' FAO has taken the leading role of biodiversity for food security, the IUCN has engaged in forest conservation, utilization and development of legal framework for protecting biodiversity in Lao PDR. National institutions under the MAF have taken a leading role in most of these projects.

6.1. Regional, Sub-regional and International Network

During the last decade, Lao PDR has actively participated in regional and international networks aiming to gain experience in transfer of technology, access to financial resources through participation, exchange of information, increased awareness of PGRFA and capacity building for future PGR programs.

As a member of ASEAN, Lao PDR has gained access to the regional cooperation network for 'South-East Asian Partnership on Access to Genetic Resources and Equitable Sharing of Benefits'. The countries involved in this network are Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.
Other international organizations involved in the cooperation network are;

- The United Nations Development Program (UNDP)
- ASEAN Regional Center for Biodiversity Conservation (ARCBC)
- The European Union
- The Global Environment Facility (GEF)

Lao PDR is interested in participating in the Global network of the early warning system of plant genetic resources.

6.2. International Programs

FAO has provided technical and financial assistance to Lao PDR for active participation in regional and international programs. Lao PDR has been engaged in several networks of different biodiversity programs through international projects. The most contributing projects for PGRFA are FAO, IRRI, DCD, SNV, IUCN, AVRDC, CIAT, SIDA, AusAID and RF .

Lao-IRRI rice program (1992-2004) has made a significant contribution towards biodiversity conservation and productivity improvement of rice. The IRRI contribution for research and technology development of rice will have a long-term economic benefit for the country. Achievements through the national rice-breeding program have been possible thanks to the vast diversity of rice germplasm collected and conserved in the past years.

Various programs on management and utilization of NTFP funded by IUCN, SNV, and FAO have improved the livelihood of rural custodians. These programs developed awareness and highlighted the economic importance of sustainable management of

biodiversity in the rural community. The vegetable seed production program funded by DED and implemented at HHRC has created a new dimension of utilization of genetic resources with an understanding of agronomic, social and economic aspects of biodiversity. This program is a successful example of utilization of biodiversity for annual crops in Lao PDR. Programs funded by the SDC, CIAT, AVRDC, ACIAR, RF and number of NGO groups have also contributed to surveying and inventorying, collection, evaluation, conservation and utilization of spectrum of plant genetic materials in the country.

Biodiversity Use and Conservation in Asia Program (BUCAP) is another regional biodiversity conservation program mainly for rice in Lao PDR. This program mainly focused on seed production and farmer participatory breeding and selection programs. Its final aim is to train farmers to control the biodiversity and sustainable management of the PGRFA by themselves in the future. So far, this program has been successful in seed production, participatory variety selection and breeding program for rice.

6.3. International Agreements and Treaties

The Government of Lao PDR acceded to the Convention on Biological Diversity (CBD) in 1996 and is committed to developing a national biodiversity strategy. The national biodiversity strategy and action plan (NBSAP) aimed to protect biodiversity resources and to ensure their sustainable use.

It has also acceded to the International Treaty on PGRFA in March 2006. The Treaty's objectives are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. Through the Treaty, countries have agreed to establish an efficient, effective and transparent Multilateral System to facilitate access to plant genetic resources for food and agriculture, and to share fairly and equitably the benefits derived from their utilization. The Multilateral System applies to over 64 major crops and forages. Jointly with representatives from more than one hundred countries, Lao PDR participated in the 1st Governing Body's meeting of the Treaty in June 2006. The Governing Body of the Treaty, which is composed of the countries that have ratified it, has set out the conditions for PGRFA access and benefit-sharing in a "Material Transfer Agreement" and has defined the initial priorities of the Treaty's Funding Strategy. These coincide with the 20 priorities of the Global Plan of Action for the Conservation and Sustainable Use of PGRFA.

The government has also signed an International Treaty for Plant Protection Convention (IPPC). This is a multilateral Treaty for plant protection where 116 countries are involved.

6.4. The Main Area of Future Collaboration

There is an urgent requirement of trained and skilled staff and funds to monitor the genetic erosion of PGR in most of the conservation areas including highly protected forests. External support for biodiversity projects is nearing completion of their funding obligations. Unless there are new programs to continue at least the most critical activities, there will be a vacuum of resources at the beginning of 2010. Remobilization of government resources must be considered.

In addition, the *ex situ* collections of vegetables, some NTFP, fruit species and medicinal plants are at risk, because these are not safety duplicated in other genebanks. The development of a central genebank facility for genetic resource conservation is necessary

in Lao PDR. International collaboration is needed to investigate the effectiveness of indigenous knowledge for *ex situ* conservation as an alternative and inexpensive approach.

Inventories are not available to identify suitable areas for *in situ* conservation of some valuable genetic material listed in the national database on PGR. In fact, less priority was demonstrated for such activities. This indicates that those locations have not yet been preserved and no incentive system adapted for their stewardship. International cooperation is necessary to accelerate the process of identification of these locations and conservation of any genetic material left behind.

Enhancing information management is a responsibility of the centre for PGR management in Lao PDR. Recruitment of adequate staff and acquiring provisions required for necessary training are important tasks to ensure the smooth functioning of national information management. Similarly, it is important to develop international collaboration to establish an early warning system for genetic erosion in biodiversity in Lao PDR. The policy on utilization of PGRFA is in place. Plant improvement programs should focus their objectives to utilize and exploit the valuable genetic variations of existing collections. These objectives can be included in the research programs funded by public or private sector.

Chapter 7
Access to Plant Genetic Resources and Sharing of Benefits Arising out of Their Use, and Farmer's Rights

7. Introduction

The Lao PDR has agreed to become part of an effective and transparent multilateral international initiative, the International Treaty on PGRFA jointly with other 113 countries, to establish cooperation and facilitate access to plant genetic resources for food and agriculture, and to share the benefits in a fair and equitable manner. Sharing the benefits of using PGRFA through information-exchange makes provisions to access transfer of technology and capacity building.

7.1. Access to Plant Genetic Resources

Prior to 2000, Lao PDR had a bilateral agreement with Thailand to share the plant genetic resources to improve rice yields. This agreement allowed Lao and Thai breeders to share their genetic material and develop high yielding, glutinous rice through a Lao-IRRI project.

Since 1992, a large number of segregating rice populations were tested in Lao PDR, which resulted in releasing few improved lines suitable for commercial use. Due to the suspension of this agreement in 2000, sharing genetic material for breeding purposes has been halted. Sadly the commercial orientation in the rice industry in both countries has undermined the bilateral relationship of sharing genetic material for further research.

More than 15,000 rice accessions from Lao PDR are in long-term cold storage at IRRI. Through an agreement, the Lao PDR and IRRI share their genetic resources in crop improvement programs. Consequently, a large quantity of rice genetic material has been imported from the international cold nursery at the IRRI. There is an increasing demand on Central and Southern Lao PDR to develop gall midge (*Orseclia oryza*) resistant rice varieties for rainfed lowland conditions. Lao PDR needs to expand their genetic resources for gall midge resistance and to screen resistant lines for different biotypes. The Multilateral System of the International Treaty provides access to genetic material from different origins available at IRRI and other parties to the Treaty through a 'Standard Material Transfer Agreement' adopted in June 2006.

The evaluation of rice genetic resources in Lao PDR for various descriptors is in progress. Accessions from the germplasm are utilized for breeding and genetic improvement of rice. As there are more environment challenges with regard to climate change, the local germplasm could play a major role in plant improvement in the country.

A Similar bilateral agreement is proposed by the ARC/NAFRI with CIAT to introduce a cassava (*Manihot esculenta*) seed population for high starch content. *Brachiaria* spp. and *Stylosanthes* spp. were introduced from Australia (AusAID) for cattle feed and are now popular in northern uplands in Lao PDR.

For tree crops, a bilateral collaborative agreement with Australia has resulted in the establishment of few exotic tree varieties in Lao PDR. These include species suitable for

industrial forestry and agro-forestry in degraded land areas. The FRC and LRC are the recipients of these foreign genetic resources.

There have been no initiatives to introduce new regulations or laws on genetic material exchange in Lao PDR. It is becoming important to introduce a quarantine ordinance to protect biodiversity. However, currently, with the existing limited facilities and shortage of skills, such ordinance could not be fully implemented.

7.2. Fair and Equitable Sharing of the Benefits from the Use of Plant Genetic Resources

The current laws in Lao PDR protects the forest and land areas, and regulates the factors related to the sharing and utilization of *in situ* resources. Sharing mechanisms are decided at a village level but conflicts can arise when there are economic advantages. However, Lao PDR has a good record in solving conflicts outside the court system with the help of impartial village leaders. The pilot projects utilizing genetic resources for community based poverty alleviation programs indicate that rural farmers are capable of sharing resources among communities.

Rural communities and the country as a whole stand to gain significant benefit from the utilization of PGR. The net saving of imports by utilization of NTFP contributes to almost 30% of the GDP. The export market for processed and fresh NTFP is almost US$ 5 million. The income generation through utilization of plant genetic resources has positive effects on local communities. A World Bank report in 2006 stated that, poverty levels in the rural community have dropped by 1.2%, but it is clear that the real benefit to the rural community who generate wealth from biodiversity is still less than expected. The drawback is that the NTFP generated income for rural farmers comes at the high cost of eroding biodiversity in Lao PDR.

There are no mechanisms in Lao PDR to implement breeder's rights. Large numbers of rice and vegetable species are collected from farms and are tested for their commercial adaptation and quality attributes by breeders and agronomists. It was estimated that more than 70% of the area under rice-cultivation contains improved varieties. Neither breeder nor the institution receives any benefit from the income generated by those selected varieties. Nevertheless, funding for the research centers is from the government and is partly from taxes collected from crops advanced through research and development programs with the help of the breeders.

Genetic resources can be used for high income generation if an appropriate market for those products is present. Rice grown in rural farms using no chemical and fertilizers can be high value-added product in the western world. However, as there are no monitoring systems for universal standards in place for such local products, it is difficult to initiate a market for them. Lao PDR needs to develop strict guidelines on such agriculture products and seek assistance from the developed countries to monitor and certify them.

7.3. Implementation of Farmer's Rights

Farmer's rights include the protection of traditional knowledge, the right to participate equitably in benefit-sharing and in national decision-making on PGR. There is no legislation to preserve the farmer's rights to indigenous crops in Lao PDR. The landraces generate substantial income to the country where rural farmers use traditional cultural practices. Some ethnic groups in Lao PDR traditionally utilise NTFP, and rising markets for many forest products give them an opportunity to raise their household incomes. In

contrast to developed countries, there are no farmer's rights to protect this material or prohibit removing planting material from their natural habitats.

Currently, the Lao Government is considering developing mechanisms to protect farmer's rights and fair income distribution among rural farmers. Lao government needs external assistance and expertise to develop such mechanisms.

Chapter 8
Contribution of PGRFA Management to Food Security and Sustainable Development

8. Introduction

The Lao economy depends greatly on agriculture. The contribution of agriculture through value-added products to the GDP is almost 46%[19]. Food security is the main issue affecting all levels of governance in the country. It is a challenging task to assure the maintenance of quality and quantity as well as equal distribution of food material across the country.

While the country moves towards a market-oriented economy, the rural communities continue to practice village based subsistence agriculture and use traditional food crops in their diet which not only ensures food security but also adds extra revenue with surplus product. The urban markets, however, continue to favor imported food products.

8.1. Contribution to Agricultural Sustainability

The main objectives of several PGR conservation and utilisation projects involve poverty alleviation, food security and sustainable development in the rural economy. Few studies have been conducted to compare and quantify the sustainability prior to and post project introductions. FAO conducted a livelihood support program (LSP) in Vientiane Province titled "Plant genetic access and utilisation: understanding and contributing to sustainable livelihoods in Lao PDR"[20]. The project focused on issues related to the farmer access to PGRFA and importance of these genetic materials in sustainable livelihood development. Rainfed and irrigated rice farmers with contrasting access to market with commercial agricultural products were addressed in this study. Small-scale rural farmers are increasingly shifting from subsistence production to market-oriented farming. The market-oriented farmer groups in dynamic farming environments require a rapid and reliable supply of seed material and timely supply of other inputs. In contrast, subsistence farmers need to acquire their own local seed material mostly landraces. Market-oriented farmers are obliged to grow modern hybrid varieties and other imported seed and consequently, local landraces will become extinct from their home gardens. The results suggested that when utilising PGRFA, a more holistic approach including technical, social, economic and political aspects is needed to improve the livelihood of farmers.

A different project was conducted on NTFP marketing and small enterprise development for poverty alleviation and food security in far rural communities namely; in Savannakhet, Luang Prabang, Champassak and Oudomxay. It was suggested that developing a market for NTFP helps farmers improve their household incomes. The system ensured the protection of biodiversity but required more policies to protect farmers. In this system, short-term effects can be measured in terms of reduction of erosion of plant genetic material because of the systematic management and careful harvesting of forest products.

The forest product dependency for food is slightly higher today (30%) than in the year 2000 (26%). The income generation from NTFP during mid and late 1990s (Table 9) came at a cost of forest destruction by slash-and-burn methods where there was no biodiversity

[19] Annual report, 2005. World Bank Annual report on Economy in Lao PDR

[20] J.T. Sescon and R. Salazar. 2007. Access to seed and plant genetic resources for food and agriculture. Their role in improving rural livelihoods in Lao PDR

policy conservation in place in the forest. The current legislations limit the slash-and-burn system and encourage sustainable development in cleared forest areas. Small plantations with traditional NTFP such as cardamom, lemongrass and groom grass are emerging on these lands.

Table 9. NTFP Crops and the foreign exchange earnings by exports of some NTFP (1995-1998)

Product	Botanical Name	Total value in US$			
		1995	1996	1997	1998
Cardamom	*Amomum* spp.	553,192	829,611	2,380,971	1,697,388
Malva nuts	*Scaphium macropodum*	911,190	10,375	-	1,340,704
Sugar palm fruits	*Arenga westerhoutii*	-	117,204	111,600	320,132
Khi si dammar resin	*Shorea obtuse*	36,262	51,894	133,898	305,113
Broom Grass	*Thysanolaema maxima*	-	56,333	3,900	214,636
Rattans (big)	*Calamus* spp.	17,961	37,095	36,564	117,503
Draceana plants	*Draceana lourei*	-	9,260	63,485	71,200
Paper mulberry	*Broussonetia papyrifera*	-	9,199	6,500	67,200
Nyang oil	*Dipterocarpus alatus*	102,667	184,770	396,300	38,416
Bong bark	*Persea kurzii*	4,132	46,587	67,616	34,405
Benzoin	*Styrax tonkinensis*	-	-	85,067	33,325
Rattan fruits	*Calamus* spp.	-	-	28,750	32,941
Peuak meuak bark	*Boehmeria malabarica*	-	27,145	55,980	18,300
Bamboo shoots	*Dendrocalamus spp*	-	-	26,280	1,200
Haktinhung ferns	*Helminthostachys zeylanica*	43,306	22,713	2,530	-
Sticklack	*Lacca* spp.	-	1,298	10,895	-
TOTAL (US$)		1,691,427	1,430,915	3,423,013	4,307,122

(Source: IUCN-NTFP project database)

In general, the contribution of PGRFA management for sustainable development is in place where rural communities continue subsistence agriculture with little ambition for cash flow from the market. The farmers in transition from subsistence to market-oriented agriculture have less time to manage PGRFA because their motivation is driven by the market hence conservation is less important for their livelihoods.

8.2. Contribution of PGRFA for the Economy of Lao PDR

Plant genetic resources for food and agriculture have contributed significantly to economic development during the last decade (Table 9). Species like cardamom, ginger and garlic are grown in home gardens and sold at markets to generate income for the household. There are community based PGRFA management systems through which local farmers effectively protect the biodiversity while they contribute to the country's economy. There

are plenty of other agricultural and horticultural crops, which could be introduced to the market for economic advantages.

Usable agricultural lands are shrinking with the ever-increasing population and rapid industrial development. Yield improvement by genetic manipulation and improved agronomic practices are the only solutions available to plant researchers. To meet future demand, a steady progress towards rice yield improvement activities is expected. Rice genetic resources, comprising landrace varieties, modern and obsolete varieties, genetic stocks, breeding lines, and wild rice varieties, will make a significant contribution towards this target.

The future of PGRFA in Lao PDR depends on the collective approach of policy makers, researchers, scientists, provincial agriculture and forestry officers, educators, farmers, traders and most importantly the public. Technical and financial assistance from the donor countries is essential to continue this most important work in Lao PDR.

Acknowledgements

The valuable information provided by representatives and scientists from several national and international organizations in Lao PDR (see annexure iii) are acknowledged. Their contribution was highly valued, in addition to the information provided by the national database for PGRFA in Lao PDR to complete this Country Report on PGRFA.

Annexure i. Plant Genetic Resources for Food and Agriculture – NTFP identified in Lao PDR.

Species	Family	Name (English)	Common name (Lao PDR)	Economic importance	Ecosystem / Location
Acacia pennata (*L.*) *insuavis*	Leguminosae	Climbing Acacia	*Phak nao,Phak ka, Cha-om (Thai)*	Edible: leaf shoots Medicinal: leaf shoots, roots, bark	Throughout Laos; in scrubby forest or swampy forest and along streams
Acacia concinna	Leguminosae	Soap-pod wattle	*Som poi, Subok, Shikakai*	Edible: leaf shoots Medicinal: pod Extracts: pod Other uses: religious	Throughout Laos; in scrubs, clearings and dry forest types
Adenanthera pavonina var. *microsperma*	Leguminosae	Coral wood, Polynesian peanut	*Phak lam*	Edible: leaf shoots Medicinal: seed, leaves; Fibre: bark Extracts: bark, wood; Fodder: leaves	Throughout Laos; prefers neutral to slightly acidic soils
Aglaonema modestum	Araceae	Chinese evergreen	*Phaen din yen*	Medicinal: stem, root Ornamental: whole plant	Throughout Laos; on limestone or shale bedrock and along streams
Albizia procera	Leguminosae	Forest siris, Brown Albizia	*Phak thon*	Medicinal: all plant parts Extracts: leaves, bark Fodder: leaves	Throughout Laos; grows best on fertile well-drained alluvial loamy or clay soils
Alpinia galanga	Zingiberaceae (Alpinioideae)	Species from ginger family	*Ginger kha, Kha ta deng*	Edible: pseudo stem/stem shoots, young inflorescences ; Spices: fruit, rhizome Medicinal: fruit, rhizome	In mixed deciduous and evergreen forest and open areas along streams, growing in deep soils
Alstonia scholaris	Apocynaceae	Milky pine	*Tin pet*	Medicinal: bark, leaves Extracts: bark, leaves	Throughout Laos; in scrub or on forest margins, on a variety of soils
Amalocalyx microlobus	Apocynaceae		*Mak sim*	Spices: fruit	Throughout Laos; often hanging on trees
Amaranthus spinosus	Amaranthaceae	Spiny amaranth, Spiny	*Phak hom nam*	Edible: leaf shoots, whole plant Medicinal: leaves, roots Fodder: leaf shoots and whole plant	Throughout Asia; common in degraded and open places, on open soil along rivers on sandy soil
Amomum spp.	Zingiberaceae	Tavoy cardamom	*Mak naeng*	Spices: fruit Medicinal: fruit	Throughout Laos; in moist riverine places within mixed and secondary deciduous or evergreen forest
Amorphophallus paeoniifolius	Araceae	Elephant foot yam	*Houa ka buk*	Edible: tuber, stem-base Medicinal: seed, tuber	Grows under some shade in secondary vegetation, on sandy soils near streams
Anomianthus dulcis	Annonaceae		*Tine tang, Kheua, khitang (Oudomxay)*	Edible: fruit Medicinal: leaves	In deciduous and evergreen forests, along streams, scattered on sandy soil or granite bedrock
Apium graveolens	Umbelliferae	Celery	*Phak si sang*	Edible: leaf shoots/stalks, roots Spices: leaves, seed; Medicinal: seed (oil)	In wild forms growing in moist places near water
Aquilaria crassna.	Thymeleaceae	Agar wood	*Mai khed sana*	Medicinal: resin Extracts: resin	In all provinces in Laos; in under storey of undisturbed evergreen, semi-evergreen and deciduous forest types
Arenga westerhoutii	Arecaceae	Sugar palm fruits	*Mak tao*	Edible: seed, leaf shoots, sap Fibre: leaves	Mainly along streams in mountainous, limestone rocky areas, in humid and cool evergreen forests everywhere in the country
Averrhoa carambola	Oxalidaceae	Star fruit	*Mak pheuang pa*	Edible: fruit, leaf shoots Medicinal: fruit, leaves, roots Extracts: fruit	Cultivated throughout Laos; prefers a climate with a dry season, on moist or acid (peat) soils
Azadirachta indica	Meliaceae	Neem, Margosa tree	*Phak kadao*	Edible: flowers, leaf shoots, fruits Extracts: leaves, seed oil, bark, resin Fodder: leaves	In deciduous and open evergreen forests, in open areas and foothills

Species	Family	Name (English)	Common name (Lao PDR)	Economic importance	Ecosystem / Location
Baccaurea ramiflora	Phyllanthaceae	Burmese grape	*Mak fai*	Edible: fruits Medicinal: fruit, bark, root, wood, leaves	In the north near streams, on a wide range of soils, such as sandstone and limestone bedrock
Bambusa arundinacea, B. tulda and other *Bamboo* spp.	Poaceae (Gramineae)	Bamboo	*Phai ba, Mai bong*	Edible: shoots; Fibre: culms (canes, stems); Fodder: leaves	In former semi-evergreen forest habitat now support what has been termed bamboo forest
Bauhinia malabarica	Leguminosae	Malabar orchid	*Som sieo*	Edible: leaf shoots, fruits, seeds Medicinal: bark, flowers, root Fibre: bark; Ornamental: whole plant Other uses: charcoal and fuel wood from stem	In mixed deciduous and dry dipterocarp forests in lowlands
Boehmeria malabarica	Urticaceae		*Peuak Meuak, Sa pan, Toutiang*	Medicinal: resin Extracts: bark; Fibre: bark	Mainly in the northern provinces
Broussonetia papyrifera	Moraceae	Paper mulberry	*Po sa*	Edible: fruits Medicinal: fruits, leaves, bark Fibre: bark; Extracts: seed oil as cosmetics; Fodder: leaves	Especially in the north, on deep, fertile soils (limestone bedrock), near streams, particularly along the Mekong
Castanopsis indica	Fagaceae	Chestnut	*Mai ko*	Edible: nuts Extracts: Tannin from bark	Throughout central and northern Laos and also on mountain ridges, granite bedrock
Celastrus paniculatus	Celastraceae	Staff tree	*Kheua mak teck*	Edible: leafshoots, leaves Medicinal: leaves, seed, roots Extracts: seed oil	In deciduous forests and plans near rice fields, even on poor soils
Centella asiatica	Umbelliferae (Apiaceae)	Asiatic pennywort	*Phak nok*	Edible: whole plant Medicinal: leaves, sap	In shaded areas and damp fertile soils, along stream banks and in open grasslands
Cinnamomum cassia	Lauraceae	Cinnamon twigs	*Khe hom*	Medicinal: bark, leaves; Extracts: bark, leaves; Spices: bark, leaves, fruits	Mainly in the northeast in upper evergreen forests
Clausena harmandiana	Rutaceae		*Song fa*	Edible: fruit, leaf shoots Medicinal: roots, leaf shoots, bark, flowers	In the under storey of deciduous and evergreen forests on various soil types, or along streams, but mainly on poor sandy soils
Clerodendrum paniculatum	Verbenaceae	Pagoda Flower	*Phouang phi*	Medicinal: leaves, stem, flowers, roots	Along evergreen and deciduous forest edges and openings in humid places, on sandstone or limestone bedrock
Colocasia esculenta	Araceae	Elephant Ears	*Pheuak*	Edible: tubers, young leaves, young leaf stalk; Medicinal: tubers	Prefers dry and fertile soils along streams to produce high yields, and is slow growing at higher altitudes
Coscinium fenestratum	Menispermaceae	Columbo wood	*Kheua haem*	Medicinal: stem, roots Extracts: stem	In central and southern Laos, and prefers mixed and dense evergreen forest with fertile soil and high moisture
Cratoxylum formosum	Guttiferae (Hypericaceae)	Mempat	*Phak tiou som*	Edible: leaf shoots, young flowers Medicinal: leaves, bark, roots, resin Other uses: charcoal from stem, branches	Scattered in deciduous and secondary forest on a variety of soils, with a grassy under storey, from ridges to limestone
Dioscorea hispida	Dioscoreaceae	Asiatic bitter yam	*Houa koi*	Edible: tuber; Medicinal: tuber Extracts: tuber	Widely distributed in lowland evergreen and secondary forest, with bamboo, grows well on all soil types
Diospyros mollis	Ebenaceae	Ebony tree	*Mak kheua*	Edible: fruits ; Medicinal: fruits Extracts: fruits; Handicraft: wood	Scattered in secondary deciduous and dry evergreen forest, on granite ridges or shale bedrock, and also on limestone
Diplazium esculentu	Athyriaceae (Pteridophytes)	Fiddlehead Fern	*Phak kout*	Edible: leaf shoots Medicinal: rhizomes, leaf shoots Ornamental: whole plant	On sandy soil in open, shady, moist and swampy places along watercourses in forests and bamboo thickets, sometimes forming extensive colonies

Species	Family	Name (English)	Common name (Lao PDR)	Economic importance	Ecosystem / Location
Dipterocarpus alatus	Dipterocarpaceae	Indonesian gurjun	*Nam man nyang, Mai nyang na*	Medicinal: oleoresin Extracts: oleoresin	In evergreen forest areas and drier forests near streams on fertile soils, mainly in the central and southern Laos
Dracaena angustifolia	Dracaenaceae (Agavaceae) (Ruscaceae)		*Khon khae*	Edible: leaf shoots, fruit, young flowers Medicinal: stem, roots, leaf shoots, Ornamental: whole plant	From Vientiane to Champassak Province, near streams or shaded areas in evergreen and deciduous forests
Dracaena loureiri	Dracaenaceae (Agavaceae)	Dragon's blood tree	*Chandai*	Edible: fruits Medicinal: resin Extracts: leaves, fruits	Throughout Lao s; on a variety of soils in deciduous or evergreen forests
Eurycoma harmandiana	Simaroubaceae		*Khok ien don*	Medicinal: roots	In dry dipterocarp or mixed forest, also in grass fields, along streams and rocky outcrops or sandy soils in southern Laos
Flacourtia indica	Flacourtiaceae	Madagascar plum	*Mak ken*	Edible: leaf shoots, fruits Medicinal: whole plant	Scattered in open places in dry evergreen and deciduous forests
Helminthostachys zeylanica	Ophioglossaceae (Pteridophytes)	Flowering fern	*Phak hak tin houng*	Edible: leaf shoots Medicinal: rootstocks	In wet, shaded places and on loamy clay soils found in most of the lowlands, from Vientiane to Attapeu
Houttuynia cordata	Saururaceae	Fishwort, Charmeleon	*Phak khao thong*	Edible: leaf shoots, roots Medicinal: leaves, roots Ornamental: whole plant	In moist and shady places like ravines, riverbanks, forests, meadows, slopes, thickets and field margins and roadsides
Hydnocarpus kurzii	Flacourtiaceae	Chaulmoogra	*Mak kabao*	Medicinal: seeds	Occurs along streams in evergreen parts of the forest and often on limestone
Hydnophytum formicarum	Rubiaceae	Baboon's head	*Houa sam phan hou*	Medicinal: tuber	On host trees, in humid areas along streams in central to southern Laos
Lasia spinosa	Araceae		*Lasia phak nam*	Medicinal: leaf shoots, roots, stem	Widespread in moist and shaded areas along rivers in evergreen forest
Limnocharis flava	Limnocharitaceae	Yellow burrhead	*Phak khan chong*	Edible: leaf shoots, flowers Ornamental: whole plant	In rice-fields and ditches
Limnophila geoffrayi	Scrophulariaceae	Sparrow herb	*Phak kha nhaeng*	Edible: whole plant ; Medicinal: whole plant	In moist places, in ponds and rice fields
Livistona saribus	Arecaceae	Ceylon oak, Taraw palm	*Mak kho*	Edible: fruits, leaf shoots, seed Fibre: leaves Ornamental: whole plant	Prefers forested hillsides and ridges in the lowlands, with poor shallow soils; mainly in (temperate) central to northern Laos
Markhamia stipulata	Bignoniaceae	Trumpet-creeper	*Dok khae*	Edible: flowers, young fruits Medicinal: bark	On basalt or granite or limestone bedrock in humid places, from Luang Prabang to Savannakhet
Melientha suavis	Opiliaceae	Melientha	*Phak van*	Edible: leaf shoots, fruits, young flowers Medicinal: roots	In deciduous forests and in limestone areas in Saravane, Savannakhet, Bolikhamxay, Sayabouly, Luang Prabang and Luang Namtha provinces
Momordica charantia	Cucurbitaceae	Bitter melon	*Phak sai, Bai maha*	Edible: leaf shoots, fruit, seed	Along roads and fences
Mushrooms	Mushrooms - many families	Mushrooms	*Het*	Edible: whole plant Medicinal: whole plant	Throughout Laos; most popular mushrooms in dry dipterocarp and oak forest
Many orchid species	Orchidaceae	Orchid	*Euang sai mai, Euang pheng si keo*	Medicinal: whole plant, rhizomes Ornamental: whole plant	Highest numbers can be observed in dry dipterocarp forest where many epiphytic orchids grow on dry dipterocarp trees

Species	Family	Name (English)	Common name (Lao PDR)	Economic importance	Ecosystem / Location
Oroxylum indicum	Bignoniaceae	Indian trumpet flower	*Mak lin mai*	Edible: leaf shoots, flowers, pods, seed (drink) ; Medicinal: seed pod, seed, roots, stem, bark Extracts: bark	Prefers deep, wet and well drained soils, and found in deciduous and evergreen forest in open parts and forest edges, foothills or along roadsides
Pandanus fibrosus	Pandanaceae	Sandan	*Teuy*	Medicinal: fruit; Fibre: leaves Ornamental: whole plant	Throughout Laos; near evergreen forests on rocky outcrops along streams, marches and ponds
Passiflora foetida	Passifloraceae	Stinking passion vine	*Phak bouang*	Edible: fruit, leaf shoots Medicinal: whole plant	In relatively open light environment, favours wet areas, but tolerates arid conditions
Pentace burmanica	Malvaceae	Burmese mahogany	*Sisiet*	Medicinal: wood Extracts: bark, wood	Prefers deciduous and lowland evergreen forest, found in south and central Laos
Persea kurzii or *P. gamblei*	Lauraceae	Omgthat	*Peuak bong*	Extracts: bark	Throughout Laos; in all forest types and on various soil types
Piper ribesioides	Piperaceae	Currant pepper	*Khua sa khan*	Spices: stem	In shaded areas in evergreen forests, near stream on granite or sandstone bedrocks, mainly in northern Laos
Plumbago indica	Plumbaginaceae	Rose-colored lead-wort	*Pit pi daeng*	Medicinal: roots, leaves Ornamental: whole plant	In deciduous forest, wet grasslands and around villages on fertile soils, lime stone, shale bedrock and near streams
Pothos scandens	Araceae		*Wai-sa-noi, Cha-kep, Ma nok hon*	Medicinal: whole plant	Prefers shade and moist areas
Calamus spp. (many species)	Palmeae (Arecaceae)	Common Sweet Flag, Rattan	*Wai*	Edible: shoots, young fruits Medicinal: roots, fruits; Fibre: canes, leaves; Ornamental: seed	Post rattans prefer wet, shady places in evergreen forests and on river edges, found in forests in Luang Namtha, Khammouane, Xieng Khouang, Vientiane, Bolikhamxay, Attapeu and Champassak
Rhus chinensis	Anacardiaceae	Chinese gall	*Som phod*	Edible: fruits, leaf shoots Spices: fruits; Medicinal: fruits, gall Extracts: gall	In deciduous or evergreen forest growing on yellow-red lateritic soils, or phyllite bedrock
Rubus multibracteatus	Rosaceae	Raspberry	*Mak thoum*	Edible: fruit, leaves	Mainly in mountainous areas in the northern Laos
Scaphium macropodum	Sterculiaceae	Malva nuts	*Mak chong*	Edible: fruit Medicinal: fruit	In small pockets of evergreen forests in southern Laos, mainly on rocky and shallow soils, often on hill slopes
Schleichera oleosa	Sapindaceae	Indian lac tree	*Mak kho som*	Edible: fruit Medicinal: seed, fruit, bark, stem, leaves	In central and southern Laos, mainly in dry dipterocarp forest or dry periodically swampy soils
Senna siamea	Leguminosae	Cassod tree, Pheasant wood	*Phak khi lek*	Medicinal: whole plant; Extracts: whole plant; Ornamental: whole plant Fodder: leaf shoots, young inflorescences Other uses: charcoal and wood from stem	In various types of forests at lower altitudes, and performs best on deep well-drained fertile soils
Dipterocarp trees	Dipterocarpaceae	Dammar trees	*Khi si*	Extracts: resin	In dry dipterocarp forests, and in evergreen or lower mixed deciduous forests found in Sayabouly, Luang Prabang, Bolikhamxay, Khammouane, Attapeu, Savannakhet and Champassak
Smilax glabra	Smilacaceae		*Ya houa*	Edible: fruit, stem Medicinal: tuber, stem	Mainly in the north in evergreen and deciduous mountain forest areas, along streams on all soil types, but often on stony soils
Spondias pinnata	Anacardiaceae	Ambra	*Mak kok*	Edible: fruit, leaf shoots, young flowers Medicinal: fruit, leaf shoots	Mainly in dry evergreen forest
Strychnos nux-vomica .	Loganiaceae	Poison nut, Quaker buttons	*Mak seng beua*	Medicinal: seed, bark	In deciduous secondary forest and open places, on a variety of soil types

Species	Family	Name (English)	Common name (Lao PDR)	Economic importance	Ecosystem / Location
Styrax spp.	Styracaceae	Gum wood, Star-leaf gum	*Nyan*	Medicinal: oleoresin Extracts: oleoresin	In the north, with large populations in provinces of Luang Prabang, Oudomxay, Houaphan and Phongsaly
Syzygium gratum	Myrtaceae	Eugenia	*Phak samek*	Edible: leaf shoots, bark Medicinal: bark Extracts: bark	In open areas in deciduous or dry evergreen forest often along river banks and wetlands, on granite or sandstone bedrock in the central and southern Laos
Thysanolaena maxima	Poaceae (Gramineae)	Broom grass	*Dok khaem*	Edible: shoots, Fibre: stem, flower Fodder: whole plant Ornamental: whole plant	In the northern provinces, and it grows well on fallow lands, in valleys and lightly shaded slopes, in ravines and on river banks
Tinospora crispa	Menispermaceae	Quinine liana	*Kheua khao ho*	Medicinal: stem Extracts: roots	In deciduous and evergreen forest as well as in secondary forest and relatively open light environment on granite and shale bedrock
Vetiveria zizanioides	Gramineae	Vetiver grass	*Fek hom*	Extracts: roots	Naturally in dry dipterocarp forest
Zanthoxylum rhetsa	Rutaceae	Indian ivy-rue	*Mak khaen*	Edible: fruit, leaves Spices: fruit, leaves Medicinal: fruit, seed oil, bark	In northern Laos, Vientiane and Bolikhamxay provinces, mainly on loamy alluvial soils of medium moisture and fertility, and also on red laterite soils, in moist areas

Annexure ii: NTFP planting and seedbank establishment in different provinces in Lao PDR.

Province	District	NTFP species and planted by
Bokeo Province:	Tounpheung	Yang bong bark planted - farmer
	Houay xai	Rattan intercropping with other tree species -farmer
Luang Namtha	Namtha	Cardamom planted - FRC
Province:	Sing	Cardamom planted - FRC
	ViengPhokar	Cardamom and lemon grass planted - FRC
Oudomxay Province:	Namor	
	Ban Pangdoo	Rattan, Peuk Meuk bark, cardamom, planted - farmer
	Pangthong	supported by Lao-Swedish Agriculture and Forestry
	Mainatao	Research Program
	Xai	Same farmer planted cardamom by themselves
		Lemongrass intercropped - FRC
Phongsaly Province:	Boun-neua	Peuk Meuk bark planted - FRC
	Boun-tai	Meuk bark planted - FRC
Luang Prabang	Xieng-ngeun	Paper mulberry and broom grass planted - FRC
Province	Ngoy	Paper mulberry and broom grass, especially Mulberry planted - FRC
	Park-seng	Paper mulberry and broom grass planted - FRC
	Phoukhoun	Broom grass planting - FRC
Houaphanh	Xam-neua	Mark-not, sweet bamboo, Manh Houasing planted -FRC
Vientiane	Vangvieng	Mulberry planted - FRC
	Hinheup	Rattan planted - FRC
Vientiane capital	Park Ngeum	Rattan planted - FRC
	Xaythani	Rattan planted - FRC
Bolikhamxay	KhamKeud	Rattan planted - FRC
	Phin	Rattan planted - farmer
Savannakhet	Song Khone	Rattan planted - farmer
		NTFP planted - SUFORD program
Salavanh	Salavanh	Bong bark planted - FRC

Annexure iii. Stakeholders contributing to the preparation of the Country Report on PGRFA.

Name	Position	Institution
Dr Monthathip Chanphengxay	Director General Research, NABP	NAFRI
Mr Bounkong Souvimonh	Coordinator, Deputy Director	Horticulture Research Centre
Mr Phumi Inthapanya	Director, ARC	Agriculture Research Centre
Ms Sengkham Lakmithri	Researcher/Plant Genetic Resources	Agriculture Research Centre
Mr Nilhom Chan Phavea	Researcher/Plant Genetic Resources	Agriculture Research Centre
Mr Khotsada	Senior Lecturer, Genetics and Plant Breeding	Faculty of Agriculture, NUoL
Dr Gary C. Jahn	IRRI Representative & Coordinator for the GMS	IRRI Lao PDR
Dr Rod Lefroy	Regional Coordinator CIAT	CIAT-Lao Project
Mr Bounphom Mounda	Acting Director	Forestry Research Centre
Mr Khamphone Mounlamai	Head Forest Research	Forestry Research Centre
Mr Sopha Xaypha	Head of Animal Breeding	Livestock Research Centre
Dr Eddie Vernon	Team leader (Fruits and vegetable improvement)	Horticulture Research Centre, FAO
Dr Matthias Plewa	Advisor, Vegetable Seed Production	Horticulture Research Centre, DED vegetable seed production
Mr Khoung Douangsila	Leader, National Rice Program	Lao-IRRI Project
Ms Latsamay Silovong	IUCN Lao People's Democratic Republic	IUCN
Mr Serge Verniau	FAO Representative	FAO, Lao Office
Ms Vu Thanh Tu Anh	Agro-Biodiversity Project Coordinator	FAO, Lao Office