COUNTRY REPORT ON THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

INDONESIA

Note by FAO

This Country Report has been prepared by the national authorities in the context of the preparatory process for the Second Report on the State of World's Plant Genetic Resources for Food and Agriculture.

The Report is being made available by the Food and Agriculture Organization of the United Nations (FAO) as requested by the Commission on Genetic Resources for Food and Agriculture. However, the report is solely the responsibility of the national authorities. The information in this report has not been verified by FAO, and the opinions expressed do not necessarily represent the views or policy of FAO.

CONTENTS

APPENDIX 1

LIST OF TABLES **28**

APPENDIX 2

LIST OF FIGURES **36**

CHAPTER 1

THE STATE OF DIVERSITY

A. The main values of plant genetic resources

There was a growing concern and recognition that biological diversity as a global asset of tremendous value to present and future generations. This was culminated by the adoption of the agreed text of the Convention of Biological Diversity in Nairobi in May 1992. The United Nation Conference on Environment and Development (UNCED) which was held in June 1992 in Rio de Janeiro, Brazil and known as Earth Summit. It was an important milestone in the sustainable development where the Convention was open for signature.

Indonesia is a country with a mega biodiversity. Biological diversity is very important for keeping balance ecosystems and biosphere life system. The lost and erosion of biodiversity, which have been due to human activities, caused the unbalance ecosystems on earth which in turn affect human life. Realizing the importance of biodiversity, Indonesia ratified the Convention of Biological Diversity (CBD) in 1994 which was followed by the enactment of Law No. 5 in 1994 for the ratification of the United Nations Convention on Biological Diversity.

Indonesia is an archipelago of more than 17 000 islands straddling the equator in Southeast Asia. About six thousands of the islands are inhabited. Indonesia has at least 47 distinct natural ecosystems which are rich in plant and animal resources and large number of island endemics, with the total known species about 1.46 million.

In addition to biological diversity, there has been traditional knowledge established in order to utilize the existing genetic resources for the people welfare. In order to be able to be a good competitor in the era of globalization, these genetic resources, however, must be sustainability and efficiently utilized.

There are nine crops of importance in Indonesia such as rice, maize, soybean, soybean, cassava, sweet potato, coffee, cocoa, oil palm, and rubber. These crops are important as dietary crops of most of Indonesian as well as crops contributing to Indonesian national income. Their productions are shown in Table 1.

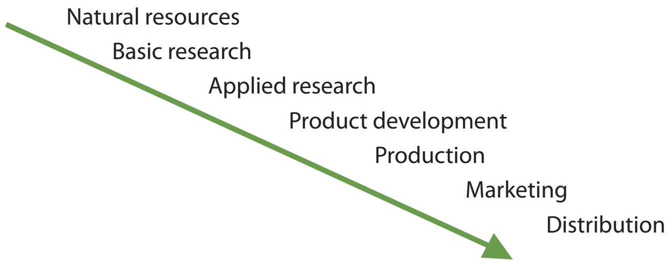
B. Diversity within and between crops and factors influencing the state of plant genetic diversity

Traditional knowledge related to the use of genetic resources, traditional agriculture pattern and natural conservation exist within communities in Indonesia has been long established. From the utilization aspect, to meet the need for carbohydrate, more than 100 species have been use as sources of carbohydrate. About 100 species of leguminous plants have been used as sources of protein and fat. About 450 species of fruit trees and 250 species of vegetables have been used as vitamin and mineral sources. Spices have been obtained from 70 species, and 40 species for beverages. For furniture and construction, about 300 species have been used. About 1 000 species have been used as ornamental plants. More than 940 species of medicinal plants have been used for traditional medicine. Traditional knowledge also includes the use of microorganisms for fermentation processes of foods.

Traditional knowledge will be very useful for future utilization of genetic resources for agriculture and medical health. However, these traditional knowledge are degrading due to several factors. In general, traditional knowledge has been inherited orally within the local cultural system, which, therefore, for those traditional knowledge that have not been documented become extinct. This situation is disadvantageous to the development of the genetic resource utilization, which, otherwise, will be utilized by industrial countries that already have the capability to further process and used it. To anticipate the global market in the years to come, this traditional knowledge have to be conserved and protected against commercial utilization without fair and equitable sharing of the benefits.

C. Future needs and priorities

Access to genetic resources, traditional knowledge and fair and equitable benefit sharing are all interrelated. Though they may be separated, to get the maximum impact on the utilization of biodiversity they should be dealt simultaneously, that is when we talk about bioprospecting. Whatever the sector chosen for development, and the strategy adopted, the end products will always reach the economy through variations of the following sequence:



Different types of industry require extremely different types of approach. The key parameter to consider is where in the process of technology and product development, the heaviest investments in human and financial capital are needed. For example, in drug development, the most complex parts are basic studies on diseases and clinical testing of potential drugs. Primary screening of molecules is relatively cheap and technologically within easier reach. A country wishes to stimulate the development of a national capacity drug development, could adopt a capacity development model starting with primary screening to acquire property on molecules and access to know-how in advanced screening, testing and clinical trial at a later stage.

Whatever the field of activity, and the choice of prime actors in the development scheme, the major element for success is a multidisciplinary approach. Moreover, on top of the required training policy, public authority faces hard choices in other fields: legislation and regulation on safety, IPR capacity development, and public information.

Strategy will depend on the type of product, existing and available technology and business strategy envisaged, and on external factors, such as international treaties. Finally, if a national or regional strategy for bioprospecting related to economic development is to have a chance of succeed, it requires efficient access to financing sources for long term programme as much as training and a legal framework.

D. State of the art

Indonesia is one of the tropical countries known as mega biodiversity country rich in biological diversity based on the types of ecosystems and characters of the species. Based on the type of ecosystems and species' characters, Indonesia divided into seven regional biogeographies:

1. Sumatera and its offshore islands,
2. Java and Bali,
3. Kalimantan, include Natuna and Anambas islands,
4. Sulawesi and its offshore islands, includes Sula island,
5. Nusa Tenggara,
6. Maluku, and
7. West Papua.

Based on the existing ecosystems, Indonesia consists of at least 42 different natural inland ecosystems and five marine ecosystems. Those ecosystems are consisted of coastal area, lowland rain forest, coral reef, mangrove, up to mountain area, even the area permanently covered with snow in Papua. These ecosystems diversity gave rise to species diversity. The number of the main biotic types in Indonesia presented in Table 2.

CHAPTER 2

THE STATE OF *IN SITU* MANAGEMENT

A. Plant genetic resources inventories and surveys

The archipelago of Indonesia has a long history of rice production across a broad range of rice growing environments resulting in a diverse array of local Indonesian rice varieties. Although some have been incorporated into modern breeding programmes, the vast majority of these landraces remain untapped. To better understand this rich source of genetic diversity 330 rice accessions, including 246 Indonesian landraces and 63 Indonesian improved cultivars have been characterized. The landraces were selected across 21 provinces and include representatives of the classical subpopulations of *cere*, *bulu*, and *gundil* rices. Genetic diversity analysis characterized the Indonesian landraces as 68% *indica* and 32% *tropical japonica*, with an *indica* gene diversity of 0.53 and a *tropical japonica* gene diversity of 0.56. All of the improved varieties sampled were *indica*, and had an average gene diversity of 0.46. A set of high quality Indonesian varieties, including Rojolele, formed a separate cluster within the *tropical japonicas*. This germplasm presents a valuable source of diversity for future breeding.

Indonesia — a country with a wealth of biodiversity that is largely untapped. A long history of traditional rice production across numerous environments in Indonesia has led to a diverse array of local Indonesian rice varieties. Indonesian rice varieties have previously been classified into three traditional categories: *cere* (or *tjereh*), *bulu* and *gundil*. *Cere* rice has been characterized as having thin stems with many tillers, narrow leaves, and no awns, while *bulu* rices have thick stems with few tillers, broad leaves, and long awns, and *gundil* types are essentially the same as *bulu* but lacking awns. Rice breeders have associated *cere* with *indica*, while *bulu* and *gundil* were once referred to as "*javanica*" (i.e. rice that was found on the island of Java, Indonesia) but the term *tropical japonica* is now preferred. This germplasm presents a valuable source of diversity for future breeding.

Several Indonesian rice varieties have been employed in international breeding programmes, such as the Peta variety that was used as one of the parents of the green revolution variety IR8. More recently, the breeding programme at the International Rice Research Institute has made use of Indonesian *tropical japonica* landraces to develop new plant type (NPT) varieties that have fewer tillers, thick stems, and large panicles for more efficient grain production. Although a few varieties have been incorporated into modern breeding programmes, the vast majority of traditional Indonesian germplasm remains uncharacterized and underutilized. While the *indica* and *tropical japonica* subsets of Indonesian germplasm both contained abundant diversity, a comparison of the improved varieties versus the landraces revealed much lower diversity in the set of 63 improved varieties sampled in this study. For example, the 168 Indonesian *indica* landraces had a gene diversity of 0.53, while the Indonesian *indica* improved varieties had a gene diversity of 0.46. The difference between the Indonesian landraces and the Indonesian improved varieties was more pronounced, where the *indica* landraces had a gene diversity of 0.60 and the *indica* improved varieties 0.55. Furthermore, the Indonesian *indica* cultivars tended to cluster in one section of the larger *indica* group, and did not cover the complete range of *indica* diversity found in the landraces. This suggests that breeding programmes can target these untapped clusters of landraces to introduce novel sources of genetic variation. One important example is a sub-group of the *tropical japonica*s that contains two popular high-quality landraces: Rojolele and Pandanwangi. These two varieties are prized in Indonesia by consumers due to their fragrant aroma and excellent taste resulting in a significant premium when sold on the market, but the desired characteristics of these two varieties have yet to be incorporated into improved Indonesian varieties. While these high quality *tropical japonica* varieties are currently grown in upland environments, it will be interesting to see if the desirable grain quality traits can be incorporated into high yielding irrigated varieties.

Ninety six accessions of sweet potato collected from Papua were analyzed genetically using 10 SSR markers indicated that among 96 accessions there is no relationships between accession and their origin, except those accessions collected from Papua, where those from Wamena were in different cluster from that of those from Manokwari. This may be due to different genetic resources and geographic isolation, which widen the genetic distance. This indicates higher genetic variability of those found in Papua which molecularly support the status of Papua as the secondary centre of diversity of the world sweet potato. Heterozygousity level indicated by high genetic variability ranging 0.51 (IB275) to 0.99 (IB255F1) with the average of 0.81.

B. *In situ* conservation of wild crop relatives and wild plants for food production

With a land area of 1 903 650 square kilometers spread over an archipelago of more than 17 000 islands, Indonesia is known as the largest country in Southeast Asia. Stretching across some 5 110 km from west to east, Indonesia encompasses the greatest part of the Malaysian floristic region, which is one of the richest botanical areas in the world with it shared with Malaysia, the Philippines and Papuasia. The country spans two of the world's major bio geographic regions: the oriental region which include the island of the Asian Sunda Shelf, Sumatera, Borneo, Java, and Bali; and the Australasian region with Papua resting on the Sahul Shelf along with the rest of Papuasia and Australia. In between lies the fascinating zoogeographic sub-division known as Wallacea which shows a mixture of elements from these two vary different part of the world.

By virtue of its vast dimensions and unique bio geographic position, Indonesia is endowed with a biological biodiversity and richness that is without compare in all of Southeast Asia. In short, Indonesia contains the greatest wealth of terrestrial and marine plants and animal life of the entire region and is therefore the most important focus for the preservation of biological diversity in this part of the world.

The Indonesian archipelago encompasses the bulk of Malaysian floristic region, and exceedingly rich area that contain more than 25 000 species of flowering plants; 10 000 of these trees nearly 40% of the plant are endemic at the generic level; many are still poorly known or even unknown to science and their benefits to men are far from being completely understood. The western part of Malaysia is the centre of diversity of the commercially important dipterocarp trees, with 262 of 386 species found on the island of Borneo (most of these in Kalimantan), a fact with has made part of Kalimantan, some of the most exploited forests for the logging industry in the country.

In situ conservation is the effort to protect species, genetic variations, and habitats in the indigenous ecosystem. The *in situ* approach comprises of the setting and management of protective areas, such as nature reserves, wildlife sanctuaries, national parks, natural recreation parks, protected forests, river boundaries, germplasm areas, and peat areas.

In practice, the *in situ* approach is also used as a strategy to manage and protect wild animals outside the protective areas. In forestry and agriculture sector, the *in situ* approach is also used to protect the genetic diversity of plants in the original habitat and in determination of protected species without specifying their habitats.

Until 2005, there are 534 units of conservation areas covering an area of more or less 28 million hectares. Terrestrial conservation areas reached 495 units (80.33%) while the marine conservation areas reached 39 units (19.67%). About 57.94% of the total conservation areas are national parks.

C. On-farm management and improvement of plant genetic resources for food and agriculture

In order to realize sustainable use of PGRFA, Indonesia has been conducting:

- identification and collection of endemic PGRFA;
- exchange of PGRFA among hobbies';
- utilization of local PGRFA;
- capacity building of hobbies, collectors, and farmers;
- improvement of local PGRFA quality.

D. Assessment of major needs for *in situ* management of plant genetic resources for food and agriculture

In order to conserve and sustainable use of PGRFA, National Committee on Genetic Resources has been motivating the establishment of Region Committee on Genetic Resources in every province with the tasks of collecting and stocking of regional PGRFA. For this purpose, the following activities are needed:

- better coordination among stakeholders in *in situ* management
    - capacity building of breeders as well as seed growers
    - establishment of national networks on *in situ* management and genetic improvement
- establishment of potential PGRFA maps based on agro-ecosystems identification of future crops in relation to climate change.

CHAPTER 3

THE STATE OF *EX SITU* MANAGEMENT

A. Sustaining and expanding *ex situ* collections

Ex situ conservation has the goal of conserving flora and fauna outside of its original habitat. Activities normally done include breeding, storing, or cloning. Habitat loss due to increasing land clearing for the purpose of industrial plant, settlement, and road construction, as well as the extension of agricultural production makes the *ex situ* conservation become necessary.

Ex situ conservation among others constructs botanical gardens, museums, zoos; collects micro organisms, seeds, and tissue cultures. Because the organisms are managed in man-made environments, *ex situ* conservation isolates species from the evolutionary process.

The most ideal way to conserve plants is in their original habitat (*in situ* conservation); however most conservation areas in Indonesia are threatened severely, and therefore the *ex situ* conservation would give better chance in conserving Indonesian flora. Collecting of a genetically appropriate and representative sample from their habitat is the beginning of starting *ex situ* conservation. There is different opinion on the number of population for each species or the number of collection for each population to be collected. It is often found that one species of plant is considered as ornamental plants or medicinal plant or spice, therefore this type of collection will be collected by different *ex situ* conservation organization.

Ex situ conservation facilities for Indonesian flora are found in different institutes or organization as shown in Table 3. *Ex situ* collections are intended to reduce population extinction risk, preserve genetic diversity and provide source of plants/seedlings for restoration and recovery programme. To restore genetic diversity of the *ex situ* plant collections, a large area is required. Therefore, conserving the diversity of Indonesian plants each institute has their own methods. Some places restore small number of species but with more genetic diversity. While Botanic Gardens usually conserve a large number of species but with a narrow genetic diversity.

The Department of Forestry with its research institutes and the local forestry offices maintain their plant collections, especially for economically important timber trees. Every province, under the Directorate General of Land Rehabilitation and Social Forestry also has nursery and produces seeds of their important local plant collections. Since 2001 to 2005, from 27 out of 33 provinces has a total of 104 201.14 hectares area and their potential production are 29 330 730.13 kg seeds. There are many garden collections under the Department of Forestry. One of them is under the Forestry Research Center, the area is 5 hectares and holds 234 species of trees (136 genera, 50 families), 167 species are local and 67 are exotic species.

Four Botanical Gardens, Bogor, Cibodas, Purwodadi and Eka Karya-Bali are under the Indonesian Institute of Sciences. All gardens not only conserving Indonesian plants but also conserve plants from other countries through routine exchange. The *Bogor Botanical Gardens* mainly conserving plants from lowland humid areas in Indonesia. The important collection of the Bogor Botanical Gardens is palms, orchids, Indonesian timber, bamboo, medicinal plants, ornamental shrubs and trees, water plants, climbers, lianas, foliage plants. Many important plants were introduced to Indonesia from other country, such as oil palm, rubber, cacao, vanilla and others. The last record of the Bogor Botanical Gardens conserved 217 families; 1 363 genera; 4 052 species and 22 439 specimens of plant collections. Storage of seeds has been started recently especially for the orthodox seed collection.v As extension of the Bogor Botanical Garden, 30 hectares of land in Cibinong Science Center were developed into Ecopark. The arrangement of plants is differ from botanical gardens because the plant collections were grouped according to the original island in Indonesia (bioregion). Since 2002, Ecopark already has 78 families; 556 genera; 1 850 species; 4 500 specimens of plant collections. *Cibodas Botanical Gardens* is a mountain garden which mainly conserving plants from the highland humid areas in Indonesia. Important collections of the Cibodas Botanical Gardens are fern, Bryophytes, cacti, orchids, Rhododendrons, Gymnosperms. *Cinchona*. The latest record of the Cibodas Botanical Gardens has 243 families, 886 genera, 2 044 species, and 9 814 specimens of plant collections. The *Purwodadi Botanical Gardens* is holding collection mainly from lowland dry areas. The Purwodadi Botanical Gardens has important collection of succulent, orchids, mango, banana, medicinal plants and others. Recent record of the garden has 174 families; 908 genera; 1 901 species and 10 934 species of plant collections. The Purwodadi Botanical Gardens also has a good garden seed collection. The *Eka Karya Bali Botanical Gardens* is conserving collections from highland areas of the eastern part of Indonesia. Some important collections of this garden are cacti, Begonias, bamboo, medicinal plants, orchid, and ceremonial plants collection. The latest record of this garden has 198 families; 988 genera; 6 471 species and 15 091 specimens of plant collections. *The Biology Garden in Wamena* was established in 1995, under the Research Center for Biology, this is the only *ex situ* plant collection in Papua. About 150 local species were planted in more than 200 hectares land area. This garden also maintains cultivars of sweet potatoes, especially from the highland of Papua.

Twenty hectares of *germplasm collection* managed by the Biotechnology Research Center, of the Indonesian Institute of Sciences, the 20 hectares area holding 2 250 collection number; 108 cultivars; of 16 species fruit trees. This garden also has 360 collection number of cassava (120 genotypes), 710 collection numbers of taro (182 genotypes), 693 collection numbers of multipurpose trees from 10 species and 43 collection numbers of *Jatropha curcas*.

The Department of Agriculture holds 10 592 accession of 23 food crops especially rice, sweet potatoes, cassava, peanut, corn, peas, minor legumes and minor tuber crops. The collections consist of field collection and short/medium/long term seeds collections. Under the Department of Agriculture the plantation plants (coconut, nutmeg, clover, oil palm, rubber, tea, cacao, coffee etc.), medicinal and aromatics, fruits, vegetables and ornamental plants collections were in the form of field collection and seeds collection. The detailed of these crops are presented in Table 4.

Research Center for spices and medicinal plants has 5 gardens, 2 gardens at the highland (Manoko and Gunung Putri) and 3 gardens at the low land (Cikampek, Sukamulya and Cimanggu). The number of collections holds in 5 gardens is 1 116 collection numbers in the form of field collection, tissue cultures and seeds. *Department of health*, it has 13 hectares area, holding 850 species of medicinal plants collections in Tawangmangu gardens in Central Jawa. *Puspitek Serpong* has 350 hectares land that hold 160 020 number of specimen from 37 families; 378 genera and 602 species.

Recently local government starts building their Botanic Gardens. These new gardens would have important roles in conservation of their local flora especially. Under the guidance of Bogor Botanic Gardens, their collections have been planned according to the themes of the garden. For example, *Sungai Wain Botanic Gardens* in Balikpapan, East Kalimantan focusing on timber trees, *Nepenthes* and orchids. *Enrekang Botanic Garden* in South Sulawesi focusing on Wallace plants. *Bukit Sari Botanic Gardens* in Jambi is the remaining lowland forest among oil palm plantations in that area. This garden was established in 2003, the area is 300 hectares and about 400 species were found in that garden. *Baturraden Botanic Garden* in Central Jawa planning to collect Jawa flora. This garden was established in 2004, the area is 142.2 hectares and 107 species has been planted in that garden. *Kuningan Botanic Garden* would represent Ceremai mountain flora and plants suitable for stony areas. *Liwa Botanic Garden* in West Lampung focusing on ornamental plants and plants from South Bukit Barisan. *Katingan Botanic Gardens* in Central Kalimantan focusing on fruit trees and *Puca Botanic Gardens* in Maros, South Sulawesi focusing on economic plants collections.

Some areas in Indonesia establishing arboretum, for example in Depok, Purwakarta and Jepara. It was also noted that there are private botanic gardens such as in Ubud (Bali) and Tomohon (North Sulawesi). Other area which has planning to build botanic gardens is Lombok (West Nusa Tenggara), Batam (Riau), Samosir (North Sumatra) and Sambas (West Kalimantan). Some university also has *arboretums*, especially under the Faculty of Forestry, Agriculture and Biology. *Mulawarman University already established a botanic garden, Botanic Gardens of Mulawarman University*, Samarinda in 2001 Several times the garden was damaged by fire, however in 2003 at this150 hectares area, 116 species of about 2 600 trees were found.

Private garden such as *Mekarsari Fruit garden* holds 78 families; 326 species and 1 463 varieties of fruit trees collection and also breeds new fruit trees hybrids. This 264 hectares garden was also act as education garden. Other private garden, *Taman Bunga Nusantara* collected mainly ornamental plants. There are many plant collectors in Indonesia whose propagate and breeds their collections. Orchid collectors usually have wild and cultivated orchid species and hybrids. Traditional medicine factory also usually has medicinal plants collection. Many ornamental plant nurseries also have private garden collection.

Safety duplication rates appear low, but precise estimates are not possible due to lack of information and documentation by many genebanks. Besides genebanks, botanic gardens hold many species of value to food and agriculture. Indonesia as one of the centres of origin of some crops like rice and banana has put attention to established safety duplication of rice and banana accessions collected through out Indonesia. Those collected accession are deposited at IRRI and INIBAP for rice and banana respectively. Some endangered medicinal crops like pulasari (*Alyxia reinwardtii* Bl**)**, pule pandak (*Rauvolfia serpentine* L.), inggu (*Ruta graveolens* L.) and purwoceng (*Pimpinella pruatjan* Molkenb) have been conserved by using *in-vitro* culture technique and *cryopreservation*.

B. Planned and targeted collecting

The construction of eight new botanical gardens in seven provinces, which was listed in the main plan of regional governments last year, now begins to be realized simultaneously. The spirit in building botanical areas in the regions is among others encouraged by the high number of visitors. The Bogor Botanical Garden, which will be nearly 200 year old, has been visited by no less than 1.4 million people annually.

These eight botanical gardens are the Bukit Sari Botanical Gardens in the Province of Jambi, Baturaden in Central Java, Balikpapan in East Kalimantan, Enrekang and Puca in South Sulawesi, Kuningan in West Java, Liwa in Lampung, and Katingan in Central Kalimantan. This will add to the number of botanical garden in Indonesia to the total of 12 botanical gardens. This is still far below that of the United States, which has over 300 botanical gardens; and Britain, China, Australia, India, and Russia, which has more than 100 botanical gardens each.

CHAPTER 4

THE STATE OF USE

A. Expanding characterization and evaluation and the number of core collections to facilitate their use

Plant genetic resources must be evaluated for their useful characteristics and be well described to be of use to farmers and breeders. There also proposed strategy to make it easier to locate useful varieties and genes in collections by developing properly identified core sub-sets of larger collections, through the development of better database. Nationally this database is maintained by the NCGR and can be accessed through http://www.indoplasma.or.id/.

Characterization and identification of several food crops using molecular markers (*simple sequence repeat*) have been conducted in some institute. Ninety six (96) accessions of rice, sweet potato and soybean have been characterized using fluorescence labelled SSR markers (*simple sequence repeat*). With the use of DNA Genetic Analyzer, obtained fragment may be accurately read. This is an important feature of variety identification for plant variety registration. Results indicated that almost all of rice accession has unique DNA finger printing. Rare alleles (with the frequency <5%) may have future use in varietals improvement. Grouping of rice accession on the basis of the size of allele are shown in Figure 1. Genetic variability parameter of 96 rice accessions analyzed with 30 SSR markers were presented in Table 5. Three hundreds and five alleles ranges from 4-22 per locus were detected. In addition, alleles specific for each cluster or combination of two or more clusters were detected. This allele specificity would be very useful in determining SSR marker for certain population of a cross. The average of gene diversity is 0.612 PIC value (*polymorphism information content*) is 0.581. Similarly genetic analysis for sweet potato using 10 SSR markers indicated that among 96 accessions there are no relationships between accession and their origin, except those accessions collected from Papua, where those from Wamena were in different cluster from that of those from Manokwari (Figure 2). This may be due to different genetic resources and geographic isolation, which widen the genetic distance. This indicates higher genetic variability of those found in Papua which molecularly support the status of Papua as the secondary centre of diversity of the world sweet potato. Heterozygousity level indicated by high genetic variability ranging 0.51 (IB275) to 0.99 (IB255F1) with the average of 0.81 (Table 6). For soybean, results of molecular analysis of 96 soybean accession using 10 SSR markers found 116 alleles ranges from 7-19 alleles per locus with the PIC 0.703 (Figure 3). Improved varieties tended to cluster together which indicated their relatedness. It was also found genetic difference between two accessions with different accession number and names. On the other hands there were also accessions with different accession number and names but the same genetic identity. So far, characters used for plant variety protection are pigmentation and other morphological characters. However, current commercial soybean varieties developed from elite lines which is very limited, therefore, it is very difficult to differentiate them if not impossible on the basis of those characters. In this situation the use of molecular marker could be very helpful. Size, number and frequency of major alleles, heterozygousity, gene diversity, and polymorphism level of 96 soybean accession identified by 10 SSR markers were presented in Table 7.

B. Promoting sustainable agriculture

This has been done through diversification of crop production and broader diversity in crops. This consists of a number of activities to increase the use of genetic diversity in the field and to reduce crop vulnerability. Amongst these are to: monitor genetic uniformity and crop vulnerability, review policies that affect diversity in the field, increase the use of mixed varieties, improve the deployment of genetic diversity as part of the strategy for integrated pest management, and promote decentralized and participatory plant breeding strategies.

C. Promoting the development and commercialization of underutilized crops and species

A large number of crops contribute to household crop security, many of which have potential for wider use and could contribute to food security, agricultural diversification and income generation. This activity aims to: identify underutilized species, develop sustainable management practices, develop post-harvest and marketing methods, and promote policies for the development and use of underutilized species.

D. Supporting seed production and distribution

Farmers benefit from access to a choice of good quality planting material. The Plan proposes actions to make available to farmers a wider range of crop varieties by:

- improved complementary between parastatal, commercial and small-scale enterprises
- expanding viable local level seed production and distribution systems
- making suitable material stored *ex situ* available for multiplication and distribution
- reviewing seed certificate regulations.

E. Developing new markets for local varieties and diversity-rich products

The Plan aims to stimulate demand for diverse products derived from landraces and farmers' varieties, including through the creation of niche markets, labelling and niche variety registration schemes to permit and promote the production and commercialization of local varieties.

F. Distribution of plant genetic resources

Several institutes in Indonesia, has established mechanisms to record the distribution of samples of conserved plant genetic resources to breeding programmes. National breeding programmes in Indonesia have been successfully conducted and implemented by the contribution of plant genetic resources accessions from core collections.

G. Utilization and enhancing the use of plant genetic resources

There are various crops have been improved for crop production especially on food crops like rice and maize. Indonesia face constraints in terms of improved use of plant genetic resources such as: lack of characterization and evaluation; lack of documentation – useful information on the conserved germplasm; lack of capacity – qualified personnel, funds, training, facilities; weak policy development; lack of integration between conservation and utilization programmes; lack of coordination among researchers, breeders, genebank managers and farmers. To enhance the use of plant genetic resources in Indonesia, the following activities have been undertaken: strengthened capacities and improved training in plant breeding; increased collaboration among researchers, breeders, genebank managers and farmers to better integrate conservation and use of plant genetic resources; placed greater emphasis on using and developing underutilized species; and implemented participatory approaches to plant breeding; explored marketing opportunities for products of local varieties and diversity-rich products, promoted the use of landraces/farmers' varieties in seed supply systems, and improved the regulatory and policy frameworks to facilitate greater use of plant genetic resources are current priorities for Indonesia and our needs to implement them. Part of our plant genetic resources for food and agriculture been adequately characterized and evaluated. Information systems on germplasm characterization have been also established in several institutes.

Our plant genetic resources for food and agriculture have been collected in a working collection or a gene bank. The collections have been established in various institutes such as Leguminous and Tuber Crops Research Institute, Agricultural Biotechnology and Genetic Resources Research and Development, Rice Research Institute, Vegetable Crops

Research Institute, Tobacco and Fibber Crops Research Institute, Citrus and Subtropical Fruit Crops Research Institute, and Fruit Crops Research Institute (Table 4). The main constraints to achieving diversification of crop production and broadening diversity in crops are policy/legal and marketing/commercial obstacles.

- The following are constraints faced in Indonesia for the utilization of plant genetic resources, namely:
- lack of characterization and evaluation,
- lack of documentation – useful information on the conserved germplasm,
- lack of capacity – qualified personnel, funds, training, and facilities,
- weak policy development,
- lack of integration between conservation and utilization programmes,
- lack of coordination among researchers, breeders, gene bank managers and farmers.

To enhance the use of plant genetic resources in Indonesia, the following activities have been undertaken: strengthened capacities and improved training in plant breeding, increased collaboration among researchers, breeders, gene bank managers and farmers to better integrate conservation and use of plant genetic resources, placed greater emphasis on using and developing underutilized species, and implemented participatory approaches to plant breeding, explored marketing opportunities for products of local varieties and diversity-rich products, promoted the use of landraces/ farmers' varieties in seed supply systems, and improved the regulatory and policy frameworks to facilitate greater use of plant genetic resources. Those are current priorities for Indonesia and our needs to implement them. Part of our plant genetic resources for food and agriculture have been adequately characterized and evaluated. Information systems on germplasm characterization have been also established in several institutes.

H. Seed supply systems and the role of markets

In Indonesia, seed production and distribution involve a public and private sector function. Sustainable seed production systems should be initiated with varietals improvement which later on to be released as a new improved variety which is better than the available variety. Figure 4 shows the relationship between seed production systems and technology used.

Development of new varieties can be done either through breeding or introduction. Both are passing through the necessary steps and testing. Varietals improvement is a breeding activities started with several testing activities, varietals release in which breeder seed production is included.

I. Supporting seed production and distribution

Farmers benefit from access to a choice of good quality planting material. Varietals release is a part of seed systems which is follow the Ministerial Decree no.902/1996 on the provision of varietals release. However, this provision need to be further improved and harmonized with regard to testing requirement in accordance with the plant variety protection law.

Figure 5 shows the flow of seed production systems started with improved varieties resulted from research and development and release by Minister of Agriculture as a new commercial variety. Breeder seed of this variety will be further planted to produce high quality of foundation seed for further production of stock seed. This stock seed maybe distributed/licensed to seed producer for further multiplication to produce the extension seed, which will be further distributed (sale) to the farmers.

From now on varietals improvement should be based on consumer preference, product oriented and for better varietals maintenance. Consumer preference can be obtained through market survey especially on the standard quality of agricultural product demanded at a particular region. Therefore, breeding programmes that so far have been oriented toward high productivity and yield stability need to be reoriented to fulfil the demand of consumer, industry, and for export quality purposes.

The availability of breeder seed is a foundation of high quality seed industry since breeder seed is the only authentic seed source. As a reward, in relation to the intellectual property of the breeder seed, the government shall give the plant variety protection rights, upon request, to the breeder(s) who developed the new variety. This reward system is expected to promote seed industry as well as the frequency of varietals development by both private and public breeding institution.

J. Developing new markets for local varieties and diversity-rich products.

Indonesian PGRFA could be further improved through breeding. Some of them could be directly consumed in the form of fresh product as well as for industrial raw materials. In addition, there are land areas available for the production of those PGRFA as well as the increasing demand for fruit, vegetable, and others.

For fruits crops, the strategy for fruit PGR utilization and development is directed toward fulfilment of domestic market and for export purposes, which, therefore Good Agriculture Practices (GAP) and Good Manufacturing Practices (GMP), as well as integrated handling of the whole processes of post harvest until the product reaching the consumers. This strategy is actually parallel with the establishment of local and regional markets for the commercialization of local varieties that gain popularity among Indonesian population.

These markets have been the place for commercialization of PGRFA listed in Table 1.

K. Crop improvement programmes and food security

The state of crop improvement programme in Indonesia is described mostly as well establish formal-sector crop improvement programme utilizing advanced methodologies and technologies in some institutes, however in several institutes are described as basic formal-sector crop improvement programme in place, germplasm identification, and evaluation programmes. Many crops have benefited from improvement programmes such as food crops like rice, soybean, maize, sweet potato, cassava, peanut; vegetable crops like potato, tomato, hot pepper; fruit crops like banana, citrus, mango; estate crops like coffee, tea, cacao, sugarcane, oil palm; industrial crops like tobacco, coconut; and medicinal crops like ginger, black pepper.

In Indonesia, breeding programmes for crop improvement have been developed more than 10 years. Crop improvements conducted were to increase crop resistance to biotic stress such as pests and diseases, to abiotic stresses like drought tolerance, and to modify quality of crops like to increase fatty acid, and sugar content. Crop improvement programmes which consists of conventional breeding, irradiation induced mutation, and biotechnology have been applied on various crops or trees such as food crops, horticulture crops, estate crops and forest trees. Conventional breeding to increase crops resistance to pests and diseases have been conducted for many years on crops like rice, soybean, maize, potato, tomato, coffee, tea, and citrus. Whereas biotechnology such as the application of *in vitro* culture techniques using somaclonal variation and protoplast fusion, molecular breeding using molecular marker, and genetic engineering have been utilized to increase crops resistance to pests and diseases, increase tolerance to drought, phosphate deficiency, aluminium toxicity, and iron toxicity, increase sugar content, increase oleic acid, delay ripening, free amylose, on different crops such as cassava, citrus, oil palm, papaya, potato, soybean, rice, and tomato.

The Indonesian tropical forests are rich in the diversity of flora and fauna life, and they arouse the interest of many domestic and foreign communities, which encourages illegal hunting and trading of various species of flora and fauna, both protected and unprotected. In order to keep them from being extinct, the government encourages the development of the breeding activities of flora and fauna. These activities are mostly done in order to save endangered species of flora and fauna; to aid the re-stocking of wildlife population in nature; to aid research; and to fulfil market demands, both domestic and export. In the interest of breeding and trading these wildlife flora and fauna, the government-determined regulations which allow the use of breeding parent stock coming from their natural habitat, and allowing the trading of their F2 offspring. Up to now, there are 171 companies, which have business permits for breeding of flora and fauna. From these 171 companies, 124 of them obtained breeding permit for protected flora and fauna, while 44 companies obtained permit for the breeding of unprotected flora and fauna.

Indonesia has been implementing participatory crop improvement programmes for many years. With the rapid development of crop improvement technologies such molecular breeding and genetic engineering, we expect it will significantly changes in the use of plant genetic resources in the next 10 years.

"The state of the art: methods being employed for plant breeding in Indonesia", are conventional plant breeding, induced mutation using gamma ray irradiation, and biotechnology. The crop improvement techniques through conventional plant breeding have been implemented and resulted in improved varieties which have been released by the Minister of Agriculture (Table 8).

The gamma ray irradiation technique has been applied for crops improvement on rice, soybean, mungbean, and sorghum. The technique have resulted 15 new varieties of rice, five of soybean, one of mungbean, and 10 elite lines of sorghum. Most of new varieties and elite lines are resistant to insect pests and diseases, some of them are tolerant to drought.

The biotechnology methods used for crop improvement are an application of *in vitro* culture techniques, molecular breeding, and genetic engineering. The application of *in vitro* culture techniques includes somaclonal variation, *in vitro* selection, anther culture, embryo rescue, and protoplast fusion. Somaclonal variation was conducted to increase genetic variation of rice, ginger, patchouli, artemisia and vanilla. *In vitro* selection for biotic resistance and abiotic tolerance were conducted on vanilla, abaca, rice, and soybean. Anther culture techniques were used making pure strain through spontaneous doubled haploid/dihaploid induction of individual on rice and maize. Embryo rescue techniques were used for wild relative's hybridization with cultivated vanilla and mungbean. Whereas, research of protoplast fusion were conducted for biotic resistance on eggplant, citrus and patchouli.

In Indonesia, molecular breeding using molecular marker has been utilized since several years ago. The use of molecular marker for crop improvement consisting of mining of new alleles and genes for biotic and abiotic stresses, transferring of trait(s) from wild or agronomically inferior donor source which is called "prebreeding" or "germplasm enhancement" and marker assisted selection. These are very important steps to follow for systematic crop improvement. Varietals improvement needs available diverse genetic variation as source of economically important traits such as resistance to pests and diseases as well as tolerance environmental stresses. In last decades molecular marker has shown its potential for genetic diversity characterization and crop improvement. The use of molecular marker for crop improvement could help solve conventional breeding unsolved persistent problems, which, mostly selection of promising lines were based on phenotypic expression. While in molecular breeding, the selection processes were also based on the phenotypic expression and at the same time the needed alleles or loci may directly be identified. The techniques have resulted two improved rice varieties and several elite lines resistant to bacterial and fungal disease. The improved rice varieties which are Code and Angke were released by the Minister of Agriculture.

Genetic engineering for crops improvement has been conducting in various institutes in Indonesia. Today, this technology has reached a stage where scientists can take one or more specific genes from nearly any organism, including plants, animals, bacteria, or viruses, and introduce those genes into another organism. This technology is sometimes called modern biotechnology. Modern biotechnology today includes the tools of genetic engineering. An organism that has been modified, or transformed, using modern biotechnology techniques of genetic transformation is referred to as a genetically modified organism ("GMO"). There are series main steps in the process of genetic engineering: extracting DNA, cloning a gene of interest, designing the gene, and transformation. Some of the more common transformation methods include the particle bombardment (gene gun); *Agrobacterium tumefaciens* mediated transformation, microfibers, and electroporation. The genetic engineering resulted different transgenic crops with improved traits such as resistance to pests and diseases, tolerance to drought, increase sugar content, delay ripening, and free amylose. The stages of the research are varies as described in Table 9.

CHAPTER 5

THE STATE OF NATIONAL PROGRAMMES, TRAINING AND LEGISLATION

The national programmes on genetic resources management has been initiated in response to global plan of action and other international agreements. For PGRFA, national network was developed through the establishment of NCGR, which there are 19 Regional Committee on Genetic Resources. Comprehensive Information Systems for Plant Genetic Resources for Food and Agriculture was initiated by the development of National Biodiversity Information Network, Information Centre for Natural Conservation, and recently http://www.indoplasma.or.id.

A. National programmes

The Ministry of Environment has been assigned as the National focal point for the biological diversity with the mandate to coordinate the national policy on biodiversity management, including the clearing house mechanism. However, the national programmes lay on related ministries such as Department of Agriculture, Forestry, Marine and Fishery, and Ministry of Environment.

In the forestry sector, research and development concerning genetic resource are under the guidance of the Agency for Research and Development in Forestry (ARDFor), Department of Forestry. As structured in the ARDFor the programmes development and research proposals are done through two way approaches. ARDFor is mainly responsible for research activities, basic as well as applied, leading to the utilization of the commodities for fulfilling the needs. Conservation aspects of the forestry species are under the organization of Directorate General of Forest Protection and Nature Conservation.

IAARD works through nine major units, among those which working also in plant genetic resources for food and agriculture are described briefly below. The Indonesian Centre for Food Crops Research and Development (ICFORD) is in charge of generating research on the country's primary staple crops including rice, maize and other cereals, and legumes (such as soybeans, peanuts, and root and tuber crops). The focus of the institute's research is broad and includes plant genetics (breeding and management of genetic resources), agronomic studies, pest and disease management, and biotechnology. The scope of ICFORD's work is compounded by the diverse growing conditions found in Indonesia. The centre manages three research institutes: the Indonesian Research Institute for Rice in Sukamandi-Subang (West Java), the Indonesian Cereals Research Institute in Maros (South Sulawesi), and the Indonesian Legumes and Tuber Crops Research Institute in Malang (East Java). In addition, ICFORD coordinates the works of a number of research stations and experimental farms. In 2003, 348 researchers were active at ICFORD.

The Indonesian Centre for Estate Crops Research and Development (ICECRD) is responsible for conducting R&D on estate crops. The centre has four research institutes: the Indonesian Medicinal and Aromatic Crops Research Institute in Bogor (West Java), the Indonesian Tobacco and Fiber Crops Research Institute in Malang (East Java), the Indonesian Coconut and Palmae Research Institute in Manado (North Sulawesi), and the Indonesian Spices Research Institute in Sukabumi (West Java). Each of these institutes performs research on cultivation, breeding, farming systems, post-harvest processing, and biotechnology. ICECRD also manages a research station focusing on intercrops. ICECRD employed 332 researchers in 2003.

The Indonesian Centre for Horticulture Research and Development (ICHORD) is in charge of horticultural R&D. The centre oversees R&D activities of four research institutes: the Indonesian Ornamental Plants Research Institute in Cianjur (West Java), the Indonesian Research Institute for Citrus and Subtropical Fruits in Batu (East Java), the Indonesian Tropical Fruits Research Institute in Solok (West Sumatra), and the Indonesian Vegetables Research Institute in Bandung (West Java). Their research includes plant breeding, germplasm conservation and use, cultivation, pest and disease control, post-harvest handling, and various socio-economics aspects. In 2003 ICHORD had 138 researchers.

The Indonesian Centre for Animal Science Research and Development (ICASRD) is in charge of animal and forage including feedstuff R&D. ICASRD has 201 researchers.

As its name implies, the Indonesian Centre for Agricultural Biotechnology and Genetic Resource Research and Development (ICABIOGRD) is responsible for the research and development of agricultural biotechnology and genetic resources. It is the leading centre within the AARD that responsible for research activity on genetic resources. Its work covers research on cell and tissue biotechnology, genetic engineering, bioprospecting of agricultural genetic resources, and biosafety. In 2003, this Bogor-based agency employed 117 research staff.

The Indonesian Research Institute for Estate Crops (IRIEC) was established by the Indonesian Planters Association for Research and Development (IPARD) and is a semi-public R&D agency. While IRIEC is not formally part of IAARD, it is managed through the agency, and the head of IAARD is an *ex officio* member of the IRIEC board. IRIEC has five research centres for different commodities, namely the Indonesian Rubber Research Institute (IRRI), the Indonesian Oil Palm Research Institute (IOPRI), the Indonesian Research Institute for Tea and Cinchona (IRITC), the Indonesian Coffee and Cocoa Research Institute (ICCRI), the Indonesian Sugarcane Research Institute (ISRI). Each of these institutes performs research on cultivation, breeding, farming systems, and post-harvest processing. In addition to these commodity-research institutes,

IRIEC is also supported by three other centres at the Bogor headquarters: the Indonesian Rubber Technology Centre (IRTC), the Indonesian Biotechnology Research Centre for Estate Crops (IBRC), and the Indonesian Information and Training Centre for Estate Crops (IITC). Combined, the R&D institutes under IRIEC employed 229 researchers in 2003.

Forestry and fisheries research were once part of the IAARD system, but now constitute separate components of the Indonesian agricultural R&D system, falling under the jurisdiction of separate ministries. The Forestry Research and Development Agency (FORDA) has its headquarters in the Ministry of Forestry's building in Jakarta. FORDA is involved in forest-product technology, biotechnology, forest-tree improvement, and forestry socio-culture and economics. The agency has four research centres and 15 research stations scattered all over the archipelago. Most of the research takes place in the agency's headquarters in Bogor. FORDA employed 546 researchers in 2003.

The Research Centre for Biotechnology (RCB) under the Indonesian Institute of Science (LIPI) provides the core scientific resources for systematic collections and associated biodiversity information in Indonesia. RCB's collections are the largest in Asia and include many unique and irreplaceable scientific reference biological specimens, including some dating from the nineteenth century. Agricultural research also plays an important role in RCB's mandate. In 2003, RCB's 81 researchers focused principally on rice, beef, and forestry research.

Outside the Ministry of Agriculture, the higher education agencies are also involved in (limited) agricultural R&D. Bogor Agricultural University (IPB) is very much at the heart of the Indonesian agricultural R&D system. It is by far the largest agricultural university in the country. Twenty-three other Indonesian universities were identified to be involved in agricultural R&D.

The ultimate purpose of PGRFA conservation and utilization is to contribute to national development and sustainable agriculture by developing and strengthening national programmes. High priority is given to establishing national committees or similar coordinating bodies to ensure the involvement of all stakeholders. In the country programming structure, all plant genetic programmes are under the coordination of the IAARD, while those concerning genetic resources of wild species are coordinated by the Department of Forestry.

As the national leading body working on genetic resources, Department of Agriculture setup NCGR. This committee has now expanded to cover not only plant, but also animal and micro organism genetic resources as well. In the scope of responsibility and mandate, the NCGR will advise the Minister of Agriculture, through the Director General of the IAARD. In addition, members of this committee consist of personal from agricultural, forestry and fishery & marine sectors, scientific community, higher education, and non-government organizations.

Programmes on plant genetic resources for food and agriculture have been implemented at the institutes under IAARD working on commodities. The programme consisting activities related to conservation and utilization of genetic resources through breeding programme. With this programme it is hoped that the genetic resources are sustainably used and resulted in improved varieties for the farmers. The implementation of the programmes on plant genetic resources is in coordination with the NCGR.

Considering the wide stretched area of Indonesia, so far the committee has been able to establish 19 Regional Committees on Genetic Resources in 18 provinces located in South Sumatera, Lampung, Jambi, Riau, West and North Sumatera, in Java there are four provincial level, namely Banten, Yogyakarta, Central and East Java, and two districts level (Tasikmalaya City and Tasikmalaya District), then those in Kalimantan are West Kalimantan, Central, East and South Kalimantan Provinces, while in Sulawesi are South Sulawesi and South East Sulawesi Province, and one regional committee in Bali. The other 15 provinces in Indonesia are in the process on establishing the regional committee.

The NCGR has been conducting activities related to conservation and utilization of genetic resources as follows: 1) Coordinating genetic resources management,

1. Analysis on genetic resources management,
2. Development of genetic resource database,
3. Promoting public awareness on the value of genetic resources. It convened two national congresses of the Regional Committee in August 2006 and June 2008 to reach the consensus on future action plans.

It encourages national cooperation, setting priorities and supporting network of stakeholders and institutions. This kind of collaboration is expected to benefit both researchers and farmers.

B. Networks

National coordination on the conservation of genetic resources should be conducted by establishing network between the national committee and the regional committees. This network should be able to overcome the problems encountered in relation to conservation activities in each region. The first workshop of this networking was conducted in August 2006 in Balikpapan which was attended by all regional committees as well as other stakeholders.

Wide Area Network (WAN) is a network consisting of several Local Area Networks in various institutes, which is meant to improve communication among scientists. There are several WAN available, such as National Biodiversity Information Networks (NBIN) of the Indonesian Institute of Sciences, which was funded by Asian Development Bank, Information System on Plant Genetic Resources of NCGR, Biodiversity Clearing House of the Ministry of Environment, Information Centre of Natural Conservation under the Directorate General of Natural Conservation and Forest Protection.

Linkages between IAARD and the university and private-sector agencies have been strengthened during the past decade with the support of loans from the World Bank and the ADB. The World Bank-financed ARMP–II and PAATP, funded by the ADB, set aside special funds for collaboration between IAARD scientists and universities, international research centres, and private-sector companies. Collaboration involved joint research, hands-on training, technical assistance, scientist/manager exchange, and information sharing. Being largely financed by the private sector, IRIEC works closely with private plantation companies such as National Private, Good Year, and London Sumatra. It also conducts research on behalf of PT Perkebunan Nusantara, a government-owned estate. At the international level, FORDA works closely with CIFOR.

C. Education and training

Education and training in agriculture had been conducted in 24 Indonesian universities. All together they employed 1 040 agricultural researchers in 2003, spread over 34 faculties. Crop research was prominent at most universities, although livestock, fisheries, and socio-economic research played an important role as well.

Indonesia made major progress during the past three decades in building agricultural research capacity. When IAARD was established in 1974, only seven scientists held a PhD degree. By 2003, this total had risen to 227 (including PhD-qualified researchers at IRIEC). Of the 3 577 agricultural researchers in a 53-agency sample, 18 percent held a PhD degree, 43 percent a MS degree, and 39 percent a BS degree. IRIEC in particular experienced a tremendous improvement in the qualifications of its research staff. In 1994, just 42 percent of IRIEC researchers were trained to postgraduate level, compared to 69 percent in 2003. This share was much higher than the corresponding share for most IAARD agencies. In comparison, ICFORD and ICSARD had postgraduate shares around the 40 percent mark during the same year. Average postgraduate shares in the higher education sector diverged widely as well, from 55 percent at the Faculty of Agriculture of Human resource development and training were an important part of the World Bank-financed ARMP–II.

The new region-based decentralized R&D approach required an extensive reorientation and retraining of staff who, thus far, had been working mostly in commodity-oriented component research. A quarter of the newly appointed AIAT staff was scheduled for long-term (degree and diploma) training during 1995–2001. In addition, considerable financial support was provided for short-term, non-degree/diploma training to strengthen staff capability in the specific skills required to effectively carry out the regional R&D programmes. ARMP–II's training component total US$8.9 million (9 percent of the total project costs). Upon the project's completion in 2001, 428 IAARD scientists had received long-term training. Of these, 8 were from the AIATs and 13 from the national research institutes.

PAATP also contained an important training component. During 1999–2003, 18 IAARD scientists received PhD training and 33 IAARD scientists MS level training at universities in Australia, Malaysia, the Netherlands, and Thailand.

Roughly 40 percent of FORDA's PhD holders received their degrees from Indonesian universities and the remaining 60 percent were trained abroad (notably in Europe, Japan, and the United States). In the past, FORDA reserved a special budget for PhD-level staff training abroad, but this has recently been cut. A small budget for MS training remains nonetheless. In recent years, an annual average of 5 to 10 researchers at R&D Centre for Biotechnology has been sent abroad for training.

However, among of those educated to gain PhD and MS level whose specialize on PGR are limited. Therefore, the needs and priorities for education and training to support the sustainable use, development and conservation of plant genetic resources are necessary. The field of study needed to improve the capability in conserving and utilizing genetic resources are plant breeding, plant biotechnology, plant physiology, plant pests and diseases resistance, research methodology, environmental risk analysis, biodiversity and genetic resources. Main obstacles to providing education and training are less number of students, limited facilities, and limited funds. In general, the interest of graduate students to study in agriculture, not to mention on the above field of study, recently has been declining. There are some possible reasons for the declining of graduate student interest, such as, the students' awareness on the genetic resources value is low, due to the fact though the understood that the genetic resources are very important but the realization of its important takes tedious effort and passion; the opportunity to get better job in this field is much lower compared to the other disciplines; and there is no appropriate reward for those who are working in the field of genetic resources conservation and utilization which normally take longer period of time.

D. National legislation

The national legislation of Indonesia consists of Law, Government Regulation, and Ministerial Decree. The national legislation relevant to PGR which have been established over the 10 past years are:

- Law No. 29/2000 on Variety Plant Protection,
- Law No.18/2004 on Estate Crops,
- Law No. 4/2006 on Accession on ITPGRFA,
- Government Regulation No.7/1999 on Preservation of Plant and Wild Animal Species,
- Government Regulation No.8/1999 on the Utilization of Wild Plant and Animal Species,
- Government Regulation No.14/2002 on Plant Quarantine,
- Government Regulation No.13/2004 on the Denomination, Registration, and Use of Initial Variety for Development Essential Derived Variety,
- Government Regulation No 21/2005 on Biosafety of Genetically Engineered Products,
- Forestry Ministerial Decree No. 104/2000 on the Procedure of Wild Plants and Animal Collection,
- Agriculture Ministerial Decree No. 67/2006 on Conservation and Utilization of Plant Genetic Resources,
- Agriculture Ministerial Decree No.37/2006 on Seed Systems.

Obstacle in developing the bill of Genetic Resources Management observed due to low priority set.

E. Information systems

Indonesia has developed information systems and data base of plant genetic resources. The Department of Forestry has developed PIKA (Information Centre for Natural Conservation), followed by Indonesian Institute of Sciences with NBIN (National Biodiversity Indonesian Networks), and INDOPLASMA (www.indoplasma.or.id) by NCGR. The Ministry of Environment has also developed the Clearing House Mechanism for biodiversity.

F. Public awareness

For the past ten years public awareness on the value of plant genetic resources for food and agriculture conservation and utilization had been promoting in Indonesia. Every year the NCGR carry out public awareness activities in several different communities at some provinces. Such activities have been put in high priority, to generate support for plant genetic resources activities at national level. National programmes need appropriate information material of plant genetic resources in local dialect, in order to be easily understood by local communities. Schools and educational institutes of all types, including specialized agricultural institutions, need to be encouraged to spread better understanding of the value of plant genetic resources to food security.

CHAPTER 6

THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

Human life are really dependent on the availability of PGRFA, however, the *in situ* and *ex situ* PGRFA are not always available in every countries, including in Indonesia. Therefore Indonesia supports the regional and international collaboration for the conservation and the sustainable utilization of the diversity of PGRFA.

National food security could be achieved through better conservation and sustainable used of PGRFA. Therefore, Indonesia has established regional and international collaboration through networks, programmes, and agreements for improving PGRFA utilization. This collaboration especially conducted with agricultural research centres (IARCs) covering research, exploration, identification, characterization, evaluation, utilization, and conservation activities of PGRFA.

These collaborations are expected to give mutual benefit. Recently the Governing Body of the ITPGRFA, agreed by member countries submitted with document for the accession, agreed to use the standard Material Transfer Agreement (SMTA) for the access and benefit sharing of genetic resources listed in Annex 1 of the Treaty under the Multilateral System (MS).

A. Regional networks

Indonesia, Malaysia, and Brunei are bordered by the area of 220 000 kilometre square interconnecting tropical rain forests. This area mutually called Heart of Borneo (HoB). The HoB area in the mountain areas, functions as the heart of life for all of the Kalimantan Island. The highlands areas have an important role in maintaining hydrological balance in Kalimantan. Therefore, the three countries agreed to develop the HoB programme by building stakeholder partnership of three countries (Indonesia, Malaysia and Brunei). To realize this, the three countries had signed the Heart of Borneo (HoB) Declaration on February 12, 2007 with the goal to protect the existing Biodiversity of the Borneo area, the ecological function of the ecosystem in the Heart of Borneo area, and livelihood sources based on continuous utilization.

B. International networks

In order to conserve and sustainable use PGRFA as well as to provide facilitated access and technology transfer, Indonesia collaborated and established constructive regional and international network. For the management of rice genetic resources, Indonesia actively participated in the rice network with IRRI (International Rice Research Institute) since 1970. Indonesia has also participated in other Asian Networks, such as Asian Rice Biotechnology Network (ARBN) and Asian Maize Biotechnology Network (AMBIONET) since 1992. From those networking new rice varieties have been developed. The awareness programme of the importance of PGRFA networking in Indonesia have been initiated through the establishment of PIKA (Information Centre for Natural Conservation) of Forestry Department, followed by NBIN (National Biodiversity Indonesian Networks) of Indonesian Institute of Science, and INDOPLASMA (www.indoplasma.or.id) of NCGR.

The regional and international network should be increased in order to better utilize more PGRFA due to the fact that:

1. Among species listed in Annex 1, there are only 7 species originated from Indonesia
2. Most of PGRFA cultivated in Indonesia are not originally from Indonesia
3. It is hoped that most of PGRFA can easily be obtained through MS

In addition it is also expected to gain non monetary benefits sharing in form of technology transfer and capacity building.

C. International agreements

So far there have been three international conventions that were used as the basis of managing genetic resources in Indonesia. Those three conventions are as follows:

Convention on biological diversity (CBD)

This convention had been ratified through Law No.5/1994 on Ratification of Convention on Biological Diversity. The following articles, Article 8, 15, 16, 17, 18, and 19 contain provision related to managing genetic resources.

Trade related intellectual property rights (TRIP)

Article 27 on Patentable Subject Matter, especially para 3 (b) plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof. The provisions of this subparagraph shall be reviewed four years after the date of entry into force of the WTO Agreement.

This Article had been used as the basis of drafting Law No.29/2000 on Plant Variety Protection. In this Law, especially Article 10 para 1 (a) allows the farmers to use the protected variety as long as not for commercial purpose. Government regulation No. 13/2004 on the denomination, registration, and utilization of initial variety to develop essentially derived variety. Article 9 para 1 of this regulation further indicates that any individual or legal entity wishing to use local variety/ landrace as an initial variety shall obtain permit from the authority. This way the government protects the local variety/ landrace from illegal utilization and at the same time the farmers' community could obtain monetary benefit from the use of their variety.

ITPGRFA

This international treaty was acceded by Indonesia through Law No. 4/2006 on Accession of ITPGRFA. This law, especially the standard Material Transfer Agreement has been implemented in the exchange of genetic materials included in Annex 1. However, in case the agreement is with the non party, instead of using the Multilateral System the Bilateral System is used.

CHAPTER 7

ACCESS TO PLANT GENETIC RESOURCES AND SHARING OF BENEFITS ARISING OUT OF THEIR USE, AND FARMERS' RIGHTS

A. Access to plant genetic resources and fair and equitable sharing of the benefits arising from their use

Biodiversity in the form of genetic resources have been accessed for a long time, for various purposes, by researchers, private companies as well as local communities, with little or no returns to conservation activities. In order to utilize genetic resources wisely, there should be two fundamental goals included: (i) sustainable use of genetic resources and their conservation, and (ii) socioeconomic development. Therefore, when assessing the genetic resources as a means to improve national capacities to add value to natural resources, and to build the skills, infrastructure and technology to develop business activities, to improve quality of life and contribute to the development of new products for global markets, at the same time ensuring that the resource is protected and used sustainably, through biodiversity prospecting (bioprospecting). Bioprospecting is the systematic search for and development of new sources of chemical compounds, genes, microorganisms and other nature's economically valuable products.

Bioprospecting is notably complex and should incorporate benefits in terms of capacity building and technology transfer for the country as a whole, direct financial benefits for conservation in addition to potential royalties, the involvement of institutions and entities on the local as well as national level, the creation of industrial incentives, and the attraction of industrial activities in general. An integrated set of biological research, business development, technology transfer options and supported by macro-policies are needed to create a bioprospecting programme that yields these long term benefits for conservation and for developing countries as a whole.

National policies and legislation on access to genetic resources

Currently we have Cultural Practices Law No. 12/1992 which regulate access to genetic resources. However, future legislation should also consider the incorporation of new legislation and policies clarifying which institutions have the authority and responsibility to grant the access to the nation's biological resources and on what terms, thus setting the conditions for bioprospecting activities and the ability to monitor them. Estimation of the volume of future request for access, land tenure and ownership, regulatory agencies, separation of land for conservation, capacity to add value to genetic resources and technical, administrative and financial capacity to create and oversee a regulatory programme are very important issues to consider.

Genetic resources can be obtained from both *in situ* or *ex situ* sources, whether privately, publicly or communally owned as well as from protected or unprotected areas. The use and free exchange of genetic resources for the economic, religious, and cultural wellbeing of indigenous or local communities are also being considered. Another consideration is the financial support to ensure and enforce the regulatory scheme as well as the management of the financial benefits from bioprospecting.

Policies and incentives to add value to genetic resources

Adequate bioprospecting frameworks must be in place while the relationships between genetic resources and the following elements are understood and nurtured: (a) policies, (b) biodiversity inventory and information management, (c) access technology, and (d) business development and planning.

In exchange to access to genetic resources, the industrial partner must agree to the fair and equitable sharing of benefits, both in the intellectual and monetary terms; implementation of collection and production methods with minimum effects on biodiversity; and the use of equitable bioprospecting practices for further research.

The fundamental policies leading to income generation: governmental and international regulations, laws and economic incentives, intellectual property rights, technology promotion, biosafety issues and industrial development.

Action plan

In order for Indonesia to use genetic resources sustainably and efficiently, in 1982 the National Conservation Plan was established to determine conservation areas. Assessment and analysis of this plan had been conducted in 1993 and 1995 in collaboration with the World Bank. Government policies on the environmental management were: Law No. 4/1982 on Environment Management Principles; Law No. 5/1992 on Conservation of Natural Resources and their Ecosystems; and Law No. 5/1994 on Ratification of Convention on Biological Diversity.

Modern agriculture has been realized to cause diversity erosion, especially the long inhabitant or landraces that have been adapted to their ecosystems. Over exploitation of certain species as well as the development activities disturbing the habitat cause the almost extinction of certain species suggest the important of *ex situ* conservation of such species. The following have been the action plan to be conducted from 2003-2020:

- Apply the Eco-tourism pattern for selected conservation areas to generate income for conservation purposes.
- Extension of the conservation areas.
- Promote people, regional and NGO participation in managing conservation areas.
- Development of national conservation areas network covering forest, ocean and wetland areas including the management and local community.
- Implement new national action plan related to *in situ* conservation in the conservation areas.
- Returning species developed from *ex situ* conservation areas to their habitat.
- Development of data base for management information system of the biological diversity.
- Continue research on taxonomy behaviour and physiology of the species as well as habitat ecology.
- Human resource development.
- Further development of the policies and institutional and capacity building.
- Promote and facilitate the development of germplasm bank at the community level.

B. Implementation of Farmers' Rights

Article 10 para 1 (a) of Law No.29/2000 on Plant Variety Protection allows the farmers to use the protected variety as long as not for commercial purpose. Article 9 para 1 of Government regulation No. 13/2004 on the Denomination, Registration, and Utilization of Initial Variety to Develop Essentially Derived Variety further indicates that any individual or legal entity wishing to use local variety/landrace as an initial variety shall obtain permit from the authority. This way the government protects the local variety/landrace from illegal utilization and at the same time the farmers' community could obtain monetary benefit from the use of their variety. Since Indonesia has no special law in Farmers' Rights, this is the way how to implement Farmers' Rights using the existing legislation.

CHAPTER 8

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

The diversity of PGRFA play important role in food diversification. There are available underutilized species that maybe further managed and developed to provide enough food to both local and national communities. Better management of available PGRFA will certainly improve the contribution of plant genetic resources management to sustainability development. Therefore, Indonesian diversified food could substantially reduce rice consumption which in turn strengthens food security.

One of the national food security problems is providing sufficient rice stock as staple food due to the government missed policy in the past. However, the use of agro-biodiversity for food diversification may highly contribute to food security, which in turn helps solve the problem. This assumption is based on the facts that a number of crops and animals are still managed in many agro-ecosystems and the owners of which are making full use of what they have. The village community have been revitalized through the use of underutilized crops such as tuber crops for their alternative food. Most of the farmers are practicing dry land agriculture, where tuber crops are suitable. Those underutilized tuber crops are suweg (*Amorphophallus campanulatus*), kimpul (*Xanthosoma violaceum*), uwi (*Dioscorea alata*), gembili (*Dioscorea aculeata*), garut (*Marantha arundinacea*), gadung (*Dioscorea hispida*), and ganyong (*Canna edulis*). To keep the communities' interest in maintaining tuber crops in their land, different food products such as flour, chips and cookies from those crops have been promoted. However, every household is unable to fulfil all aspects of food security, but at least the quantity of daily food required is secured. A more comprehensive study is needed to substantiate this assumption.

Many plants and animals managed in the existing agro-ecosystems are generally generated from local sources. So, it will not be surprising if the majority of these groups of species are native species which are in the process of domestication. Some are well selected, but many are just brought into cultivation. Thus, an agro-ecosystem can be regarded as a man made ecosystem in which utilization and conservation of species go hand in hand. With the many types of agro-ecosystems it can be expected that many species of plants and animals of local value are conserved. At the same time wild species of plants, animals, and microbes associated with those crops and animals capable of freely interacting.

Agrobiodiversity consist of species which are underutilized crops, are very important for food security at household level, even possibly at village level. The number of biodiversity we have is enormous, but we cannot possibly develop them all at the same time, therefore setting priority is a must. In order to realize the important of those species the scientific community can be the agent of change. Those consider to be agent of changes are NCGR, a unit specifically mandated for biodiversity in the context of the Convention on Biological Diversity under the Ministry of Environment, a research institute under the Indonesian Institute of Sciences mandated for doing research in biology, the Department of Forestry, the Department of Agriculture, and research units dealing with biodiversity under the universities.

The availability of PGRFA diversity maintained by local community also plays important role in poverty alleviation. There are available underutilized species that maybe further managed and developed to provide enough food to local community, this will improve local economy and at the same time alleviate the poverty.

APPENDIX 1

LIST OF TABLES

TABLE 1

Production of PGRFA in Indonesia

No.	PGRFA	Yield (000 tonnes)		
		2004	2005	2006
1	Rice	54 088	54 151	54 455
2	Maize	11 225	12 524	11 609
3	Soybean	723	808	748
4	Cassava	19 425	19 321	19 987
5	Sweet potato	1 902	1 857	1 854
6	Shallot	757	733	795
7	Potato	1 072	1 010	1 011
8	Chilli	1 101	1 058	1 185
9	Mango	1 438	1 413	1 622
10	Citrus	2 071	2 214	2 566
11	Banana	4 874	5 178	5 037
12	Durian	676	566	748
13	Mangosteen	62	65	73
14	Ginger	105	126	177
15	Kaemferia	22	35	47
16	Alpine	24	36	44
17	Turmeric	40	82	113
18	Coconut	3 055	3 097	3,157
19	Rubber	2 066	-	-
20	Oil palm	11 087	-	-
21	Cocoa	644	-	-
22	Coffee	635	-	-
23	Sugarcane	2 172	-	-

TABLE 2

Estimated number of main biotic types

Group	Indonesia (species)	Global (species)
Bacteria, blue-green algae	300	4 700
Fungi	12 000	47 000
Sea weed	1 800	21 000
Moss	1.500	16 000
Fern	1 250	13 000
Flowering plant	25 000	250 000

Source: KLH, 1989

TABLE 3

Institutes/organization in Indonesia responsible on ex situ conservation of plants

No.	Organization	Plant groups	Type
1.	Department of Forestry	Forest trees	Arboretum
2.	Center for Plant Conservation, Bogor Botanic Gardens, Indonesia Institute of Sciences	Wild flora and introduction from other countries	Four Botanic Gardens + Ecopark
3.	Center Research for Biology, Indonesia Institute of Sciences	Native species	Biology gardens
4.	Center Research for Biotechnology, Indonesia Institute of Sciences	Fruit tree germplasm	Field Collection & culture collection
5.	Department of Agriculture	Food crops, fruits, vegetables and ornamentals	Field collections, seeds
6.	Research Center for spices and medicinal plants, Department of Agriculture	Spices and medicinal plants	Field collections, tissue culture, seeds
7.	Department of Health	Medicinal plants	Field collections
8.	Puspiptek Serpong	Indonesian plants	Field collections
9.	Local government	Wild flora	Botanic gardens
10.	University	Forest trees, botanical collections	Arboretum
11.	Private gardens (Mekarsari, Taman Bunga Nusantara, Orchid gardens)	Fruit trees or ornamental plants	Field collections

TABLE 4

Number of accession of collected PGRFA[(*)]

No.	Scientific Name	Indonesian name	Number of Accession
1	*Oryza sativa*	Padi	3 891
2	*Zea mays*	Jagung	800
3	*Trithicum aestivum*	Gandum	77
4	*Sorghum bicolor*	Sorgum, Cantel	225
5	*Glycine max*	Kedelai	1092
6	*Phaseolus radiate* L.	Kacang hijau	1 024
7	*Arachis hypogea Linn.*	Kacang tanah	1 194
8	*Vigna unguiculata*	Kacang tunggak, kacang tolo	112
9	*Cayanus cayan*	Kacang gude	10
10	*Vigna subterranea*	Kacang bogor	2
11	*Manihot utilissima*	Ubi kayu	450
12	*Ipomoea batatas*	Ubi jalar	1 506
13	*Colocasia esculenta* L.	Talas	367[**]
14	*Xanthosoma nigrum* (Vell.) Manst.	Belitung	70
15	*Dioscorea alata* L.	Ubi kelapa	34
16	*Dioscorea esculenta* L.	Gembili	33
17	*Dioscorea hispida* (Dent.)	Gadung	18
18	*Maranta arudinacea* L.	Garut	20
19	*Canna edulis* (Ker.)	Ganyong	55
20	*Amorphophalus campanulatus*	Suweg	13
21	*Musa* spp.	Pisang	475[***]
22	*Garciana mangostana*	Manggis	20

No.	Scientific Name	Indonesian name	Number of Accession
23	*Nephelium lappaceum*	Rambutan	21
24	*Hevea brasiliensis*	Karet	25
25	*Theobroma cacao* L.	Kakao	571
26	*Coffea* spp.	Kopi	1 292
27	*Leucaena* spp.	Lamtoro	179
28	*Camelia sinensis* L.	Teh	41
29	*Cinchona* sp.	Kina	34
30	*Cocos nucifera* L.	Kelapa	136
31	*Arecha catechu* L.	Pinang	20
32	*Nicotiana tobaccum* L.	Tembakau	1 395
33	*Gosypium hirsutum*	Kapas	669
34	*Ceiba petandra* Gaerf	Kapuk	147
35	*Sesanum indicum*	Wijen	65
36	*Hibiscus cannabinus* L.	Kenaf	1 581
37	*Boechmeria nivea* Gand	Rami	58
38	*Phaseolus vulgaris* L.	Buncis	60
39	*Allium cepa* L. var. *aggregatum*	Bawang merah	55
40	*Allium fistulosum* L.	Bawang daun	30
41	*Capsicum annum* L.	Cabai merah	255
42	*Capsicum frutescens* L.	Cabai rawit	46
43	*Solanum lycopersicum*	Tomat	145
44	*Solanum melongena*	Terong	106
45	*Solanum nigrum*	Leunca	2
46	*Solanum torvum*	Takokak	2
47	*Solanum tuberosum*	Kentang	95
48	*Daucus carrota*	Wortel	20
49	*Amaranthus* sp.	Bayam	103
50	*Apium graveolens*	Seledri	6
51	*Lactuca indica*	Selada	2
52	*Ipomea reptans*	Kangkung	5
53	*Brassica parachinensis*	Caisim	51
54	*Cucumis sativus*	Mentimun	200
55	*Cucurbita moschata*	Waluh kuning	10
56	*Luffa acutangula*	Gambas / Oyong	20
57	*Momordica charantia*	Paria	10
58	*Lagenaria siceraria*	Labu air	2
59	*Trichosantes anguina*	Paria belut	5
60	*Coccinia grandis*	Mentimun telunjuk	1
61	*Sechium edule*	Labu siem	4
62	*Phaseolus lunatus*	Kacang koro	50
63	*Vigna angularis*	Kacang merah	20
64	*Pisum sativum*	Kacang kapri	20
65	*Psophocarpus tetragonolobus*	Kecipir	20
66	*Vigna sinensis*	Kacang panjang	205
67	*Vanilla planifolia*	Vanili	5
68	*Anacardium occidentale* Linn.	Jambu Mente	175
69	*Syzygium aromaticum* L.	Cengkeh	16

No.	Scientific Name	Indonesian name	Number of Accession
70	*Cinnamomum burmannii*	Kayu manis	19
71	*Chrysanthemum cinerariaefolium*	Piretrum	99
72	*Gnetum gnemon*	Melinjo	6
73	*Vetiveria zizanioides* Stapf.	Akar wangi	45
74	*Pachyrrhizus erosus* (L.) Urban	Bengkuang	27
75	*Piper retrofractum*	Cabe Jawa	23
76	*Zingiber officinale*	Jahe	27
77	*Guazuma ulmifolia*	Jati Belanda	21
78	*Sauropus androgynus*	Katuk	8
79	*Aleurites moluccana*	Kemiri	124
80	*Kaempferia galanga* L.	Kencur	40
81	*Curcuma longa* L.	Kunyit	66
82	*Morinda citrifolia* Linn.	Mengkudu	11
83	*Mentha piperita*	Menta	20
84	*Pogostemon cablin*	Nilam	12
85	*Centella asiatica*	Pegagan	11
86	*Curcuma xanthorrhiza* Roxb.	Temulawak	20
87	*Saccharum officinarum*	Tebu	321
88	*Saccharum spontaneum*	Kaso	128
89	*Saccharum edule*	Terubuk	17
90	*Saccharum barberi*	Kerabat liar tebu	25
91	*Saccharum sinensis*	Kerabat liar tebu	26
92	*Saccharum robustum*	Kerabat liar tebu	71

* Under the management of Research Institutes of Indonesian Agency of Agriculture Research and Development, Department of Agriculture.
** Under the management of the Indonesian Institute of Sciences and Department of Agriculture.
*** Under the management of Yogyakarta Local Government and Department of Agriculture.

TABLE 5

Genetic variability parameter of 96 rice accessions analyzed with 30 SSR markers

Panel	Marker	Allele size (bp)	Major allele frequency	No. of allele	Gene diversity	Heterozygousity	PIC
1	RM5	108-132	0.351	9	0.773	0.043	0.741
1	RM433	212-228	0.810	4	0.325	0.022	0.300
1	RM55	201-243	0.637	11	0.564	0.042	0.538
1	RM215	127-157	0.474	12	0.690	0.042	0.650
1	RM514	246-272	0.411	8	0.727	0.042	0.686
2	RM214	88-158	0.768	15	0.405	0.011	0.399
2	RM11	122-146	0.453	9	0.740	0.021	0.715
2	RM144	160-277	0.527	14	0.665	0.043	0.632
2	RM237	115-151	0.536	12	0.657	0.052	0.624
2	RM171	321-345	0.533	6	0.645	0.011	0.602
3	RM133	227-233	0.489	4	0.557	0.053	0.459
3	RM287	83-117	0.272	12	0.828	0.011	0.808
3	RM259	145-177	0.447	12	0.721	0.021	0.687
3	RM250	138-178	0.734	16	0.450	0.032	0.439
3	RM507	224-260	0.811	5	0.322	0.021	0.294
4	RM161	143-179	0.806	10	0.343	0.000	0.334

Panel	Marker	Allele size (bp)	Major allele frequency	No. of allele	Gene diversity	Heterozygousity	PIC
4	RM283	95-167	0.718	9	0.462	0.021	0.439
4	RM124	259-297	0.441	7	0.649	0.022	0.582
4	RM162	189-241	0.495	13	0.676	0.000	0.636
4	RM277	106-126	0.704	6	0.471	0.011	0.437
5	RM431	241-265	0.478	9	0.701	0.000	0.666
5	RM154	100-226	0.266	22	0.863	0.011	0.851
5	RM484	292-310	0.810	5	0.323	0.000	0.296
5	RM105	89-137	0.525	7	0.656	0.013	0.616
5	RM536	226-266	0.458	10	0.712	0.011	0.677
6	RM125	104-149	0.760	8	0.403	0.039	0.379
6	RM19	194-260	0.380	9	0.782	0.013	0.757
6	RM541	104-192	0.560	14	0.653	0.011	0.631
6	RM413	76-182	0.321	10	0.784	0.000	0.752
6	RM474	228-280	0.313	17	0.819	0.016	0.799
	Mean	**165.4-211.7**	**0.543**	**10.2**	**0.612**	**0.021**	**0.581**

TABLE 6

Number and size of alleles, and heterozygousity level detected on 96 accessions of sweet potato using 10 SSR markers

Panel No.	Primer	No. of allele	Range of allele size	Heterozygousity level
1	IB286	8	88-106	0,932
1	IB316	6	128-146	0,614
1	ASUS P 3	14	158-206	0,953
2	IB318	20	66-177	0,966
2	IB248	18	82-272	0,939
2	IB255F1	15	216-298	0,988
3	ASUS P 12	11	75-113	0,933
3	AUS P 16	10	86-123	0,655
4	IB275	16	87-261	0,511
4	ASUS P7	53	65-385	0,597
Mean		**17,1**		**0,81**

TABLE 7

Size, number and frequency of major alleles, heterozygousity, gene diversity, and polymorphisme level of 96 soybean accession identified by 10 SSR markers

Panel	SSR marker	Allele size (bp)	No. of allele	Major allele frequency	Heterozygousity	Gene diversity	PIC
1	SATT308	118-172	12	0,3421	0,0316	0,7998	0,7757
1	SATT038	157-191	10	0,3263	0,0000	0,8211	0,8014
1	SATT114	79-107	7	0,4740	0,0104	0,6181	0,5460
1	SATT242	103-160	10	0,4375	0,1250	0,6603	0,5971
2	SATT147	190-326	12	0,6421	0,0421	0,5573	0,5317
2	SATT243	261-295	11	0,2708	0,0000	0,8105	0,7846
2	SATT414	268-314	13	0,4239	0,0000	0,7481	0,7203
2	SATT294	253-300	14	0,5000	0,0100	0,7061	0,6830
3	SATT009	142-245	19	0,2500	0,0104	0,8629	0,8494

Panel	SSR marker	Allele size (bp)	No. of allele	Major allele frequency	Heterozygousity	Gene diversity	PIC
3	SATT177	105-117	8	0,3177	0,0208	0,7746	0,7405
Mean		**167,6-222,7**	**11,6**	**0,3984**	**0,0251**	**0,7359**	**0,7030**

TABLE 8

Food crops varieties released in 1940-2008

No	Crop	Year				Total
		1940-2005	2006	2007	2008	
1	Rice	211	13	3	16	243
	Hybrid	20	9	2	4	35
	Non hybrid	191	4	1	12	208
2	Maize	128	5	8	14	155
	Hybrid	85	5	8	14	112
	Non hybrid	43	-	-	-	43
3	Soybean	64	-	-	7	71
4	Groundnut/peanut	31	-	-	-	31
5	Mungbean	19	-	-	1	20
6	Cassava	15	-	-	-	15
7	Sweet potato	23	4	-	-	27
8	Sorghum	18	-	-	-	18
9	Wheat	4	-	-	-	4
10	Taro	-	1	-	-	1

Source: Directorate General of Food Crops (2008)

TABLE 9

Research on genetic engineering for crop improvement at different stages (laboratory, greenhouse/ screenhouse, or confined field trials) on various institutes in Indonesia

At laboratory stage				
No	**Crop improvement for**	**Crop**	**Gene**	**Institutes**
Resistance for biotic stress				
	Insect pest	cacao	*cry*1Ac	BRIEC
	Virus	Pepper	CP	BAU
	Fungal disease	Potato	hordotionin	BAU
	Fungal disease	Soybean	*chitinase, glucanase*	BU
		Abacca	*chitinase, glucanase*	BU
		Jatropha	*chitinase, glucanase*	BU
		Citrus	*chitinase, glucanase*	BU
Tolerance for abiotic stress				
	Drought	Rice	*DREB1A*	ICABIOGRAD
			trehalose	BAU
		Sugarcane	*P5CS*	BRIEC
	Aluminum toxicity	Soybean	*Mamt2*	BAU
Quality modification				
	Nitrite efficient	Maize	CsNitri1-L	ICABIOGRAD
	Delay flowering	Teak wood	*leafy*	BTI
	Early flowering	Mangosteen	*Apekalla-1* (*AP-1*)	BRIEC

At laboratory stage				
No	**Crop improvement for**	**Crop**	**Gene**	**Institutes**
	Low calory sugar content (palatinose)	Sugarcane	*pall*	BTI
	High amylose content	Cassava	*BE-1* dan *BE-2*	RCB-IIS
	High oleic acid content	Oil palm	*KASII, Palmitoyl ACP Theoesterase*	IBA-AAAT

CP = *coat protein*, BRIEC = Biotechnology Research Institute for Estate Crops; BAU = Bogor Agricultural University; BU = Brawijaya University; ICABIOGRAD = Indonesian Agricultural Biotechnology and Genetic Resources Research and Development; BTI= Bandung Technology Institute; RCB-IIS = Research Center for Biotechnology, Indonesian Institute for Science; IBA-AAAT = Institute for Biotechnology Assessment, the Agency for Assessment and Application Technology.

At greenhouse/screenhouse stage					
No	**Crop improvent for**	**Crop**	**Gene**	**Greenhouse/ screenhouse**	**Institutes**
Resistance for biotic stress					
	Insect pest	Rice	*cry1*Ab	Greenhouse	ICABIOGRAD
			cry1B-cry1Aa, cry1B	Greenhouse	RCB-IIS
	Insect pest	Soybean	*pin* II	Greenhouse	ICABIOGRAD
			*cry1*Ab	Greenhouse	ICABIOGRAD
	Bacterial and fungal diseases	Rice	OsWRKY76	Greenhouse	ICABIOGRAD
	Fungal disease	Rice	*entC, pmsB*	Greenhouse	RCB-IIS
	Viral diseases	Tomato	CP	Screenhouse	ICABIOGRAD in collaboration with BAU and IVEGRI
	Viral disease	Peanut	CP	Greenhouse	ICABIOGRAD
				Greenhouse	BAU
	Fungal disease	Potato	*chitinase*	Greenhouse	BAU
	Golden nematode	Potato	*chitinase*	Greenhouse	BAU
	Bacterial disease	Citrus	*CVPD*^{r}	Greenhouse	BU
				Greenhouse	UU
Tolerance for abiotic stress					
	Drought	Rice	*Hd-Zip* (*oshox*)	Greenhouse	RCB-IIS
Quality modification					
	Nitrite efficient	Rice	CsNitri1-L	Greenhouse	ICABIOGRAD
	Delay ripening	Papaya	Antisense ACC Oxidase	Screenhouse	ICABIOGRAD
	Parthenocarpy	Tomato	*defH9-iaaM* dan *defH9-RI-iaaM*	Greenhouse	ICABIOGRAD
	High albumin content	Soybean	*albumin*	Greenhouse	UU
	High production	Soybean	SPS	Greenhouse	UU
	High glucose content	Sugarcane	SoSPS1	Greenhouse	PTPN XI in collaboration with JU
	Increased P absorbtion	Sugarcane	phytase	Greenhouse	BAU
	Faster growth and high cellulose content	Sengon	*Xylolase, xylo-glucanase, poly galacturonase, dan xylanase*	Greenhouse	RCB-IIS
	Faster growth and high cellulose content	Acasia	*Xylolase, xylo-glucanase, poly galacturonase, dan xylanase*	Greenhouse	RCB-IIS

CP = *coat protein*, ICABIOGRAD = Indonesian Agricultural Biotechnology and Genetic Resources Research and Development; RCB-IIS = Research Center for Biotechnology, Indonesian Institute for Science; BAU = Bogor Agricultural University; IVEGRI = Indonesian Vegetable Research Institute; BU = Brawijaya University; UU = Udayana University; PTPN XI = semi private company; JU = Jember University.

At confined field trial				
No	**Crop improvent for**	**Crop**	**Gene**	**Institutes**
Resistance for biotic stress				
	Insect pest	Rice	*cry*1Ab	RCB-IIS
	Fungal disease	Potato	RB	ICABIOGRAD in collaboration with IVEGRI
Tolerance for abiotic stress				
	Drought	Sugarcane	*betA*	PTPN XI
Quality modification				
	Free amylose content	Cassava	*IRC-GBSS*	ICABIOGRAD in collaboration with RCB-IIS
	High glucose content	Sugarcane	SoSPS1	PTPN XI in collaboration with JU

RCB-IIS = Research Center for Biotechnology, Indonesian Institute for Science; ICABIOGRAD = Indonesian Agricultural Biotechnology and Genetic Resources Research and Development; IVEGRI = Indonesian Vegetable Research Institute; PTPN XI = semi private company; JU = Jember University.

APPENDIX 2

LIST OF FIGURES

FIGURE 1

Dendogram of 96 rice accession anaylized using 30 SSR markers clustered into 3: wild relative, Japonica and indica

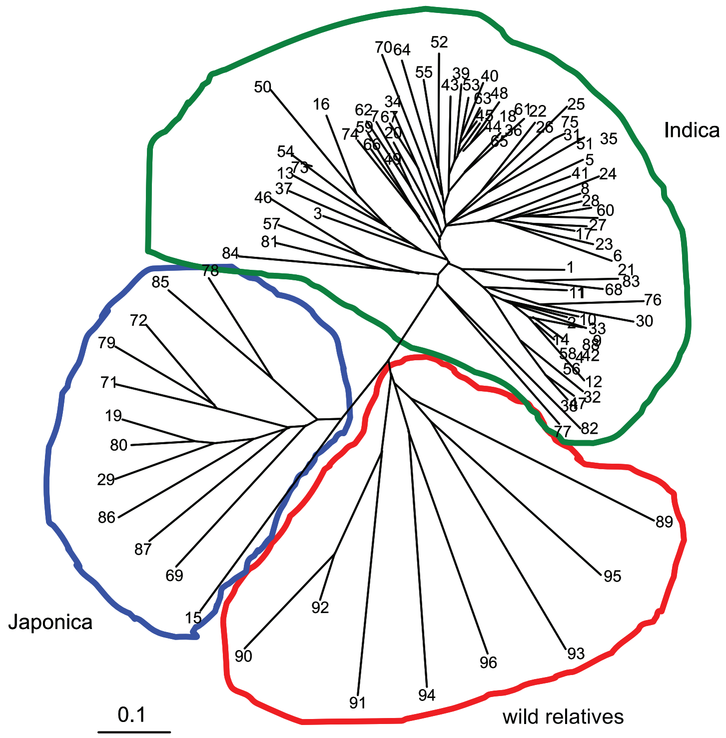


FIGURE 2

Dendrogram of 96 accessions of sweet potato analyzed using 10 SSR markers

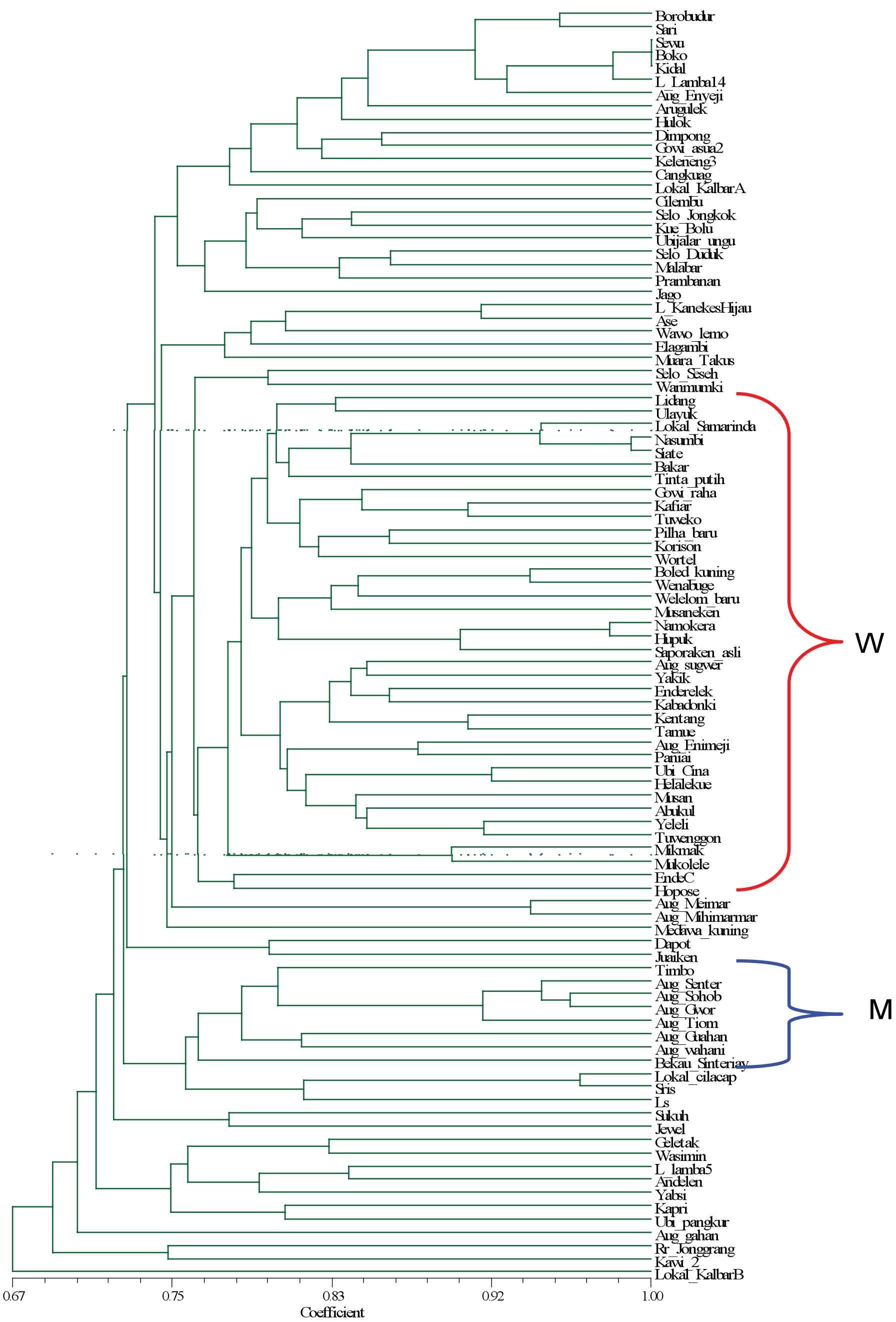


FIGURE 3

Dendogram developed using PowerMarker of 96 soybean accessions analyzed by 10 SSR markers

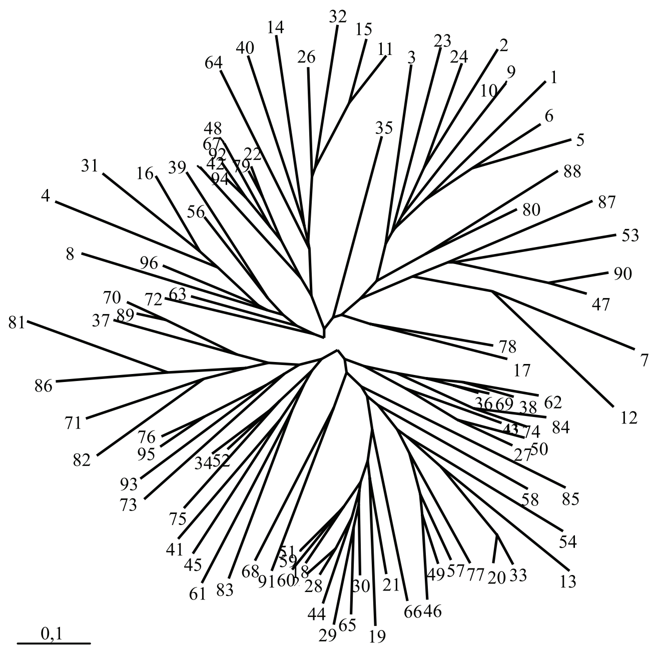


FIGURE 4
High quality seed production in relation to technology used.

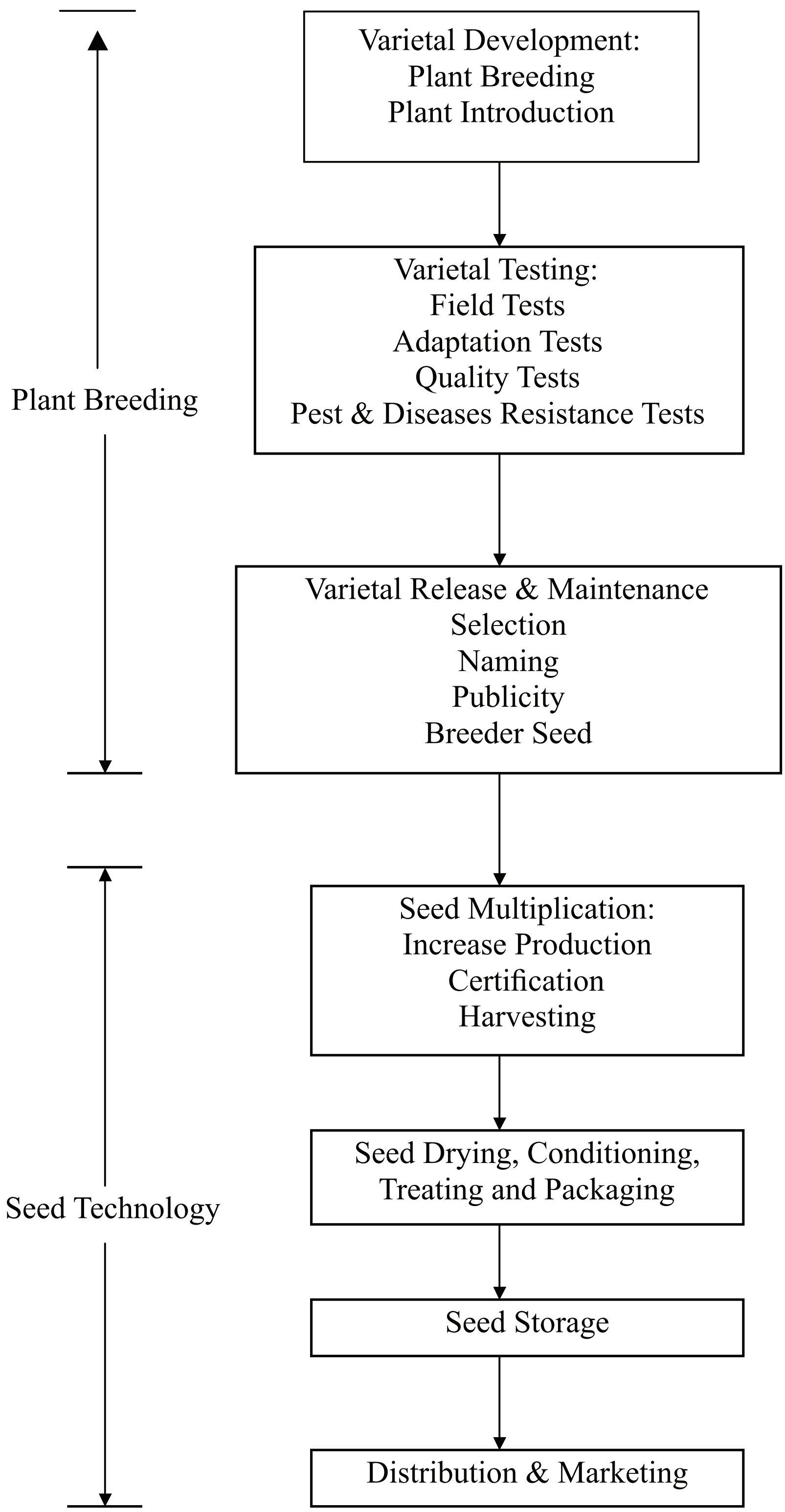


FIGURE 5

Diagram of Seed Systems