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Biological Resources Potential and the Recent State of International Cooperation in Indonesia

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SYNOPSIS

Indonesia is a mega-biodiversity country having at least one trillion US Dollars value of biological resources per year over the next 20 years. Indonesia is home to 11 percent of the world's flowering plant species and 12 percent of all mammals. Many of Indonesia's species and more than half of the archipelago's endemic plant species are found nowhere else on the Earth. This information is just a small portion of all higher plants and animals being found in Indonesia. Former studies described that total number of species in Indonesia is estimated more than 1,000,000 and most of them remain unknown scientifically. Most of lower plants and animals have not been studied yet, so that greatest portion of Indonesia's biological resources has never been assessed with respect to its economic value or conservation status. Many developed countries are building cooperation with Indonesia on resources, mainly in the fields of grant aid, socio-economic services, R & D, researcher exchange, technology transfer, infrastructure, education/training, finance, etc. Indonesia will obtain greater benefits and management of its biological richness via increasing its international capacity to add value and information to its biological diversity. These goals can be achieved by close international collaboration on search of important biological resources and other bioactive products that have potential economic values. Development of biological resource-based technology stands as the industry of the 21st century and, therefore, Indonesia has a unique opportunity to lead the process in the world.

Keywords: biological resources, biodiversity, collection, potential, international treaty, international cooperation, Indonesia

Introduction

Biological diversity is more than just the sum of species numbers but it encompasses the variety, variability, and uniqueness of genes, species, and the ecosystems where they occur. But a more important thing for us is to use the biological resources properly in sustainable ways. Biological diversity will reward society by continuously providing its tremendous benefit to our present and future generation.

Indonesia with more than 17,500 islands is a mega-biodiversity country that is ranked as the first in the world for number of mammals, palms, swallowtail butterfly, and parrot species. Further, it is the center of plant species with a number of genera diversity and one of the world's centers of species diversity of hard corals and many groups of reef-associated flora and fauna[1-3]. This plenty of biological resources makes Indonesia to be labeled as one of 17 mega-diverse countries, with two of the world's 25 hotspots, 18 World Wildlife Fund's Global 200 ecoregions, and 24 of Bird Life International's Endemic Bird Areas[4]. As well known, Indonesia is home to 11 percent of the world's flowering plant species and 12 percent of all mammals. Many of Indonesia's species and more than half of the archipelago's endemic plant species are found nowhere else on Earth.

Indonesian government has a plan to send a team of negotiators to upcoming biological diversity talks in Japan to encourage nations to adopt a treaty guaranteeing benefit sharing from the use of biological resources. An Indonesian negotiator said that benefits could take the form of money, capacity building, or technology transfer which would be awarded to the country of origin of the genetic resources[5]. This measure of Indonesian government shows that origin countries having rich biological resources like Indonesia has begun to protect their own resources and to assert their rights to user or developed countries. Indonesia as a leading member country of Association of Southeast Asian Nations (ASEAN) may further affect other member countries of ASEAN with this resource right issue in the future.

Under the new Convention of Biological Diversity (CBD) treaty, known as the Nagoya Protocol, countries providing genetic resources would receive fair compensation for the use of their biological resources[4]. This concern indicates that both providers and users are necessary to have further discussion on how we will approach their potent partnership under regulations in each country that includes material transfer agreement, benefit sharing, capacity building, agreement, and other measures among them.

Therefore, Indonesian will obtain greater benefits and greater control of its biological richness if Indonesia can increase its international capacity to add value and information to its biological diversity. These goals can be achieved by close mutual or multilateral collaboration on search of important plant and animal species, microorganisms, genes, enzymes, or other bioactive products that have potential economic value. Indonesia's biological diversity has untapped biotechnology potential for agro-industry, pharmaceutical industry, environmental technology, mining industry, and in biochips, biosensor, and microelectronic industry. The biological resource based technology stands as the industry of the 21st century and, therefore, Indonesia has a unique opportunity to lead the process in the world.

This paper is to review Indonesia's biological resources potential and its recent state of international cooperation.

Table 1. Diversity of biological resources in Indonesia[1-4]

Taxonomic Group	Species	Endemic Species	Percent Endemism
Plants	25,000	15,000	60.0%
Mammals	380	172	45.3%
Birds	769	142	18.5%
Reptiles	452	243	53.8%
Amphibians	244	196	80.3%
Freshwater Fishes	950	350	36.8%

Results and Discussion

Potential of biological resources

Recently, a report described that the Greenomics of Indonesian biological diversity value estimates at least one trillion US Dollars per year over the next 20 years[6]. As explained by the report, Indonesia is one of the centers of mega-biodiversity in the world, with 47 ecosystem types ranging from ice fields and alpine meadows in Papua to a wide variety of humid lowland forests, from deep lakes to shallow swamps, and from spectacular coral reefs to sea-grass meadows and mangrove swamps. According to prior studies[1-4,7], approximately 17 percent of the total number of species in the world is found in Indonesia. The country harbors at least 10-11 percent of the world's known flowering plant species, 12 percent of the world's mammals, 15-16 percent of all amphibians and reptiles, 17 percent of all birds, and at least 25-37 percent of the world's fish (Table 1).

In general, the diversity of ecosystems and species naturally leads to biological diversity. Indonesia is the center of biological diversity for many important food and economic crops such as bamboo, orchids, rattan, nutmeg, cloves, and tropical fruits. This biological diversity of Indonesia has developed further through traditional agro-forestry and cultivation systems. This is reflected in the numerous varieties of rice, taro, bananas, and mangoes (not native to Indonesia) and other cultivated crops in Indonesia[1-3]. Also, Indonesia's forests are one of the top ranks in the world for species richness. The forests harbor the world's greatest diversity of palms (477 species), 3,000 species of medicinal plants, and more than 477 species of economically important dipterocarps including ebony, teakwood, sandalwool, and over 350 species of rattan[4,7].

However, this information is only a small portion of all higher plants and animals which can be found in Indonesia. According to other researches[1,3,4,6,7], total number of species is estimated at more than 1,000,000 and most of them remain unknown in terms of scientific measure. Also, most of lower plants including microorganisms, the most important one for industrial use, and lower animals have also not been studied yet. For example, more than 99.5 percent of microorganism's species has not been studied yet. The effort to study microbial community is also hampered by the fact that very few bacteria, especially from the tropical region, can be grown on conventional media. Only 0.001-1 percent of bacteria from some ecosystem in Indonesia is cultivable, and mostly belongs to viable but non cultivable bacteria (VNB).

About 17 culture collections (CCs) of Indonesia were registered in the World Dater Center for Microorganisms in Japan (WDCM) (Table 2). According to other report[7], among them, the Indonesian Center for Biodiversity and Biotechnology (ICBB) Culture Collection is the largest collection of microorganisms in Indonesia with almost 10,000 isolates. Among them, 2,926 isolates have been studied further and 1,188 strains have been already identified by conventional method as well as 16S ribosomal RNA gene sequencing as follows:

Table 2. Indonesian culture collections registered in WDCM by October, 2010[8,9]

Culture Collections	Status	Main Subjects	Entry Year
BPPT Ethanol-Single Cell Protein-Fructose Syrup Technical Unit (BPPT-ESC)	Governmental	Agriculture, Applied & Industrial Microbiology, Fermentation	1989
LIPI Biotechnology CC (BTCC)	Governmental	Agriculture, Applied & Industrial Microbiology	1989
Center for Research and Development of Isotopes and Radiation of Technology CC (CAIRCC)	Governmental	Applied & Industrial Microbiology, Food Science	1987
Dept of Microbiology, University of Indonesia (DMUIJ)	University	Medical Microbiology	1981
Faculty of Biology, Gadjah Mada University (FBGMU)	University	General Microbiology	1989
Inter University Center of Food & Nutrition, Gadjah Mada University (FNCC)	University	Applied & Industrial Microbiology, Food Science	1993
FORDA CC for Microorganisms (FORDA-CC)	Governmental	Forest Microbiology	2009
ICBB CC for Microorganisms & Cell Culture (ICBB)	Private	Agriculture, Applied & Industrial Microbiology, Food Science	2003
Indonesian Sugar Research Institute (ISRI)	Governmental	Agriculture, Applied & Industrial Microbiology, Food Science, Pharmacology, Plant Pathology	1989
Institute of Technology Bandung CC (ITBCC)	University	Agriculture, Applied & Industrial Microbiology, Food Science	1984
Research & Development Center for Biology, LIPI (LIPIMC)	Governmental	Biology	1996
Perum Bio Farma (PBF)	Governmental	Medical Microbiology	1989
Pusat Veterinaria Farma (PVF)	Governmental	Applied & Industrial Microbiology, Veterinary, Immunology	1989
Research Institute for Tobacco & Fiber Crops (RITFC)	Governmental	Plant Pathology	1989
Seameo-Biotrop (SEAMEO)	Private	Plant Pathology	1989
Sungei Putih Microbial CC (SPMCC)	Semi-governmental	Environmental Protection	1989
University of Indonesia CC (UICC)	University	General Microbiology, Physiology, Fermentation, Food Science	1982

- 53 identified yeasts belong to the genus *Candida*, *Aureobasidium*, *Cryptococcus*, *Pseudozyma*, *Trichospora*, *Hyphophicia*, and *Rhodotorula*
- Around 500 identified bacteria belong *to Bacillus sp.*, *B. cereus*, *B. thuringiensis*, *B. fusiformis*, *Thiobacillus thiooxidans*, *Thiob. ferrooxidans*, *Brevibacillus choshinensis*, *Desulvovibrio sp.*, *Desulvotomaculum sp.*, *Paenibacillus chondroitinus*, *Micromonospora floridensis*, *Rhodococcus erhytropholis*, and *Klebsiella planticola*
- 600 strains belong to *Streptomyces* and other member of *Actinomycetes*
- Some fungi

Even though Indonesian government has created 179 protected areas and nature reserves since 30 years ago, i.e. 29 in Sumatra, 40 in Java and Bali, 16 in Kalimantan, 23 in Sulawesi, 31 in Nusa Tenggara, 16 in Maluku, and 18 in Papua[7], millions of hectares of tropical rainforest was destroyed by fires occurred almost every year with slash-and-burn farming. Deterioration of biological resources was also accelerated by extensive cultivation of perennial plants (plantations such as oil palm, rubber, coconut palm, etc.), agricultural development projects, development of new settlement and industrial areas, deforestation, poverty, and economic crisis in the recent years. The loss of biological diversity represents one of the most noticeable natural resource destruction.

In addition, Indonesia harbors great knowledge on the uses and development of biological diversity embedded in the cultural forms and knowledge systems of its many and varied traditional communities. Some 6,000 plants, 1,000 animals, and 100 microbe species are used by Indonesian communities in their daily life. Knowledge on medicinal and food values of wild and cultivated species are interlinked with cultural systems that are fast disappearing in Indonesia. Thus, it is obvious that the erosion of Indonesia's biological diversity and traditional knowledge on biological diversity is not just a matter of national concern but international concern as well[1,2,4,10].

National biodiversity strategy action plan

Under these circumstances, opportunities to develop new varieties of food crops, new medicines, and new industrial raw materials may be lost with the erosion of Indonesia's biological and cultural diversity. In line with this concern, Indonesia has enacted several pieces of legislation or action plan in support of its commitment to conservation of biological diversity[1,2,10]. For instance, in 1990, Indonesia promulgated Act No.5 on the Conservation of Natural Resources and their Ecosystems. This Act encompasses policies on protection of biological diversity in accordance with the various treaties signed by the Indonesia. For example, Article 21 of the Act states that "any person found killing, injuring, transporting or trading in protected animals or destroying their eggs or nests is subjected to a maximum one year imprisonment and a fine of one hundred million rupiah".

In 2003, Indonesian government has enacted a new national biological diversity strategy action plan which consists of 10 parts. The major objectives of the national biological diversity strategy action plan are[4,7,11]:

- To slow the loss of primary forests, wetlands, coral reefs and other terrestrial and marine habitats of importance for biological diversity

Table 3. List of plant resources collection institutes in Indonesia

No	Name of Institute	Abbreviation
1	Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development	ICABIOGRAD
2	Rice Research Institute	RRI
3	Legume and Tuber Crops Research Institute	LTCRI
4	Corn and Other Cereals Research Institute	CCRI
5	Ornamental Research Institute	ORI
6	Vegetables Research Institute	VRI
7	Fruit Research Institute	FRI
8	Coconut and Palmae Research Institute	CPRI
9	Citrus and Subtropical Fruit Research Institute	CSTFRI
10	Center for Estate Crops Research Institute	CECRI
11	Medical and Spice Crops Research Institute	MSCRI
12	Oil Palm Research Institute	OPRI
13	Tobacco and Fiber Crops Research Institute	TFCRI

- To expand the data and information available on the nation's biological diversity and make it available to policy makers and the public
- To foster the utilization of biological resources in ways that are sustainable and less harmful than current practices

According to prior reports[4,11,12], a major objective of the Action Plan is increasing participation of the public, particularly local community dependant on areas of high biological diversity. The first priority for maintaining biological diversity is *in situ* conservation, both within the protected areas network and in oceans, coastal zones, forests, and multiple use, and agricultural landscapes outside protected areas. Objectives and priority actions have been developed for each of the 4 main components (*In-situ* conservation in national parks and terrestrial areas; *in situ* conservation outside protected areas including forest, wetland, and cultivated areas; conservation of coastal and marine resources; and *ex situ* conservation through gene and seed banks, protection of plant varieties, and breeding programs) of the action plan and include activities such as:

- Updating and implementing existing management plans for selected conservation areas
- Ensuring that management plans specify manpower, resource, and training needs for each park
- Developing and promoting methods for economic evaluation of the goods and services provided by tropical wetlands
- Extending the clean river program from the present 25 rivers to include other major river systems
- Survey of the extent and status of mangrove habitats
- Monitoring and evaluating on-going captive breeding and reintroduction schemes for rare Indonesian animals such as rhinos, birds of paradise, parrots, and the Bali starling

Management of major biological resources

(1) Microorganism resources

Indonesia as a tropical country contains diverse and potential microorganisms. However, awareness of the need for the conservation and sustainable use of microorganisms is still weak. There is no doubt that the role of CC in conservation of microorganisms is very important. In the past, several CCs of microorganisms in Indonesia belong to universities, research institutes, and private companies[8,9]. They have developed independently without any networking or coordination among them. Initiated by several curators and researchers, who are involved in CC management, Communication Forum for Indonesian CC Curators has been established since 1996. The forum, which conducts regular meeting, became a bridge for members: to exchange ideas and experiences; to solve common problems on CC management; to assist the authorities in the implementation of the CBD with respect to microorganisms. Recently, sponsored by IBF, the Forum developed a software to establish a database system among the members on general information of microbial collection[8,9,12].

Now, as shown in Table 2, 17 CCs of Indonesia were registered in WDCM[8,9] and these CCs are mainly working for domestic or international collections performing isolation, identification, deposit or storage, patent, exchange or distribution, training (such as management, quality control, culture, preservation, isolation, detection, and systematics), consultation services (such as preservation, propagation, detection, improvement, industrial application, and shipment regulations) for algae, bacteria, fungi, yeasts, rhizobium, lactobacillus, and so on.

(2) Plant resources

Plant biological resources in Indonesia have been conserved by research institutes based on their national mandates, which is coordinated by the Agency of Agricultural Research and Development (AARD), Ministry of Agriculture[13,14]. Institutions intensively involved in managing plant resources in Indonesia are mostly 13 major crop research institutes under the AARD as shown in Table 3 and plant resources have been conserved mostly through *ex situ* conservation. To collect and manage complete data for the characteristics of all plant resources in Indonesia, the National Committee on Genetic Resources established an Online Portal, named Information System of Agricultural Genetic Resources, having 16 members of collection institutes, and this System is managed by ICABIOGRAD since 2001. Also, since 2001, the National Committee on Genetic Resources has encouraged genetic resource stakeholders at the provincial level to establish a network. As a result, to date, 17 regional committees have been established and one of the network's activities is to conduct a congress of the Regional Committee on Genetic Resources.

Table 4 shows the number of collections of plant resources and introduction of major research institutes under the AARD[13]. *Ex situ* conservation for plant seeds consists of cold storages with seed viability being monitored yearly. *Ex situ* conservation of vegetatively

Table 4. Plant genetic resource collections under AARD in Indonesia

Crops	Institutes[1)]	No. of Accessions
Cereals, Legumes, and Tuber Crops	ICABIOGRAD	10,563
Medical and Spices-industrial	MSCRI, TFCR, CPRI	3,590
Ornamentals	ORI	961
Vegetables	VRI	1,507
Fruits	FRI, CSTFRI	799
Estate Crops	CECRI, OPRI	26,259
Coffee		1,292
Cacao		570
Sugarcane		6,009
Tea		870
Cinchona		600
Rubber		9,130
Oil Palm		7,788

[1)] Abbreviations are shown in Table 3 above.

propagated resources such as tuber crops which are difficult to be propagated by seed is generally carried out in the field bank. *Ex situ* conservation of sweet potatoes, taro, and cassava has been performed in the field and *in vitro*. Methods of *in vitro* conservation have been applied to taro, sweet potatoes, and cassava germplasm[13,15].

(3) Forest resources

Forest resources are considerably important for Indonesia. These resources account for approximately 17 percent of Indonesia's total forest area, and together with protection forests, form a total protected area of 54 million hectares or roughly 45 percent of the total forest area. Considering the inherent characteristics of conservation forests, Indonesian government has taken various measures to secure them by law. According to other report[16], several legal instruments have been put into effect and various planning frameworks have been developed through national initiatives as well as through cooperation with international partners. The government has also recognized the value of Indonesia's protected areas that are of particular global importance. In line with this concern, the government has given for the designation of biosphere reserves by UNESCO. Two distinct forms of forest resource management can be detected in Indonesia. Forests in Java consist predominantly of teak plantations, while natural forests of the outer islands are more diverse and contain a mix of commercial species varying between regions. For example, dipterocarp species predominate in Kalimantan and Sumatera, *Diospyros* species predominate in Sulawesi, *Eucalyptus* in the Moluccas, and *Pometia, Agathis* and *Araucaria* species in Papua.

A number of legal measures have been put into effect as the basis for implementation of forest resources conservation activities. According to some prior reports[11,16,17], in addition to the legal instruments, Indonesia's Biodiversity Action Plan has been used as a guide for natural resource conservation schemes such as *in situ* conservation in terrestrial parks and protected areas, *in situ* conservation outside the protected area network, coastal and marine conservation, and *ex situ* conservation.

Ex situ conservation activities have been carried out by establishing botanical gardens and arboreta. 17 botanical gardens have been established in Indonesia. Among others, Bogor Botanical Garden in West Java, Purwosari Botanical Garden in East Java, and the Bali Botanical Garden conserve plant germplasm from forests. *Ex situ* conservation is also an integral part of tree improvement activities. This includes gene banks for seed and pollen, clonal banks, breeding populations and cryopreservation. The development of botanical gardens in Indonesia started in 1817 through the establishment of Bogor Botanical Garden, covering an area of 87 ha. The species collections for Bogor Botanical Garden are mostly from tropical rain forests. The second botanical garden, Purwodadi Botanical garden was established in 1841 and is located in Malang, East Java, with deciduous forest species as the primary collection. In 1959, the third botanical garden was established in Bali, the Eka Karya Botanical Garden, which possesses a collection of 937 species belonging to 156 families[16,17].

According to former reports[16,17], various research institutes have also established arboreta. Under the Forestry Research and Development Agency, Ministry of Forestry, there are 10 research institutes all over Indonesia as well as two R & D Centers located in Bogor and Yogyakarta. Each of these 12 institutions has established at least one arboretum or conservation plot. The *ex situ* conservation of teak in Java was first initiated by Perum Perhutani (PP) in 1980, and by 1999, PP successfully completed its effort in establishing *ex situ* conservation of plus trees collected from all teak origins throughout Indonesia. As part of its long-term research program, the Centre for Forest Biotechnology and Tree Improvement Research and Development (CFBTI) has recently established *ex situ* conservation plots in Gunung Kidul, Java for *Santalum album* (sandalwood) and *Artocarpus* (sukun). *Ex situ* conservation of *Shorea leprosula* and *Lophopetalum multinervium* is currently in progress under an ITTO-Ministry of Forestry project. The project is implemented by the University of Gadjah Mada in collaboration with some state-owned and private enterprises, and conservation plots is being established in several locations such as Carita, Palembang, Balikpapan, Central Kalimantan, Pulau Laut, and East Kalimantan.

Table 5. Status of *in situ* conservation areas of forest resources in Indonesia, 2001

Type of Conservation Area	Terrestrial Conservation		Marine Conservation	
	Units	Area (1,000 ha)	Units	Area (1,000 ha)
Nature reserves	175	2,354.3	8	211.3
Wildlife sanctuaries	47	3,517.5	3	65.2
Nature recreation parks	81	281.2	14	668.9
Hunting parks	15	247.4	-	-
National parks	34	11,069.4	6	3,681.4
Grand forest parks	16	332.5	-	-
Total	368	17,802.3	31	4,626.8

Also, PP, a state-owned forestry enterprise, has established conservation stands for various teak varieties collected from all geographical areas in Indonesia since 1998. The CFBTI has an *ex situ* conservation program as a part of tree improvement activities for some tree species (*Acacia mangium*, *Eucalyptus pellita*, *Paraserianthes falcataria*, and *Melaleuca cajuputi* sub sp. *cajuputi*) since the early 1990s. Later, the CFBTI also started *ex situ* conservation of some other species such as *Santalum album*, *Tectona grandis*, *Eusideroxylon zwageri*, *Araucaria cunninghamii*, *Alstonia* sp., and *Artocarpus altilis*. Furthermore, *ex situ* conservation plots for a number of dipterocarps were already established in Java during the 1950s by the Centre for Forest and Nature Conservation Research and Development[16].

Indonesia is one of the first tropical countries in the world to create a protected area system which includes *in situ* conservation efforts. *In situ* conservation is mainly designed to protect ecosystems or natural habitats. By 2001, Indonesia has established 399 terrestrial and marine conservation areas, which account for 22.5 million ha in total (Table 5). Furthermore, 692 protection forest areas have been established, which cover approximately 34 million ha[16,17].

(4) Animal resources

In 2002, the population of major animal resources (livestock and poultry) in Indonesia estimated about 354 thousands of dairy-cattle, 11.4 millions of beef-cattle, 2.4 millions of buffaloes, 13 millions of goats, 7.6 millions of sheep, 6.1 millions of pigs, 446 thousands of horses, 280 millions of indigenous chicken and 30 millions of ducks, 76 millions of layers, and 890 millions of broilers[18-20]:

- Cattle resources were collected from the native and imported genetic resources. The three types of cattle are the draft, beef or slaughter, and milk types. The native cattle are Java, Sumatera (Pesisir), and Bali. The import of the Indian *Bos indicus* such as Ongole, Hissar, and other Zebu cattle was started in early 20th century and has played an important role in cattle development of Indonesia.
- Buffaloes are known in Indonesia since long ago. They consist of Asian buffaloes and the domestic buffaloes such as Swamp

buffalo, Water buffalo, Spotted buffalo, and Kalang buffalo.

- The Kacang is an Indonesian native small goat. Ettawah goats were imported from India and Saanen came from Australia in 1978. Angora or Montgomery goats were imported for the experimental stations in Bogor, Bandung, and Padang Mangatas. Hollandsche-Edelgeit was brought to Java and Sumba. More than 60 percent of 13 millions of goats are in Java.
- There are native and imported sheep in Indonesia. Both the government and the traders have taken a role in the import of sheep. The native sheep are short and small. The government imported Romney and Kashmir and brought these to Timor and Sumba islands in 1912. There is also the Kaapstad breed from South Africa.
- Horse was developed from the native, Mongol, Persian, and Arabic. Some of the horses are Gayo, Batak, and Priangan. In the last 30 years, Thoroughbreds were imported. A male of thoroughbred with a clear pedigree should be imported and crossed with local horses to get a horse, which has more speed and power. The growth of the horse population in Indonesia is a little bit slow, around one percent per annum.
- Before 1960, there were Deutsche Landrace (VDL), Netherlands's Landrace (VNL), Tamworth, and Saddleback pigs available in Indonesia. After 1960, Hampshire, Duroc, Landrace, Poland China, and Yorkshire (Large white) pigs were imported. The potential area for pigs is in North Sumatera and West Kalimantan. Indonesian native pigs are Batak, Nias, Bali, and Celeng.
- The import of poultry breeds and strains started since 1950. In the first years, the main role was taken by the government but later, mainly, the private sectors have imported poultry until now. There are two native chicken groups known in Indonesia. The first one is the specific poultry including Cemani, Kedu, Nunukan, Pelung, etc. while the second one comprises the non-specific native chicken named as Kampung chicken or Local-chicken.
- The duck resources of Indonesia have a good performance in egg production in the tropics. Usually, they are used to form a new duck breed. The native duck breeds include Alabio, Bali, Mojosari, Kisaran, Tegal, etc.

The conservation of animal resources and the breeding development policy are carried out simultaneously and conservation refers to on farm conservation (*in situ*) and the cryo-preservation (*ex situ*) breeding effort. The governmental breeding institutes for animal resources consist of the Embryo Transfer Center Institute, the AI Center Institutes, and the Livestock and Poultry Breeding Institutes in the national, provincial, and district level governments. Especially, the Village Breeding Centers are contributing more than 90 percent of total livestock production of dairy, beef cattle, buffalo, goat, sheep, and duck in Indonesia. The governmental stakeholders of animal resources in Indonesia are[18,20]:

- State Ministry of Life Environment
- Ministry of Agriculture: Center for Agricultural Data and Statistics; Agency for Agricultural Quarantine; Directorate General of Livestock Services; Directorate of Livestock Breeding Development (Institute of Artificial Insemination in Lembang and Singosari, Institute of Livestock Embryo Transfer in Cipelang, Institute of National Livestock Breeding at Indrapuri, Siborong-borong, Padang Mangatas, Sembawa, Baturraden, Pleihari, and other provincial and district livestock breeding institutes); Directorate of Animal Health (Institute of Animal Drug Quality Control and Certification, Center of Veterinary and Animal Pharmacy Production, National Institute of Veterinary Diseases at Medan, Bukittinggi, Lampung, Yogyakarta, Denpasar, Banjarbaru, and Maros); Agency for Agricultural Research and Development (Central Research Institute for Animal Sciences, Research Institute for Animal Production, Research Institute for Veterinary Sciences)
- Ministry of Forestry: Directorate General of Conservation and Forestry Resources; Directorate of National Parks; Flora and Fauna Conservation; Agency for Forest Research and Development; Center for Research & Development of Forest & Natural Resources
- Agency for the Assessment and Application of Technology
- The Indonesian Institute of Sciences
- State Ministry for National Development Planning
- State Ministry for Eastern Indonesia Development

Recent state of international cooperation

The United Nations declared 2010 to be the International Year of Biological Diversity. In line with this concern, the 2010 International Meeting of the Association of Tropical Biology and Conservation (ATBC) opened on July 19, 2010 in Indonesia amid growing concerns that the world is facing a biological diversity crisis on an unprecedented scale. Theme of this year's meeting was tropical biological diversity: securing the food, energy, and climate crisis, as habitat destruction from agricultural expansion and climate change is likely to lead to the mass extinction of irreplaceable plant and animal species.

As shown in Table 6, Indonesia has signed and ratified several international agreements or treaties such as the Convention on International Trade in Endangered Species in 1978, the World Heritage Convention in 1989, and the Ramsar Convention in1991 (through Presidential Decree No. 27, 1991). As a follow-up to the

Table 6. Some international treaties related to biodiversity signed by Indonesia[21]

Legislation/Treaty	Date (year)
Signatory to The Convention on International Trade in Endangered Species (CITES)	1978
Signatory to The World Heritage Convention (WHC)	1989
The Ramsar Convention on Wetlands of International Importance (Ramsar)	1991
Signatory to Convention on Biological Diversity (CBD)	1994
Signatory to The Cartagena Protocol on Biosafety	2005
Signatory to Migratory Bird Treaty	Did not sign
Member of International Whaling Commission	Currently not a member
Signatory to other international treaties designed to protect or manage biological resources	Party to: Biodiversity, Climate Change, Endangered Species, Hazardous Wastes, Law of the Sea, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Tropical Timber 83, Tropical Timber 94, Wetlands signed, but not ratified: Desertification, Marine Life Conservation

ratification of Ramsar Convention, the government issued Government Regulation PP No. 27 of 1991 on Wetlands. This regulation addresses the use of wetlands for development purposes, and includes a regulation on the protection of deep peat swamps as water resource areas[1,2,21]. Also, Indonesia was signatory to CBD in 1994 and to other international treaties designed to protect or manage biological resources (Table 6). Recently, Indonesia was signatory to the Cartagena Protocol on Biosafety in 2005.

Since Indonesian Biodiversity Foundation (IBF) was established in 1994 based on the MOU between USAID and IBF[12], Indonesia and USA launched a biodiversity research center (IBRC) on the Bali Island for further study of the archipelago's rich and diverse species on August 2010. The IBRC, funded by USAID, is a collaboration between three local universities and Old Dominion University in Virginia and the University of California, Los Angeles (UCLA)[22]. This event indicates that USA has systematically built a comprehensive partnership with Indonesia in the field of biological resources and USAID has an essential role in the partnership, empowering people and institutions to advance USA.

According to other report[23], in 1992, the governments of USA and Japan announced the USA-Japan Global Partnership Action Plan and commenced on a collaborative environmental project to manage and conserve natural resources in a developing country. The countries appointed Indonesia as a counterpart of the project. Indonesian government agreed and then requested Japanese government for technology and grant aid cooperation for the project. In response, grant aid, namely technical cooperation to support research during eight years from July 1995 to June 2003, was provided for the Biodiversity Conservation Project (Phase I from 1995 to 1998 and Phase II from 1998 to 2003) as well as for the construction of facilities for biodiversity conservation in 1997. Also, using grant aid, the Japanese government supplied the zoological division of the Research Center for Biology of Indonesian Institute of Sciences with research facilities and a specimen repository during two years from 1995 to 1996. According to Xinhua[24], the Japanese government will continuously support Indonesia in biological diversity sector with projects for mangrove conservation, national park rehabilitation, and forest management expertise in the future.

On the other hand, the Bilateral Research Cooperation projects between Japan and Thailand, Indonesia and Malaysia respectively started in April 1993 and had continued for 6 years until March 1999. The projects exchanged a total of 591 Japanese and Southeast Asian scientists, installed the most-needed equipment and instruments in local research facilities, and sponsored domestic research programs. Japan Bioindustry Association (JBA) carried out these projects under a contract with the New Energy and Industrial Technology Development Organization (NEDO), Japan. The primary objectives of the projects were: to assist the Southeast Asian countries in their own efforts to conserve and use biological diversity in a sustainable manner; to train the Southeast Asian scientists and help develop their scientific skills through collaborative research; and to pave the way for future international research cooperation. This research cooperation addressed both conservation and utilization aspects. The three participating countries, all located in Southeast Asia, have different situations of biological diversity and different sets of priority issues. Therefore, the research cooperation had to cover a broad area, from conservation to utilization, with individual projects to meet different countries' needs and priorities[25].

Indonesia, recently, is actively participating in an Exchange Program for East Asian Young Researchers hosted by Japan[26]. From 2008 to 2009, 63 institutions from Indonesia including mainly universities, research institutes, and governmental institutes, were invited to participate to 29 projects of the program in the field of biodiversity, anthropology, resource conservation science, boundary agriculture, living organism molecular science, environmental impact assessment, earth and planetary science, informatics, energy engineering, food science, society medicine, and so on in Japan. Also, the CC Program in the Bioresources Center (BRC) started in 2002 by the Ministry of Economy and Industry (METI), Japan with activities in CC research and the gene collection project for Southeast Asian countries including Thailand, Indonesia, and Philippines[27].

As reviewed briefly above, in general, many developed countries including the United Nations, Japan, and Netherlands, are building cooperation or partnership with Indonesia on biological resources, mainly focused on technical (grant aid) project, socio-economic services, research and development cooperation, exchange of researcher, knowledge or technology transfer, infrastructure (facilities and building) support, education and training, finance assistance, scientific networking, and others[16,25,28-32].

Conclusion and Prospects

The plenty of biological resources makes Indonesia to be labeled as one of 17 mega-diverse countries in the world, with 15,000 species of endemic plants, 172 species of endemic mammals, 142 species of endemic birds, 243 species of endemic reptiles, 196 species of endemic amphibians, and 350 species of endemic freshwater fishes. Many of these Indonesia's species and more than half of the archipelago's endemic plant species do not be found anywhere else on earth. These indicate that Indonesia has a unique and competitive potential of biological resources compared to other countries.

Some leading biological resources which are discussed in this paper such as plants, microorganisms, animals, and forest resources are being managed well by the governmental and or private institutes under Indonesian government's effort of action plan and strategy for their management and preservation. However, it is estimated that Indonesia has a higher latent power than already explored information not only on higher plants and animals but also on lower plants, microorganisms, and lower animals, so that the greatest portion of Indonesia's biological resources has never been assessed with respect to their economic value or conservation status.

Under the present situation of Seed War or Genetic Resources War among countries, various international treaties related to biodiversity become major daily issues to protect their intellectual rights of biological resources. In this perspective, Indonesia as a stockholder having highly potential biological resources has also begun to protect the country's resources and to assert its rights to user or developed countries. This concern is strongly supported by the Nagoya Protocol emphasizing that countries providing biological resources would receive fair compensation for the use of their biological resources.

In future perspective, it seems that the best way to cope with this strained international issue is that both providers such as Indonesia and users such as developed countries share their benefits based on various cooperation programs as described above through the case study regarding the recent state of international cooperation. Therefore, because Indonesia has a higher potential to explore its distinguished biological richness which are able to lead the country's capacity further, the country may obtain greater opportunity to assess its values more under bilateral or multilateral cooperation such as South-South or South-North Cooperation Programs in the future.

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