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Biodiversity Information System: Tropical Rainforest Borneo and Traditional Knowledge Ethnic of Dayak

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***Abstract*—Although it has become an important theme, and it is mainstreaming in national development planning system, biodiversity is still not seen as a matter of urgency. The biodiversity data of existing plants in Kalimantan is still separated and scattered in various government and private research institutions; it has not been collected in a database management system. This research is an advanced research and development of plant biodiversity information system. To date, the collections of data include 1.497 species of trees, 276 species of wood, and 233 species of medicinal plants based on traditional knowledge of 45 sub-ethnic of Dayak. Efforts to accelerate research and development of biodiversity on Borneo island needs to be driven at high speed, given the environmental changes that occur at present; we are in a race with deforestation and forest degradation. Many potentials plant species that hurried-extinct before it is discovered, only because we pursue economic growth that converts areas of tropical rainforest into oil palm plantations, agricultural land, and other plantations.**

***Index Terms*—Biodiversity; Plants; Tropical-rainforest; Borneo; Dayak.**

I. INTRODUCTION

The conservation and management of biodiversity have become the main target of every country in the world [1]. It is a matter of urgency and has become a global commitment to address the changes in today's world [2], the Aichi Biodiversity Targets [3], and Agenda 2030 for Sustainable Development Goals (SDGs) [4], [5]. In [6] the world's Governments agreed on actions that will accelerate implementation of global biodiversity targets and enhance the linkage of the biodiversity agenda with other global agendas, including the Sustainable Development Goals, the Paris Climate Agreement, and others.

In an effort to better direct and accelerate the achievement of goals and objectives, each country should develop strategies and action plans. Particularly in Indonesia, the government has prepared a document, the Indonesian Biodiversity Strategy and Action Plan (IBSAP) 2003-2020 [7], which was later revised to IBSAP 2015-2020 [8].

Indonesian biodiversity present status [9], explains that many ecosystem diversity and number of species yet known, and waiting to be found mainly in areas that have not been fully explored, such as the island of Borneo.

However, the performance of the discovery and publication of new species (plants) from Indonesia in years 2006-2015 is only 602 species [10]. In fact, Indonesia posses extended biodiversity and has potential achievements generated as a country. However, when comparing these achievements with the current attainments today, it is still far from the intended target. Moreover, what is to be achieved within the next three years (2020), according to the Aichi Biodiversity Targets seem to be very heavy, even with the implementation of the existing IBSAP 2015-2020.

Moreover, with the trend of environmental change which occurs at the moment, the destruction of habitat (degradation) due to climate change and global warming [11], natural disasters [12], fires and environmental pollution pose a serious threat to the biodiversity [13]. In addition, to loss of habitat (deforestation) due to land conversion-inhabited areas of biodiversity into agriculture land, plantation, oil palm, mining, industrial, or over-exploitation on biodiversity [14].

The facts show that the research and development of biodiversity in Indonesia are still very scarce [15]. The research interest received low priority from the government. Further research would satisfy the need for an accurate biodiversity information database [9] which in turn would be for policies' development. Although it has become an essential theme in the national development planning system, biodiversity is still recognised as a matter of urgency. Attention to biodiversity is scattered in several ministries and institutions which resulted in duplication, strict and poor coordination of budget structure.

This paper presents an idea of researchers to develop a Borneo's Biodiversity Information System (BBIS). The system focuses on diversities of plants (tree, wood, and medicinal plants) based on traditional knowledge from ethnic of Dayak. This work also intended as a support to the government initiatives to develop data management of plants in Borneo and as a part of efforts towards achieving the Aichi Biodiversity Targets 2020, and Agenda 2030 for SDGs.

II. LITERATURE REVIEW

Research of the Biodiversity Information System (BIS) for the plants has been carried out previously [16]-[21]. In developed countries, information technology has been adopted early on in providing free data access and open biodiversity site. Among sites are

- gbif.org
- cbd.int
- ncbi.nlm.nih.gov
- wood-databse.com
- biodiversity.europa.eu
- iobis.org
- bis.iirs.gov.in
- bamboogarden.com
- forestry.gov.uk
- bioversityinternational.org
- mybis.gov.my
- australia.gov.au

In general, the web-portal of the BIS focuses on the management of species in each country. Furthermore, the availability of a complete and specific data is not obtainable. Only the data collection name or a total number of species are available publicly whereby the visual data and attributes of the species are not accessible. The data limitation is because different regions have diverse endemic species.

III. Objectives

This study aims to develop a web-based Borneo's Biodiversity Information System (BBIS) of plants from tropical rainforest, with a specific focus:

1) Data collection of plants:
   - various types of tree species in Borneo
   - various types of wood and its characteristics
   - traditional knowledge of forest medicinal plants from ethnic of Dayak.
2) Design models and implementation system of plants

IV. Research Methodology

A. Data, Sources, and Collection Methods

The primary source of plant data is captured and collected by government institutions, agencies and private organisations. These stakeholders handled the operations of plant biodiversity in Borneo. Some of the main sources are shown in Table 1.

Table 1
The main Source Data of Plants

Source	Descriptions
DISHUT	Provincial Forestry Office of East Kalimantan site: dishut.kaltimprov.go.id/
B2PD	Research Center of Dipterokarpa forest ecosystem site: http://www.diptero.or.id/
FORDA	Forest Research and Development Agency http://www.forda-mof.org/
BALITEK KSDA	Research Institute for Natural Resource Conservation Technology of Samboja
BALITTRO	Research Institute for Spices and Medicinal Crops balittro.litbang.pertanian.go.id/
BALITBANGDA	Regional Research and Development Agency of East Kalimantan
BPTP	Assessment Institute for Agricultural Technology site: http://kaltim.litbang.pertanian.go.id
B2P2TOOT	Research and Development of Medicinal Plants and Traditional Medicine site: www.b2p2toot.net/
BALITBANGKES	Agency for Health Research and Development
TNK Bontang	Kutai National Park, Bontang-East Kalimantan
UPTD Kebun Raya Balikpapan	Balikpapan Botanical Garden - Sungai Wain Protection Forest, Balikpapan, East Kalimantan site: http://kebunraya.balikpapan.go.id/
Forest Park Bukit Soeharto	Bukit Soeharto Great Forest Park Management, Loa Janan Regency Kutai Kartanegara

The data source of forest medicinal plants which are based on the traditional knowledge collected from 45 sub-ethnic of Dayak is shown in Table 2.

Table 2
Group and sub-group Dayak Tribe

Group	Sub-group ethnic of Dayak
dayak ngaju	ethnic paramasan, meratus, seruyan, katingan, banjar hulu, bakumpai, wehea, jangkang tanjung
dayak apo kayan	ethnic kayan, kenyah, bahau, kelabit, lundayeh, uma'lung
dayak iban	iban, seberuang, randu', kendayan, melanau.
dayak murut	ethnic okolod, agabag, tagol, paluan, tidung
dayak ot-danum	ethnic ma'anyan, tunjung, kapuas, benuaq, lebang, siang, paser, buro mato, pesaguan, suruk, kaburai.
dayak punan	ethnic punan, bukat, aput, hovongan, merapi.
dayak klemantan	kanayatn, salako, daro', bakati', ahe

The primary sources are listed in Tables 1 and 2. Data collection are derived from a variety of scientific references, such as the results of research, exploration, activity reports, books, journals, local wisdom culture of indigenous peoples, and other sources.

B. Software Development Life Cycle (SDLC) Models

The SDLC is a domain of competency used in systems engineering, information system and software engineering to describe a process for planning, creating, testing, and deploying an information system [22]. The software life cycle models for the development of BBIS is using the waterfall model as shown in Figure 1.

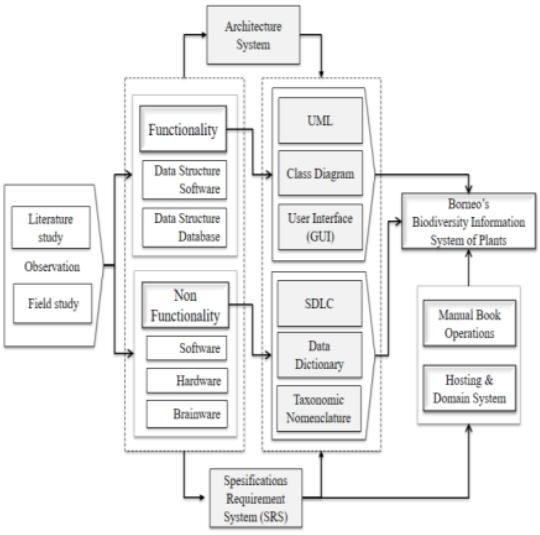

Figure 1: Waterfall process model for BBIS of plants

C. Software Analysis and Design

The analysis and software design used in the development of this system is based on the object-oriented modelling Unified Modeling Language (UML) [23]. In Figure 2, the use case purposes is to describe the role of a user to access the system functions. Some activities that can be performed such as accessing data through searching, dataset, exploring data, and view information.

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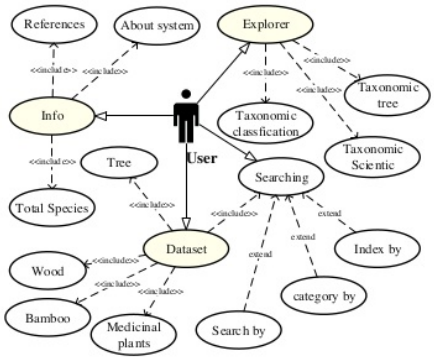

Figure 2: Use case diagram for user

V. THEORY

A. *Nomenclature of Plants*

International Code of Botanical Nomenclature (ICBN) is the set of rules and recommendations dealing with the formal botanical names that are given to plants. It intends that each taxonomic group ("taxon", plural "taxa") of plants has only one correct name that is accepted worldwide [24]. Seven general classification categories have been defined in plants. An example of species *"eleutherine"* classification is presented in Table 3.

Table 3
An Example of Scientific Classification of Plants for Eleutherine Palmifolia

Taxon	Scientific	Common Name
kingdom	plantae	plant
division	tracheophyta	vascular plants
class	liliopsida	monokotiledon
order	asparagales	herbaceous plants
family	iridaceae	flowering plants
genus	eleutherine	herb. Flower
species	*e. palmifolia (l.) merr*	bawang dayak (local)

B. *Traditional Knowledge Ethnic of Dayak*

Dayak is a term for natives of the island of Borneo [25], [26]. Ethnic of Dayak is divided into 405 sub-ethnics. Each sub-ethnic Dayak has common traditional knowledge and cultures in accordance with the local wisdom, social community and language. These characteristics of each sub-ethnic are shared either by ethnic Dayak in Indonesia, as well as ethnic of Dayak in Sabah and Sarawak, Malaysia.

The wealth of traditional knowledge medicinal using plants is a legacy from generation to generation of ethnic Dayak. The practice of utilising the forest medicinal plants have been carried out by various ethnic groups hereditary.

VI. TESTING AND ANALYSIS

A. *Implementation: Three-tier Architecture*

The development of BBIS can be implemented with a variety of approaches and technologies. Scale enterprise applications, such as BBIS for medicinal plants in Figure 3, was developed with the object-oriented approach using a three-tier-architecture, i.e. presentation layer (client environment), the application layer (network-internet), and database layer [27].

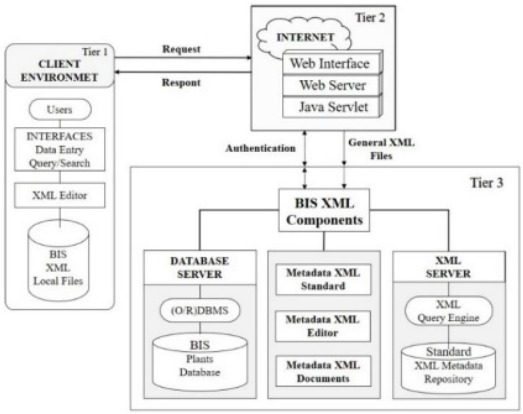

Figure 3: Three-tier architecture for biodiversity information system

B. *Implementation: Graphical User Interface (GUI)*

The user interface, also sometimes called human-computer interface, handles interaction between the user and the system, as for the front-end display the main menu for BBIS that has been developed as shown in Figure 4.

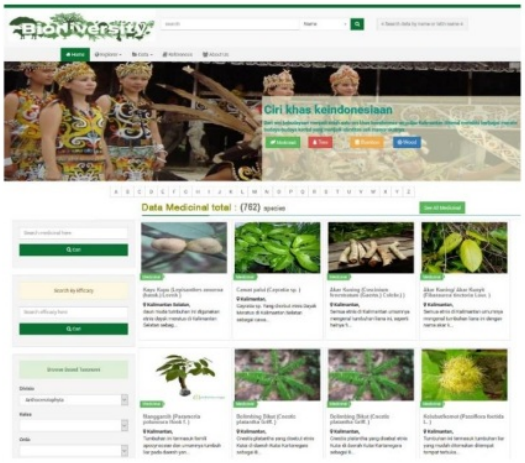

Figure 4: Screenshot of the main interface for Borneo's biodiversity information system

We have developed a biodiversity information system of the tropical rainforest Borneo with a particular focus on plants data collection:

1) Species of tree

Tree data study is conducted by collecting primary and secondary data. Primary data is retrieved by surveying several areas, including the collection of original local types and necessities of the growth, as well as interviews with relevant agencies (Table 1). Secondary data were obtained by collecting the results of research that has been conducted by the Forest Research and Development Agency (FORDA) and other agencies.

The characteristics of tree species are obtained by studying the results of studies that have been done before. The characteristics of tree species include common name, scientific name, height, skin colour outside tree trunk, Habitat

and Ecology, colour gland, fruit, leaves, flowers, and seeds. Based on an inventory of tree species conducted by various agencies and other literary works, a total of 1,497 species has been collected with its characteristics with its distribution within the region of Borneo. The user interface in the application of the BBIS for trees is shown in Figure 5 and 6.

Figure 5: Screenshot of the species of tree

Figure 6: Screenshot of the species "eusideroxylon zwageri" (ironwood)

2) Species of wood

Information on the types of wood found in Borneo has been presented in [28]. In this book, the type of wood arranged no grouped in classification based on family and genus, just refer to some local names so often occur repetition of the same type.

For wood species "dipterocarpaceae", Information about the family and the number of species in each genus of the dipterocarpaceae in Borneo then presented in Table 4 and Figure 7.

Figure 6: Screenshot of the species "dipterocarpaceae"

Table 4
The General and the Number of Species in Each Genus of the Family Dipterocarpaceae

Genus	The number of species
Anisoptera	5
Cotylelobium	3
Dipterocarpus	41
Dryobalanops	7
Hopea	43
Shorea	135
Parashorea	6
Upuna	1
Vatica	35
Total	276

Family *dipterocarpaceae* primary habitat is in Kalimantan (Indonesia), Sabah and Sarawak (Malaysia), and Brunei Darussalam. On this island, there are 9 genera with 276 species.

3) Medicinal Plants Ethnic Dayak

The medicinal plants are available in the forests of Borneo from the bottom and up to the habitus plant trees as well as from the well-known plants to the wasted plants (because it is considered as wild plants and pests). Often, plants that are considered as pests turn out to have benefits and medicinal values.

Ethnic Dayak has been using plants in the treatment of various diseases. Dayak's traditional medicine is very diverse. Treatment is done by people who are considered to have intelligence (called *dukun* = healer = shaman), both regarding knowledge of the use of plants and animals and things that are magical and using mantra in the treatment methods.

For example, similar plants that have a different colour of flower are considered a pair. The variance size or shape of the leaves also will be categorised as a couple of plants and is considered to have better efficacy in treatment. The Dayaks method, in their beliefs, is by taking medicine plant from nature using its own way, they also need to request permission to guard the plants.

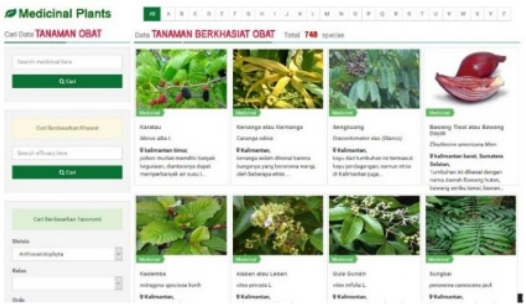

Figure 8: Screenshot of the medicinal plants of traditional knowledge Dayak

Medicinal plant data derived from the tropical forests of Borneo have been collected and stored in the database system of BBIS. There are about 233 species derived from the traditional knowledge of 45 ethnic sub-Dayak as shown in Table 2. The user interface in the BBIS system is shown Figure 8.

The utilisation of forest medicinal plants by ethnic of Dayak is still performed straightforwardly and traditionally during the treatments and processing. The medicinal plant's raw materials are taken from the forest. After cleaning the plants, it is directly soaked or boiled immediately to be drank or bathed. The plants can also be partially processed by crushed, pulverised or heated in a bundle of leaves. If concoctions or raw materials for medicine are not used immediately, the medicinal plants are dried, stored and used when needed.

Figure 9: Screenshot medicinal plants of the species "bawang dayak"

In addition to the data of medicinal plants, we also present the efficacy of medicinal plants to cure various diseases by way of treatment and information processing. For example, the efficacy of medicinal plant species "eleutherine palmifolia", the local name of "Bawang Dayak" is one of the medicinal plants that grow in the forests of Borneo as shown in Figure 9.

C. *Implementation: Nomenclature of Plants*

In the BBIS system, the search and browsing modules implemented by determining the name of medicinal plants based on the rules in the International Code of Botanical Nomenclature (ICBN). This convention made the system becomes user-friendly in searching or data retrieval of medicinal plants, searching the taxon from the kingdom, division, class, order, family, genus, and species. The system BBIS provides an interface to searching and browsing of plants taxonomy. Data flow is presented in Figures 10 and 11.

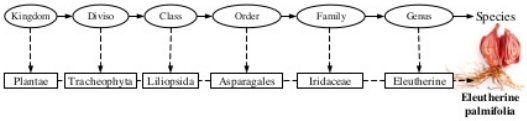

Figure 10: Data flow for nomenclature plants of "eleutherine palmifolia"

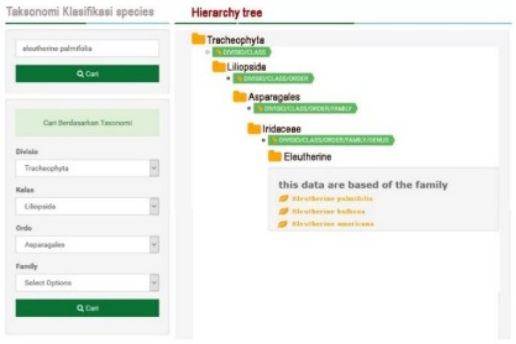

Figure 11: Screenshot for taxonomic classification and hierarchy tree of plants

VII. Results and Discussions

A. *Results*

The knowledge of traditional medicine of ethnic Dayak who uses forest plants as raw materials in the treatment has been documented and inventoried digitally. This research has developed a biodiversity information system of medicinal plants from tropical rainforest Borneo based on traditional knowledge ethnic of Dayak, which can be used as a media for information (information society) exchange on Borneo's biodiversity. The system is also able to preserve the culture local wisdom in traditional medicine and avoid its extinction.

Furthermore, the availability of medicinal plant database can support ongoing research on the medicinal plant by building a modern knowledge base. To date, as many as 1,497 entries have been documented as plants data species of tree types. There are also 276 types of wood and 233 species of medicinal plants from tropical rainforests based on traditional knowledge ethnic of Dayak.

B. *Discussions*

Efforts to accelerate basic research in the form of exploration of biodiversity on Borneo island needs to be done at faster pace, given the environmental changes that occurred lately. There is a threat with the reduction of forests (deforestation) and forest degradation. Many potential types of plants and animals would be extinct before it is known. As they pursue economic growth, the area of tropical rainforests is converted into oil palm plantations and other plantations. Globally, one in five plants are endangered, or extinction risk of plants is at 21% [10].

So, it is ironic that there are other living things, which represents a form of life, should disappear and vanish from this earth because of humans' greed in the name of "prosperity and wellbeing". In the future, the endemic species, rare, singular genus type, sole-type species, will also disappear or destroyed because of our negligence.

VIII. Conclusion

Richness and diversity of the biological resources of plants on Borneo island are still unpublished, anonymous, non-identification and have untapped potential as a source of livelihood of the future. Its also open up opportunities in sustainable utilisation of biodiversity. Structuring the management of plants biodiversity as a development asset should be an essential part of updating, perfecting and accommodating new issues. These processes are in accordance with the Biodiversity Action Plan in 2020, Agenda 2030 for Sustainable Development Goals (SDGs), Aichi Target, Access and Benefit Sharing (ABS), the economics of biodiversity and climate change.

Development web-portal of Borneo's biodiversity information system is an effort to support the achievement of these targets. Also, the system can be used as a media of information to the public (information society), about the potential of biodiversity on Borneo island. This includes various types of trees and endemic, woods and set of characteristics, and the potential of various types of medicinal plants, and efficacy which comes from the tropical rainforest of Borneo based on the traditional knowledge of ethnic Dayak.

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