Borneo Smart Forest Information System for Management of Dipterocarp Plants in Kalimantan Rainforest

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***Abstract*—Kalimantan's tropical rainforest is home to indigenous plants of the *Dipterocarpaceae* family (tribe), which is renowned for having the most endemic species. Dipterocarp is a family of pantropical plants, many of which are used in the wood industry. The average height of this tribe is 70 to 85 meters. This kind of tree can be found in abundance in Kalimantan's forests. This study aims to provide information on the potential of Dipterocarp in Kalimantan forests. Education and conservation efforts for Dipterocarp trees, a prominent component of the forest ecosystem, are crucial in light of the significant harm done to Kalimantan's rainforests. The authors develop the Borneo Smart Forest information system. This system digitally organizes data on the diversity of Dipterocarp in the Kalimantan rainforest based on Web and QR-Code technology. Borneo Smart Forest (BSF) system for monitoring plant inventory and plant markers can be read by smartphones using QR codes. It gives visitors a comprehensive overview of the plants. A QR code is a printed, two-dimensional barcode with limited space for data storage. This technology allows the plant to show earlier administrator-made additions to the inventory information system. Using this tool, administrators may easily manage all plant data. Most individuals have smartphones with cameras for QR code scanning. The QR code will direct the user to the BSF website, which has data about the plants. The development of this system is one of the efforts to support the achievement of Dipterocarp conservation.**

Keywords*—*Information System, QR Code, Dipterocarp, Endemic plants, Borneo.

I. INTRODUCTION

Indonesia is one of the countries where the natural resources of living organisms, especially endemic plants (flora), are known to be highly diverse. *Dipterocarpaceae* is one of the endemic plants in the Kalimantan tropical rain forests. A family is recorded as having the most endemic species, amounting to 695 species. The pantropical plant family Dipterocarp is extensively employed in the lumber industry. This family can grow up to 70 to 85 meters tall and is often very large. Kalimantan's forests are a center for this ethnic diversity. Dipterocarp woods are typically managed selectively in Indonesia and other Southeast Asian nations. Different dipterocarp species yield excellent timber [1] . Since they are widely exploited, several influential members of this family have been included in the IUCN (International Union for Conservation of Nature and Natural Resources) Red List as endangered species. The forestry industry benefits significantly from Dipterocarp forest preservation because it preserves biodiversity, prevents landslides, and sequesters carbon dioxide from the atmosphere. Dipterocarp is a subfamily with many species and a reasonably wide distribution. This subfamily has 13 genera and 470 species, 9 of which are found in Indonesia: *Shorea*, *Dipterocarpus*, *Dryobalanops*, *Hopea*, *Vatica*, *Cotylelobium*, *Parashorea*, *Anisoptera*, and *Upuna*. Its distribution starts from Africa, Seychelles, Sri Lanka, India, China, and the Southeast Asian region (Burma, Thailand, Malaysia, and Indonesia). Sumatra, Java, Kalimantan, Lombok/Bali, Sulawesi, and Irian are the starting points for the distribution of the Dipterocarp in Indonesia. In Kalimantan, there are 267 different species of Dipterocarp, 60% of which are indigenous and dispersed throughout lowland plain forests [2] [3] [4][5]. This aim study is the conservation project's effort to promote digital literacy using information technology to provide knowledge about Borneo's biodiversity, particularly Dipterocarp.

II. LITERATURE REVIEW

The related study [6] suggested a method to make it simpler to add privacy to patients' medical photos while retaining the privacy of their medical information. Information in QR codes to customize the patient's care. Other research, the electronic ticketing system was presented by him [7], who primarily used QR code technology. Further research, in [8] suggested a system for indoor guidance to visitors using mobile phones and based on the Android operating system. The system also supported both Arabic and English. In contrast, [9] suggested a system based on a QR code, is shown to students before or during each class. The students will have to scan the code to confirm their attendance. Furthermore, in [10], the authors presented an overview of observational data on "smart farms" and suggested a traceability system.

This article develops the Borneo Smart Forest (BSF) web information system for managing biodiversity data in the forests of Kalimantan. The Dipterocarp biodiversity in the Kalimantan rainforest is digitally managed through this system based on Web and QR-Code technology. QR code as a Dipterocarp plant marker simply by scanning the QR code with their smartphone.

III. RESEARCH METHOD

A. Dipterocarpaceae

The Pamah forest, also known as the lowland dipterocarp forest, is most prevalent in Kalimantan. This forest type grows on red-yellow podzolic soil at an elevation of 0-1000 m above sea level. The forest's main canopy reaches 30-45m with a tree height of up to 60m. It is called the Dipterocarp forest because it is dominated by plant species from the Dipterocarp tribe, especially the genera *Anisoptera*, *Balanocarpus*, *Cotylelobium*, *Dipterocarpus*, *Dryobalanops*, *Hopea*, *Parashorea*, *Shorea*, *Upuna*, and *Vatica*. Not infrequently, in one location, several types of Dipterocarpaceae grow together and dominate the upper canopy[11]. These tree are the main wood-producing trees from tropical rain forests widely found in western Indonesia, Malaysia, Brunei, and the Philippines and spread eastward to Papua and Papua New Guinea. In eastern Kalimantan, the distribution is dominated by the genera *Shorea*, *Hopea*, *Dryobalanops*, *Vatica*, and *Dipterocarpus*[12].

Most of the Dipterocarp species grow in slightly flat and wavy areas at an altitude of ± 300 m above sea level [4]. According ecology, this tribe dominates the lowland forest in Kalimantan, even becoming a towering tree in the forest community since that is the name of the tribal group. Although most of the Dipterocarp species like dry and acidic soil, a few can grow on soils with calcareous, sandy, and peat conditions[16]. On calcareous soils, the types of Dipterocarp that can be found are *Hopea aptera*, *Hopea billitonensis*, *Shorea guiao*, *Shorea harilandii*. On sandy soils, among others *Dipterocarpus aromatica*, *Shorea stenoptera*, *Shorea falcifera*, *Hopea bacariana*, *Upuna borneensis* and *Cotylolebium malanaxylon*. On peat soil there are *Shorea pltycarpa*, *Shorea teysmanniana*, *Shorea uliginosa*, *Shorea albida*, *Shorea pachypylla*, *Shorea balangeran*, *Dryobalanops rappa* and *Dipterocarpus corieceus* [17].

Taxonomists have a challenge when trying to categorize plants and create accurate maps of their distribution: a paucity of data in the form of herbarium specimens. Data from the herbarium were organized by habitat. Lowland, hill, riparian, and coastal forests comprise most of Shorea's forest types [5]. Table 1 describes the taxonomic of Dipterocarp.

TABLE I. TAXONOMIC OF DIPTEROCARP

Kingdom	*Plantae*
Division	*Magnoliophyta*
Class	*Magnoliopsida*
Order	*Malvales*
Family	*Dipterocarpaceae*
Genera	*Shorea, Dipterocarpus, Vatica, Cotylelobium, Anisoptera, Dryobalanops, Hopea*

Shorea smithiana is a term in the world of timber trade intended for red wood of the *Shorea* genus, in addition to Balau and Bangkirai. Red Meranti is one of the essential commercial timbers in Southeast Asia. In addition to producing wood, almost all Red Meranti produce damar, a type of resin that comes from injured stems or pepagan [18][19][20]. Fig.1 is an example of a Dipterocarp of the genus *Shorea smithiana* (Red Meranti) in the BBPSILH Samarinda with a regular signboard. The proposed information system, a tree with a conventional signboard attached to the tree trunk, will generate a QR Code. The plants' names will be QR code generated. Visitors to urban forests can use their smartphones to scan that QR Code to learn more about dipterocarp trees.

Fig. 1. Red Meranti Tree (*Shorea smithiana*) (*Source: J.A.Widians*)

B. Data Collections

The data were obtained from the literature study and data collections and observations at several related research sites in East Kalimantan. According [4], in the Gunung Lumut conservation Forest area were identified 24 species of Dipterocarp, consisting of 6 genera, namely *Anisoptera*, *Dipterocarpus*, *Dryobalanops*, *Hopea*, *Shorea*, and *Vatica*. The species with a broad growth distribution are *Shorea leprosula Miq*., *Shorea parvifolia Dyer ssp. parvifolia Ashton* and *Shorea smithiana Sym*. Generally, the type of *Dipterocarpaceae* grows a lot on hilltops, hillsides, ridges, and along riverbanks. While on PT. Balikpapan Wana Lestari, part of Mount Meratus, identified 27 species consisting of 6 genera: *Anisoptera*, *Dipterocarpus*, *Dryobalanops*, *Hopea*, *Shorea*, and *Vatica*.

PT. ITCI Kartika Utama is one of the holders of a Timber Forest Product Utilization Business Permit. The PT.ITCIKU is located in the Meratus Mountains area with an area boundary to the west of the Bongan river, north of the Mahakam river, south of Balikpapan bay and PT. Balikpapan Wana Lestari. PT. ITCIKU is a type of wet tropical rainforest. The growing trees are dominated mainly by Dipterocarp species, especially Meranti, Kapur, Keruing, and Bangkirai, and non-Dipterocarp tree species [21].

KHDTK Labanan is a tropical natural forest area designated for research and development with a total area of 7,959.10 ha. It is located in Berau, East Kalimantan, based on the Decree of the Minister of Forestry Number 64/Menhut-II/2012. In KHDTK Labanan, there are 6-7 genera and 26-29 plant species from the dipterocarp family [5][21]. Table 2 contains data collections regarding Dipterocarp in East Kalimantan. Table 3 displays the information sources.

TABLE II. TABLE OF DATA COLLECTIONS

Genera	Number of Species			
	PT. ITCIKU	***Gunung Lumut Conservation Forest***	***PT. Balikpapan Wana Lestari***	***KHDTK Labanan***
Anisoptera	-	1	1	1
Dipterocarpus	1	4	5	4
Dryobalanops	2	1	1	1
Hopea	3	3	3	1
Shorea	5	14	12	16
Vatica	1	3	2	3
Parashorea	-	-	-	1
Cotylelobium	-	-	-	1

TABLE III. TABLE OF DATA SOURCES

Source	Description
Dishut Kaltim	Forestry Department of East Kalimantan www.dishut.kaltimprov.go.id
DLH Kaltim	Environment Department of East Kalimantan www.dinaslh.kaltimprov.go.id
B2P2EHD	Center for Reasearch and Development of Dipterocarp Forest Ecosystem
BBPSILH Samarinda	Center for Environmental Instrument Standard Testing, Samarinda
BPSILHK Samboja	Center for The Application of Environmental and Forestry Instrument Standards, Samboja http://herbarium-wanariset.or.id
DLH Kukar	Department of Environment and Forestry, Kutai Kartanegara
KHDTK Sebulu	Special Purpose Forest Area, Sebulu, Kutai Kartanegara
UPTD Kebun Raya Balikpapan	Balikpapan Botanical Garden – Sungai Wain
Hutan Raya Bukit Soeharto	Soeharto Hill Forest Park
BALITEK KSDA Berau	Research Institute for Natural Resource Conservation Technology of Berau
Royal Botanic Garden	Royal Botanic Garden: Plants of the World Online Website https://powo.science.kew.org
Plants of Southeast Asia	Plants of Southeast Asia Website by Ferry Silk https://asianplant.net

C. *Structure of QR Code*

The Quick Response Code (QR Code) is a white background with a square grid of black squares. Finding details about connected products or services is made straightforward thanks to the two-dimensional code symbol. One of the most dependable data storage methods is QR Codes, which have become more popular as e-commerce and mobile marketplaces have expanded dramatically. Robustness and affordability are two of the critical features of QR Code. As a result, it acknowledges the expanding breadth of demand for many reasons, such as object monitoring and labeling attached products by providing pertinent information across various industries (such as industry, trade, etcetera.)[22] [23]. Developed by Denso Wave, a division of the Japanese business Denso Corporation, the QR Code is a sort of matrix code or two-dimensional barcode that was first used for inventory tracking in the production of auto components. It was published in 1994[23][24][25].

QR codes have expanded to numerous industries today, including entertainment, in-store product labeling, and apps for mobile users. After scanning the QR code, users can access the URL and read the text. Users can create and print their QR-code to check and use using QR code generating websites or applications[26][27]. Each QR code character is composed of the function coding patterns and regions and is constructed from a square module organized in a standard rectangular configuration. Data, including version information, information format, data, and an error-correction password, are represented in the coding section [28]. Fig2. illustrates the structure of a QR Code symbol[24].

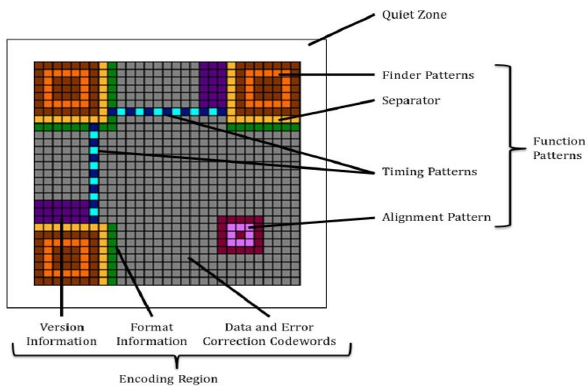

Fig. 2. Structure of QR Code Symbols

- Finder pattern. The search pattern is a unique position detection pattern in the three corners (upper left, upper right, lower left) of each icon.
- Separators. Each recognition pattern and each coding area have a substantial module space as a divider.
- Timing pattern. The horizontal and vertical time patterns are the two types of time patterns. They comprise modules that are alternately dark and bright. On the sixth line of the QR code, the flat time pattern is positioned in the space between the separators. The six-column QR code between the divisions contains a vertical time pattern.
- Mapping pattern. The alignment pattern consists of a 5x5 dark module, a 3x3 light module, and a central dark module. A placement pattern and a number are necessary for QR codes version 2 or later. Depending on the symbol version will determine the positioning pattern.
- Alignment pattern. The alignment pattern consists of a 5x5 dark module, a 3x3 light module, and a central dark module. QR code version 2 or later requires a placement pattern and number. The placement pattern depends on the symbol version.
- Encoding region. Dates, version numbers, format details, and error-correction codes are all contained in the encoding region. The search pattern and version information should be pinned near the modular array at the top left, top right, and bottom left of the format information. Then reserve a 6x3 block area above the viewfinder on the left side of the base, a 3x6 design,

and a block above the left and right pattern viewfinders.

- Quite zone. A sizable space of four modules with no data is used to stop nearby text or markers from misinterpreting the QR code data.

IV. Result and Discussion

A. Software Development Models

A website is a piece of information made available online and can be accessed from any location in the globe as long as it is connected to the internet. A website is a part or group of parts that includes text, photos, sound, and animation to make it enjoyable to visit [29]. Moreover, a website is an internet facility that connects documents locally and remotely. Web pages are what the website refers to as documents[30]. In developing a website-based information system, a software development model is needed. The authors use the System Development Life Cycle (SDLC) to help specify the software requirements for this system. A research stage and information system design is described by the area of competency known as the SDLC in systems engineering, information systems, and software engineering [31].

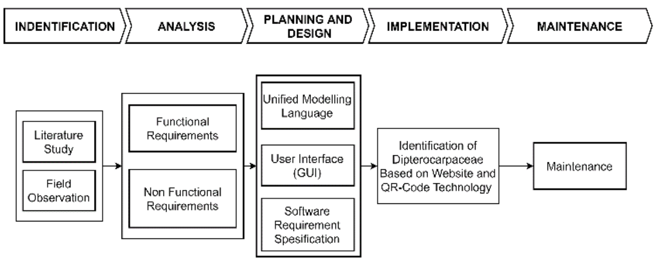

Fig. 3. Research stage

Fig 3 describes the research stages. In the early stages are literature studies and field observations. The following phase is analysis, planning, and design, giving the system development team a complete image of what they should perform. During the implementation phase, a website-based system that employed QR codes as tree tags to identify species was put in place to show information about Dipterocarp in the forests of Kalimantan.

The use case diagram is shown in Fig. 4. Visitors can view the plant collection page through interactions. Visitors can search for any Dipterocarpaceae species collection. Users are sent to a plant article page after selecting the exact plant information they want to examine, which includes taxonomy, description, extinction status, local name, use, and location distribution. The website is also accessible to visitors, who can consult the support page if they encounter any issues. Users also have the choice of switching between Indonesian and English.

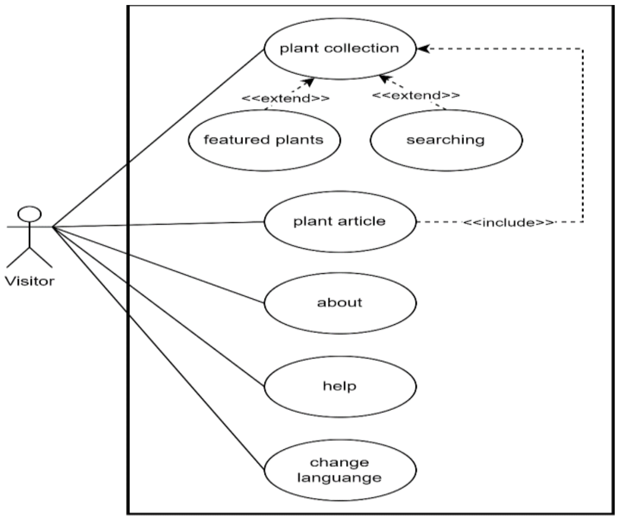

Fig. 4. Use case diagram for Borneo Smart Forest system

B. Implementation System

The architecture of the BSF system is shown in Fig. 5. Users check the label for plant labeling or branding using QR code technology on their smartphones. It will go to the Uniform Resource Locator (URL) BSF website address. The BSF website provides information about Dipterocarp plants. The BSF website provides information about Dipterocarp plants.

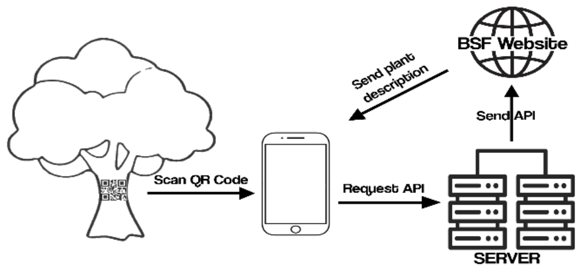

Fig. 5. BSF system architecture

The interface between the user and the design, often known as the human-computer interface, manages user interaction[32]. Fig. 6 illustrates the human-computer interfaces. A plant article explains Dipterocarp, including plant images, morphology, extinction status, use of plants as ingredients or herbs, herbarium images, and distribution areas. For instance, *Shorea laevis*. *Shorea laevis* is the name of a species of tree in that family. According to outlining the plant's physical qualities, classification, extinction status, herbarium, regional titles, local applications, and geographic range.

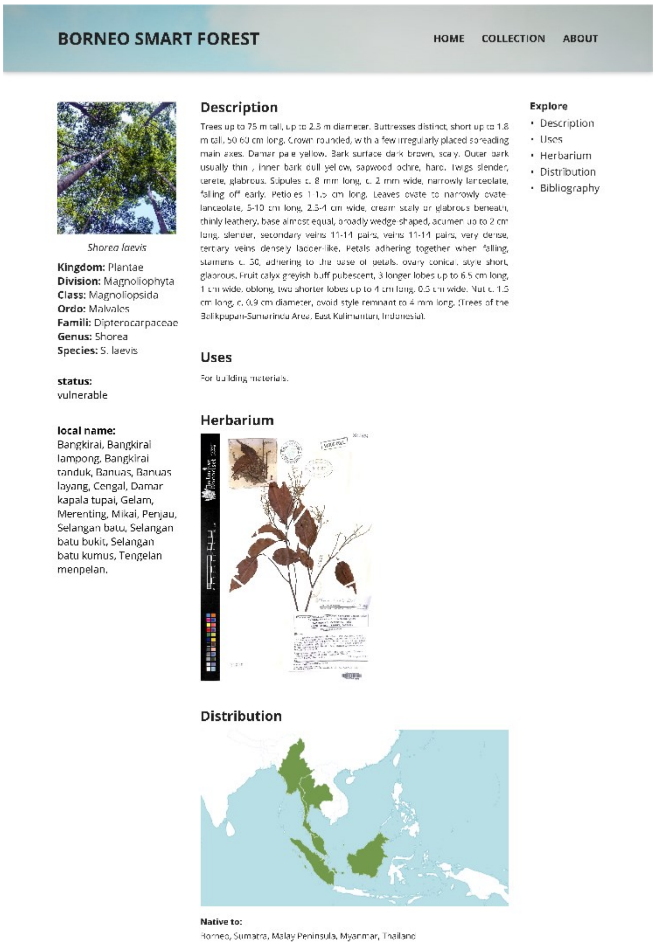

Fig. 6. Plant Description Page

C. Analysis System

The revenue and ranking of web pages will be impacted by web performance. The performance also influences how well Web Performance Optimization is (WPO). WPO is the understanding of how to enhance the functionality of websites. WPO examines page elements, HTML content, display elements, page assets, and similar items. The WPO also includes methods, best practices, guidelines, and procedures for enhancing complete web performance. The web server's speed and the web page's size significantly impact how stable a web connection is. The version of scripts and content is the focus of the topics mentioned. In general, TABLE IV presents a summary of the findings from measurements of the performance of the BSF web page. There are many picture files, and since graphics make up the majority of websites (86.72%), optimizing images is essential. The uncompressed and improperly formatted images can significantly slow down; it takes time for a BSF web page to load.

TABLE IV. SUMMARY OF THE PERFORMANCE BSF HOMEPAGE

Content Type	Content Size		Request	
	Size	*Percent (%)*	*Requests*	*Percent (%)*
Image	4400.00 KB	86.72%	5	27.78%
Script	465.20 KB	9.15%	7	38.89%
HTML	5.56 KB	0.11%	1	5.56%
CSS	204.00 KB	4.02%	5	27.77%
Total	5074.76 KB	100.00%	18	100.00%

V. CONCLUSION

The significant degree of richness of *Dipterocarpaceae* plants in Kalimantan's forests is currently under a lot of stress due to overexploitation and abuse of forest products. Furthermore, environmental change, including the deterioration brought on by climate change, global warming, fires, and environmental pollution, poses a significant threat to biodiversity. Building the Borneo Smart Forest information system based on the website and QR-Code is one project to help conservation success. QR Code makes it more straightforward for everyone to learn about Dipterocarp plants with only a quick scan on their smartphone. This aim research can identify many Dipterocarp species, especially those of high economic value, which will help future management to achieve sustainability and conservation of Kalimantan's tropical rainforests. For future projects, relevant research to identify plants, such as medicinal plants, by QR Code technology.

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