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Lessons from Integrated Biodiversity Information System Implementation Initiatives

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***Abstract*—Biodiversity information system (BIS) plays an essential role in supporting research, exploration, and conservation activities of biodiversity. However, the implementation of BIS is complex and challenging because it involves many stakeholders and various datasets and systems. As a developing country, Indonesia started to implement the integrated BIS because of its benefit to managing Indonesia's biodiversity effectively. This paper attempted to explore the lesson learned of BIS implementation in several countries that may be useful for other countries to develop and implement BIS. This research was accomplished by conducting four focus group discussions (FGDs) that involved a representative of stakeholders, practitioners, and experts of a biodiversity information system in discussing issues in BIS implementation. The first FGD was conducted in Jakarta, Indonesia, which involved 16 participants. The second FGD has invited thirteen members and conducted them in Taiwan. The third session of FGD has been done by discussing with six members of FGD in Spain. The last FGD was held in Japan and invited eight members from several South Korea and Japan institutions. The output of FGDs was an analysis of five themes were identified, including data management, technology infrastructure, funding management, stakeholder involvement, and specialized agency. Stakeholder involvement is important to formulate policies and support BIS implementation and utilization sustainability. The lesson related to funding resources is that many organizations or people must be managed in centralization. It means a specialized agency is needed to conduct and control all programs related to BIS implementation.**

***Keywords*— Lesson learned; biodiversity; information system; developing countries.**

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I. INTRODUCTION

Biodiversity or biological is huge in the variability of living organisms on earth at all levels, including genetic diversity, species, and habitat [1]. Exploration of biodiversity has been done to support human living. However, it is needed to control and manage since the exploration was ignored by the policies and was impacted by biodiversity damage [2]–[5]. In the era of technology, the control and management of biodiversity have been utilized to support Biodiversity Information Systems (BIS). BIS is very useful to support conservation and research of biodiversity [6]–[8]. Through BIS, many experts, such as biologists, chemists, physicists, geographers, geologists, geneticists, and so forth, can be communicated and exchanged samples and or specimens data to ease them in analyzing data collecting other geographical information [9]–[11].

Some previous studies researched Biodiversity Information Systems (BIS) in Indonesia [12]–[18]. However, the research mentioned before only focuses on architecture and model of Biodiversity Information System (BIS) only for one type of biodiversity. Whereas, the system for managing biodiversity information was complex because it was developed to handle huge heterogeneous data from many systems or databases [19], for instance, ecological and geographical features. These separated data resources occurred because biodiversity research institutions intended to use their databases to extract new knowledge and share their discoveries [20]. Moreover, implementing BIS for achieving the goals of system development needs stakeholder

involvement. The role of stakeholders is related to make regulations and policies [6], [21].

Because of those complex problems, this study presents a critical review of a successful BIS implementation in developed countries and then maps to conditions of developing countries with Indonesia as a case study. This review was needed to understand and identify key lessons learned to implement BIS for developing countries, especially in Indonesia. The findings presented here can be a reference or insight for project or committee leaders and other stakeholders to face complex challenges of BIS implementation in developing countries.

II. Material and Method

A. Research Phase

This research used focus group discussion (FGD) to gather opinion statements regarding the practical plan to manage large-scale biodiversity information. FGD was selected as a method because it is suitable for exploring new problems or things [22]. The opinion statements from the participant in FGD were transcribed, analyzed, and categorized into four-lesson themes to manage biodiversity information in Indonesia. The structure of FGD sessions are presented in Fig. 1.

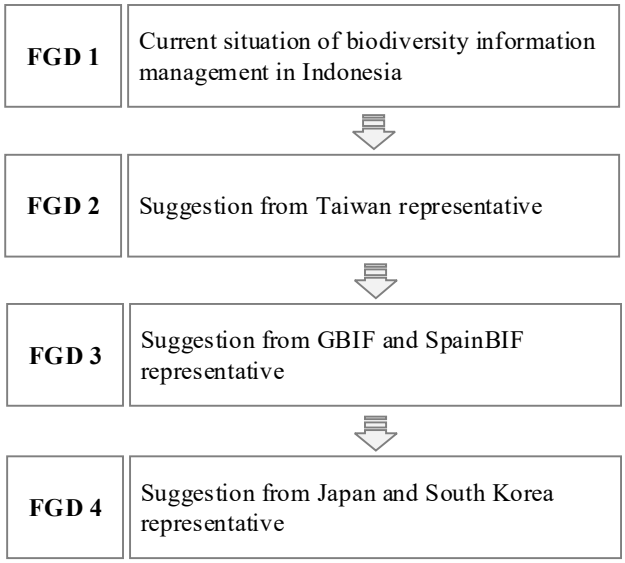

Fig. 1 Research phase

The focus group discussions were conducted as many as four times with different purposes. The first FGD was conducted to gather information about the current situation of biodiversity information management in Indonesia. Then, other FGDs were conducted in other countries to get feedback to implement information management of biodiversity in Indonesia. Before we started FGDs, we have been delivered an overview of the current situation of biodiversity information management in Indonesia based on the first FGD result to ensure all relevant feedback or suggestion.

These FGDs focus on some issues on biodiversity information management, including its vision and specific purpose, integration, architecture, result, and benefit. These FGDs is used to get suggestion from developed countries related to the biodiversity management system in Indonesia.

B. Participants

The first FGD was conducted in Jakarta, Indonesia, which involved 16 participants. Then, the next FGD has invited 13 members and conducted in Taiwan. The third session of FGD has been done by discussing with six members of FGD in Spain. The last FGD was held in Japan and invited eight members from several South Korea and Japan institutions. The demographic of the participant of four FGDs is presented in Figure 2.

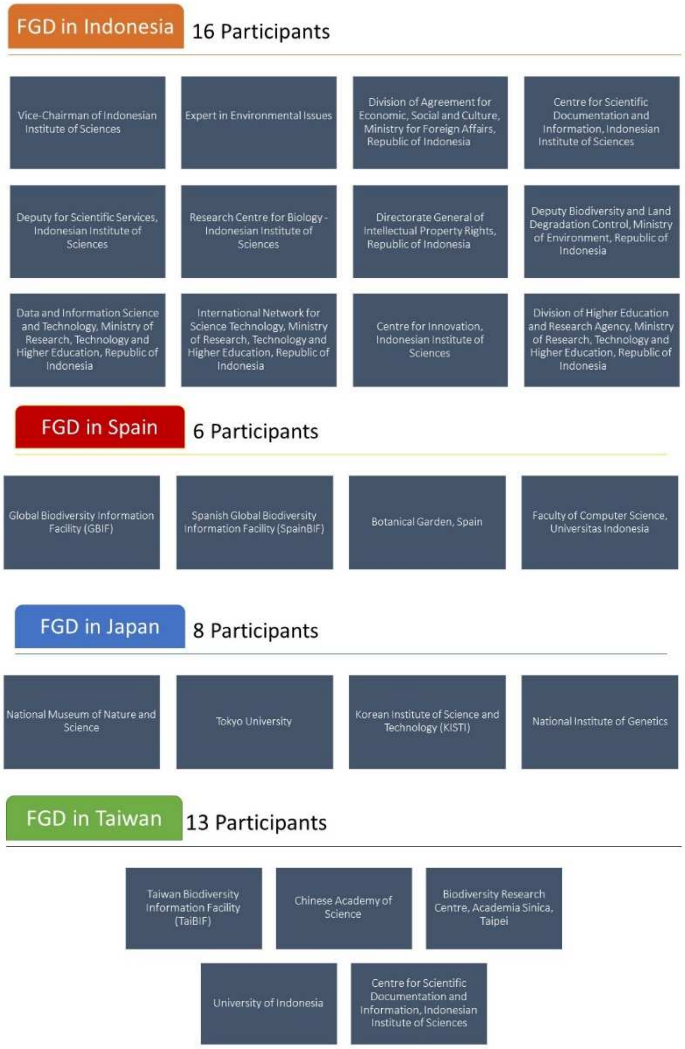

Fig. 2 Demographics of focus group discussion participant

C. Data Analysis

Thematic analysis is an approach within the qualitative descriptive methodologies by classifying and initial codes, defining and naming themes, reviewing themes, and searching themes from data [23]. This approach has been widely used in social science and developed to enable thematic analysis for other domain fields.

This study employed the thematic analysis and studied previous works to identify qualitative information. For example, thematic analysis is used to identify factors in software development [24] and mobile application adoption [25]. Those studies have been chosen because they completely presented how to practice thematic analysis for

information systems and computer science domain from familiarizing with data until defining and naming theme.

III. Result and Discussion

Based on the research result, the government should be considered the five lessons for implementing a successful BIS, including huge data management of biodiversity, the supporting technology infrastructure, funding management, stakeholder involvement, and specialized agency that conducted, solved, and controlled all programs related to BIS implementation as presented on Fig. 3.

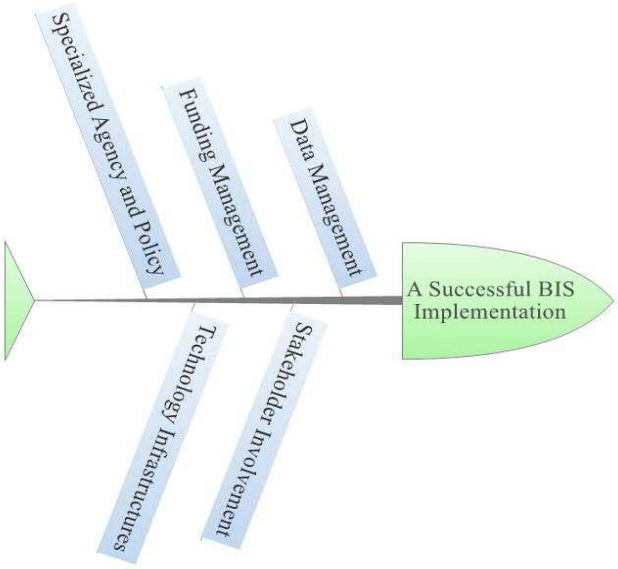

Fig. 3 Five lesson themes of BIS implementation initiatives

A. Data Management

Data management is the basis for the exchange and sharing of biodiversity data. Based on the literature study and FGDs, we found four phases to manage biodiversity data, as shown in Figure 4 effectively.

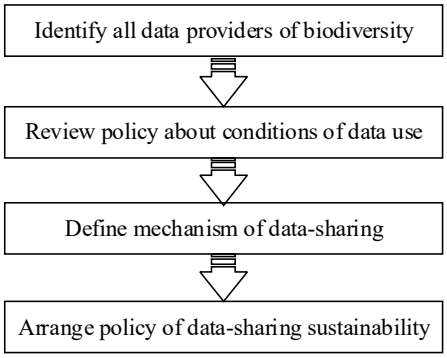

Fig. 4 Phases for biodiversity data management plan

In the first phase, we identified all of the data resources. It must be clearly defined as the provider of biodiversity data. Based on FGD, the distribution of databases of Indonesia can be seen in Figure 5. The second phase is to review policies of storage and transfer of biodiversity data because not all data can be used and shared with the public. We must review the specific policy issues related to access privilege, ownership, and intellectual property rights informed by data providers [26], [27]. Every data provider has its policies and may be different among them, so that it must be clearly defined before the data is published in a biodiversity information system [28], [29].

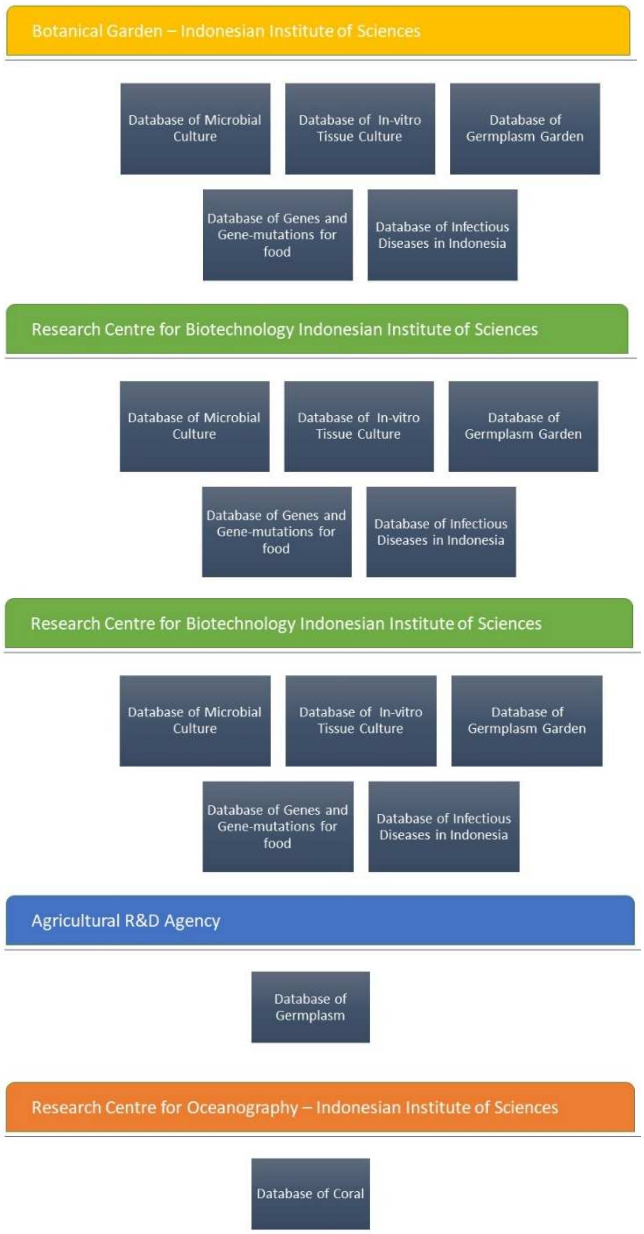

Fig. 4 Distribution of biodiversity databases in Indonesia

The result of data provider policies reviews can be basic to arrange data-sharing mechanisms to be implemented into the biodiversity information system. In general, there are three common data-sharing mechanisms [30]. First, the biodiversity data can be published or shared with the public without any conditions and regulations. Second, the biodiversity data is shown on data listings of biodiversity information systems, but the provider limits the use. To download or get full access to data, the user must be requested the written approval from the data provider. Third, the biodiversity data is confidential or commercially sensitive to access [26], [31], [32].

The mechanism of data-sharing also relied on metadata format. Metadata usually describes the location, source, content, or other specific information about its data or dataset. Metadata provides purposes and descriptions of data or datasets for supporting the data-sharing process among other systems or people. To support data-sharing to people (user), metadata can help designing powerful features for information search, such as query by title and query by author and so forth [33]–[36]. Then, to enable data-sharing among systems, metadata elements with similar values are connected to provide complete information about biodiversity [37]. The workflow of proposed data-sharing is shown in Figure 6 below.

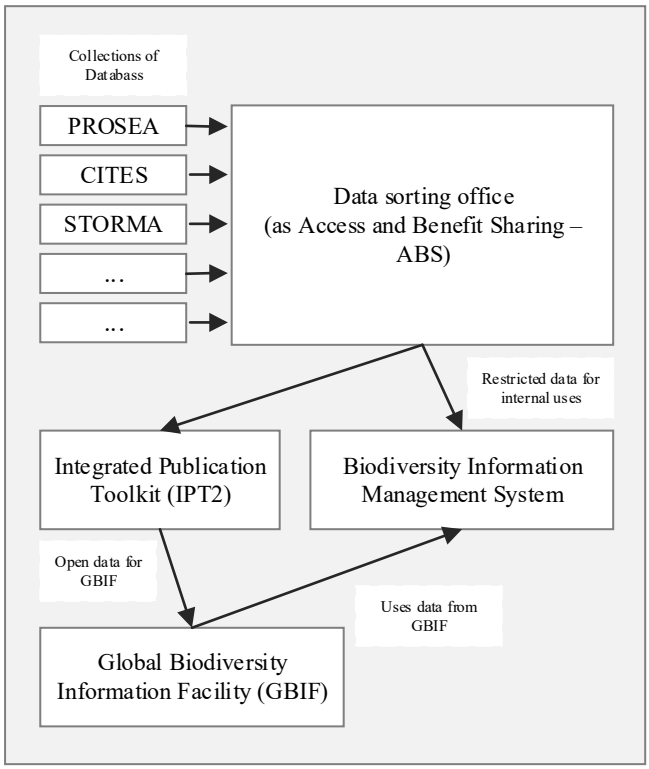

Fig. 6 A proposed data-sharing of biodiversity workflow

B. Stakeholder Involvement

Stakeholder involvement becomes important to biodiversity management since the number of biodiversity has been lost dramatically over past years. The lack of surveillance by stakeholders is one factor of this biodiversity loss. For example, illegal logging operations in the restricted area are still often conducted by the company, whereas that is the place for the extinction of certain species living. Biodiversity management was a complex issue because it is involved many stakeholders. It generally involves stakeholders from NGOs, public authorities (governmental agencies and other governmental organizations), experts and scientists, and coalitions of companies [38], [39].

Stakeholders were needed to ensure the public regulation and policy for preserving biodiversity obeyed by companies that work with natural resources. Based on FGD, the stakeholders of BIS implementation at least must be involved in six types of stakeholders that detail can be seen in Table 1.

TABLE I
STAKEHOLDER OF BIODIVERSITY INFORMATION MANAGEMENT SYSTEM IMPLEMENTATION

Stakeholder	Description
Government (Regulator)	Central *Government (Ministry of Law* and Human Rights, Ministry of Environment, Ministry of Health, *Ministry* of *Research, Technology* and Higher Education, Indonesian Institute of Science) and Regional *Government*
Head of Research Division	Advising and policy-making to define access privilege, ownership and intellectual property rights of electronic biodiversity data
Researchers	Conducting research about biodiversity and requesting electronic biodiversity data for research purpose only
Information Technology Staff for Research Division	Responsible to manage electronic biodiversity data in local system
Manager of Biodiversity Management System	Responsible to ensure all collected data from local system has been managed, secured disseminated based on status of electronic biodiversity data
Information Technology Staff for of Biodiversity Management System	Developing information system and its supporting infrastructures

C. Funding Management

There are two issues about funding resources to support biodiversity information system implementation, i.e., funding resources and fund management. According to developed countries, Japan and China, a key factor of successful biodiversity information system management activities is a stable funding resource and centered-funding management [40]–[42]. Using ICT to control biodiversity requires high cost because it is required in IT infrastructures and involved many stakeholders and experts. There is not enough public sector money to handle and cover all costs. Funding resources are dependent on government aid and seek new cooperation with national or international private sectors [33], [43].

The amount of funding from government aid for control biodiversity resources has declined over the I990s [44]. However, investment from the private sector has expanded dramatically, especially for developing countries. Even though various companies, institutions, and others invested funding resources, it should be monitored, managed, and controlled by a specialized agency or committee [45]. In Indonesia, the information system of biodiversity has been separated because of the development of a system using different funding resources, for instance, *http://www.indobiosys.org* and *http://flora-indonesia.id*.

In China, biodiversity information system implementation was on the high priority level of China Agenda 21. The financial support of this project was estimated at 1.2 billion Chinese yuan (USD 9.6 million) for 15 years or 80 million Chinese yuan (USD 9.6 million) a year. [33]. The fund resources are collected and managed by only one agency named National Bio-Resource Project (NBRP) in Japan.

D. Technology Infrastructure

Technology infrastructure support is important to achieve a successful BIS implementation. According to Sharma and Bashir [46], technology for sustainable biodiversity needs to be pursued. In general, a biodiversity information system consists of two components, including data stores and data analysis platforms [27], [33], [47]. In China, to connect and access a whole of biodiversity data, the government has been set up four network infrastructures, including China Science and Technology Network (CSTnet), China Education and Research Network (CERnet), Golden Bridge Network (GBnet), and Chinanet [33]. For system development in order to support the database sharing, many technologies (for example, database management system (DBMS), structural query language (SQL), Common Gate Interface (CGI), or Application Program Interface (API)) can be used and implemented [33], [48]–[51].

For developing an internal component system, the main feature that must be improved is the search system. A large amount of data in an integrated biodiversity system should be managed effectively and efficiently. These issues can be solved by using a semantic search system by using technology about ontology, natural language processing, and information retrieval so that system can understand the contextual meaning of terms in order to generate more relevant results [20], [52], [53]. Furthermore, the result of data analysis is data visualization, prediction, statistics, and assessment to ease the user to interpret the meaning of data in order to get the best decision making [33], [54], [55].

E. Specialized Agency and Policy

Japan established the information center for biodiversity named Japan Biodiversity Information Facility or JBIF. This organization was structured into two main layers based on the task. First, the direction committee (about ten members that also work in universities or national agencies of Japan) plays a role in decision-making. Second, the substantive committee is assigned to report all events or activities of JBIF to the direction committee. Some members of JBIF work as substantive and direction committee to ease them understand the problem issue to define the best decision-making [3], [33], [56]–[58].

As the respondent explained, “the specialized agency has roles in the developing system and create a training module to use the system in order to give the knowledge to train new people that will interact to BIS”. Another respondent said, “the specialized agency will be easy to integrate and coordinate all activities of biodiversity data management”. Moreover, another respondent said, “the specialized agency should coordinate to local government because they fully conduct biodiversity surveillance in their region respectively [59]–[61]. In China, a specialized agency also has been established, which can be seen in the Figure 7 below.

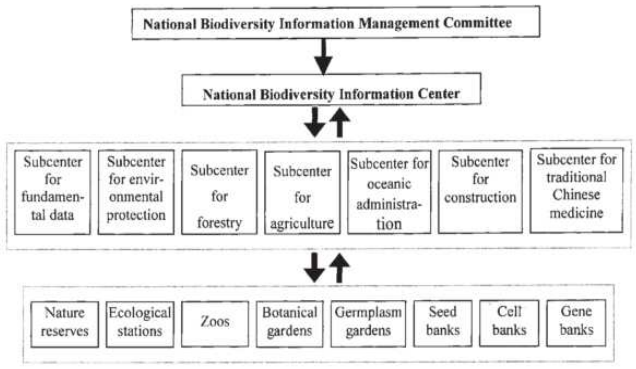

Fig. 5 Role of a specialized agency to manage BIS in China [33]

F. Initial Proposed of Biodiversity Information System

Based on the focus group discussion (FGD) result, we attempted to propose the Indonesian government's biodiversity information system. This information system will be involved several government institutions, such as The Indonesian Ministry of Agriculture, The Indonesian Ministry of Environment and Forestry, The Ministry of Marine Affairs and Fisheries, The Indonesian Institute of Sciences, and The Higher Education Institution Partnership. This organization can be seen in Figure 8 below.

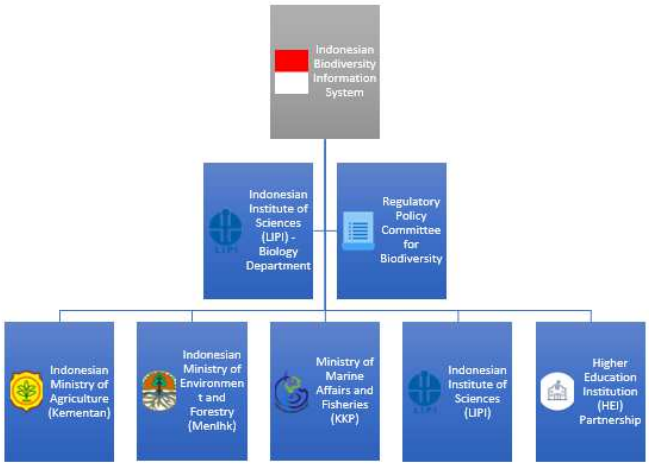

Fig. 6 Main actors of biodiversity information system

As initial development, by synthesizing results from previous FGD, we proposed essential concepts to understanding the information system needs of Indonesia's biodiversity information system. We mapped the BIS needs based on the dimension of people, process, and technology, as depicted in Figure 9. Moreover, this BIS's main concern is about data attributes because it proceeded large-scale data. This system should be defined and maintain reasonable data standards, types of data, data quality, and data volume.

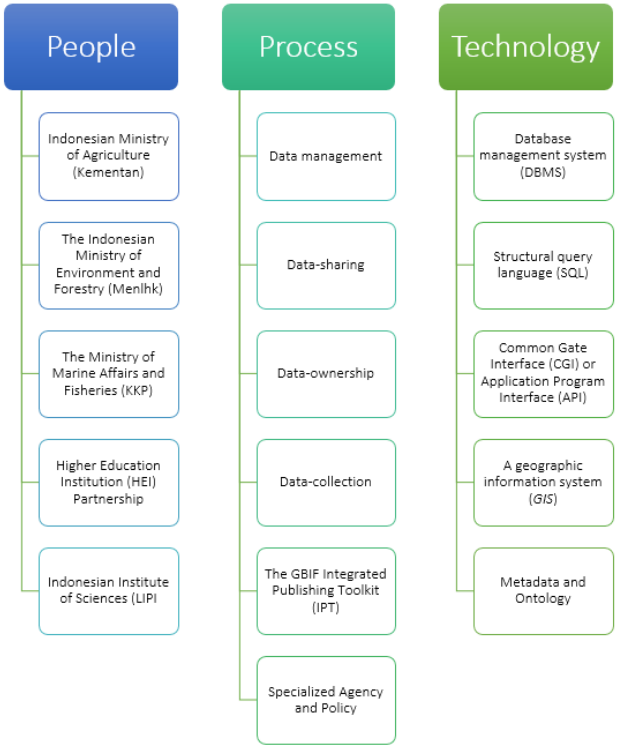

Fig. 7 Initial concept of biodiversity information system

IV. Conclusion

Based on FGDs, lessons learned for biodiversity information management system initiatives can generally be categorized into data management, stakeholder involvement, funding management, technology infrastructure, and specialized agency and policy. Lessons of data management are identifying all of data resources, reviewing data use policies, defining data-sharing mechanisms, and arranging policy of sustainability of data-sharing. Then, stakeholder involvement is important to define policies and support BIS implementation and utilization sustainability. The lesson related to funding resources is that many organizations or people must be managed in centralization. It means a specialized agency is needed to conduct and control all programs related to BIS implementation.

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