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Development and Evaluation of Internet-based Geographic and Environment Biodiversity Information System in Nueva Ecija

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Abstract

This study delved on the development and evaluation of an Internet-based geographic, environment, and biodiversity information system in the province of Nueva Ecija, Philippines. The purpose of this study was to help facilitate various environment and biodiversity management processes, which includes a tool for facts-based decision-making, operation, monitoring, and evaluating ecosystems. The researcher implemented a research and development design wherein the developed system underwent design and development, testing, and evaluation for its significance. This research design used the SCRUM Agile Methodology as a guide in developing and improving the capability of the system. The system was developed based on the requirements of the users and pilot tested to determine its usability. The end users consisted of ten (10) Provincial Environment and Natural Resources Office (PENRO) employees and Biologist/Biodiversity Monitoring Committee members, and twenty (20) people from the community. They agreed that the developed system was usable, functional, reliable, and user-friendly. Moreover, three (3) Information Technology (IT) experts agreed that the system uses an appropriate database design, user interface. The IT experts also approved that the developed system was functional, maintainable, and secured.

KEYWORDS: biodiversity; environment; information system; Internet-based GIS; Nueva Ecija

Introduction

Digital technology for nature conservation holds much potential for the advancement of understanding and facilitating interaction with the natural world. It increasingly influences the way members of the public perceive, think about, and engage with nature. These technologies promise more data, faster processing, better information access and connectivity, new communication routes, visual representations, and facts-based decision-making support systems. With the growing technological advancement and industrialization, the purity of the environment has been threatened to an appalling extent (Global Biodiversity Information Facility, 2017). The need to protect and improve the environment is so compelling for the peaceful survival of mankind and other life forms on earth. The wholistic and relevant information on the environment in turn is a prerequisite to manage natural resources towards achieving sustainable development.

At present, there is no computerized online system dealing with environment and biodiversity information in Nueva Ecija; thus environment and biodiversity data in the province are not readily available to interested people. Though prolific in data, environment and biodiversity information in the province are scattered, fragmented, and heterogeneous. For these reasons, there is a need to integrate these data by developing a system that is beneficial in consolidating the vast amount of information on environment and biodiversity that uses the

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Internet as a medium (Arvanitidis, et. al., 2006). The Provincial Environment and Natural Resources Office (PENRO)-Nueva Ecija also recognizes the need for integrating information on environment and biodiversity.

The Internet-based Geographic and Environment Biodiversity Information System is designed to assist safeguarding of the environment. This system is a single-entry point for data and information for the province. Its goal is to strengthen the knowledge base and support facts-based decision-making. By using this information system, communities could automatically craft plans and take appropriate actions custom-fit to the needs of the environment in their localities. This information system improves biodiversity conservation, human livelihoods, ecosystem productivity, and facilitates community empowerment. These are essential fraction of location-specific information that needed attention for inventory and monitoring of the state of the environment and biodiversity (Rambaldi, et. al., 2015; Salem, 2003; Sieber, 2006).

Objectives

This study intended to design, develop, and evaluate an Internet-based geographic and environment biodiversity information system in Nueva Ecija that helps facilitate various environment and biodiversity management processes which includes tool for facts-based decision-making, operation, monitoring, and evaluating ecosystems.

Specifically, the study aimed to achieve the following objectives:

1. Design and develop an Internet-based geographic and environment biodiversity information system with mobile application;
2. Determine the level of acceptability from the point of view of:
    2.1. IT Experts
        2.1.1. Database Design;
        2.1.2. Functionality;
        2.1.3. Maintainability;
        2.1.4. Security; and
        2.1.5. User Interface.
    2.2. End-users
        2.2.1. Usability;
        2.2.2. Functionality;
        2.2.3. Reliability; and
        2.2.4. User Interface.

Methods of Study and Sources of Data

The researcher's study used the Research and Development (R&D) design, which is associated with the SCRUM Agile methodology in software development. Descriptive design was also utilized as this study assessed the level of acceptability of end-users and Information Technology (IT) experts on using the system.

Model

Figure 1 illustrates how the researcher arrived with the final version of the Internet-based Geographic and Environment Biodiversity Information System. The top box represents the input component in the development of the system, which comprised of the basic information management functions found in the current way of managing environment and biodiversity information. These functions are enhanced by web and mobile innovations, and geographic information system. The researcher used the SCRUM methodology in developing the information system. Schwaber (2004) mentioned that such method enables one to rapidly build the system by working side by side with the clients or users and to quickly respond to their feedbacks. The information system

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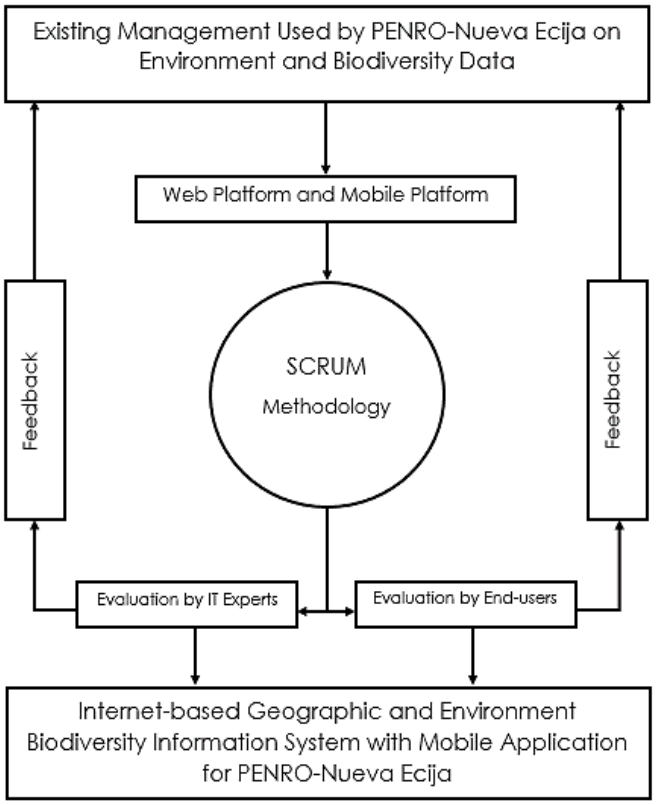
developed was subjected to evaluation by IT experts and by end-users. Feedback and suggestions from both experts and end-users were noted and implemented into the system.

Figure 1

Conceptual Model of the Internet-based Geographic and Environment Biodiversity Information System with Mobile Application for PENRO-Nueva Ecija



Sources of Data

The study was conducted at the Provincial Environment and Natural Resources Office (PENRO)-Nueva Ecija that is located at Brgy. Singalat, Palayan City, Nueva Ecija. Simple random sampling technique was used in selecting samples from the given population of the end-users. The ten (10) system end-users were PENR Office employees, the biologist/Biodiversity Monitoring Committee, and twenty (20) people representing the community/general public. Three (3) experts from the Information Technology industry were chosen by the researcher to evaluate the system. These experts came from different companies and institutions, were particularly knowledgeable and have profound experience in their respective fields, which include software development, and geographic information system.

Instrumentation

To evaluate the acceptability of the system, the researcher used necessary software quality characteristics as identified by ISO 9126. The IT experts used a set of scales that assess the system's five main quality characteristics: database design, functionality, maintainability, security, and user interface. Likewise, the end-users (PENRO employees, biologists and/or Biodiversity Monitoring Committee, and people of the community) used different sets of scales to evaluate the system on four characteristics: usability, functionality, reliability, and user interface.

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The evaluation of the information system by the IT experts and end-users were analyzed and interpreted using a Likert Scale as scoring guide as shown in Table 1. The mean rating given by the IT experts and end-users was used as baseline in giving the qualitative rating of the information system. Higher mean ratings on the quality characteristics implied positive quality; while low mean rating implied negative characteristics.

Table 1

Likert scale/measuring scale for system's characteristics

Units of Indexes	Adjective Description
4.50 – 5.00	Acceptable
3.50 – 4.49	Slightly Acceptable
2.50 – 3.49	Neutral
1.50 – 2.49	Slightly Unacceptable
1 – 1.49	Unacceptable

Statistical Treatment

Responses from the evaluation by IT experts and end-users were analyzed using the arithmetic weighted mean formula:

$$WM = \frac{\sum_{i=1}^{n} f_i x_i}{n}$$

Where: n – number of respondents; fi – weight of each item; xi – item value

Results and Discussion

Development of the Internet-based Geographic and Environment Biodiversity Information System

Table 2 shows the product backlog or user stories and estimation of PENRO-Nueva Ecija with regards to the development of the system.

Table 2

Product backlog lists/user stories

Stories	Estimation
Provide an organized and centralized data storage for environment and biodiversity records.	6 days
Deliver a web-based application for descriptive information.	20 days
Provide a secured management of System Users.	5 days
Develop visual representation for different topics (Maps, Charts, and Tables).	30 days
Deliver mobile application that deals with biodiversity (species) information.	20 days
Modules Revisions	15 days
Total	96 days

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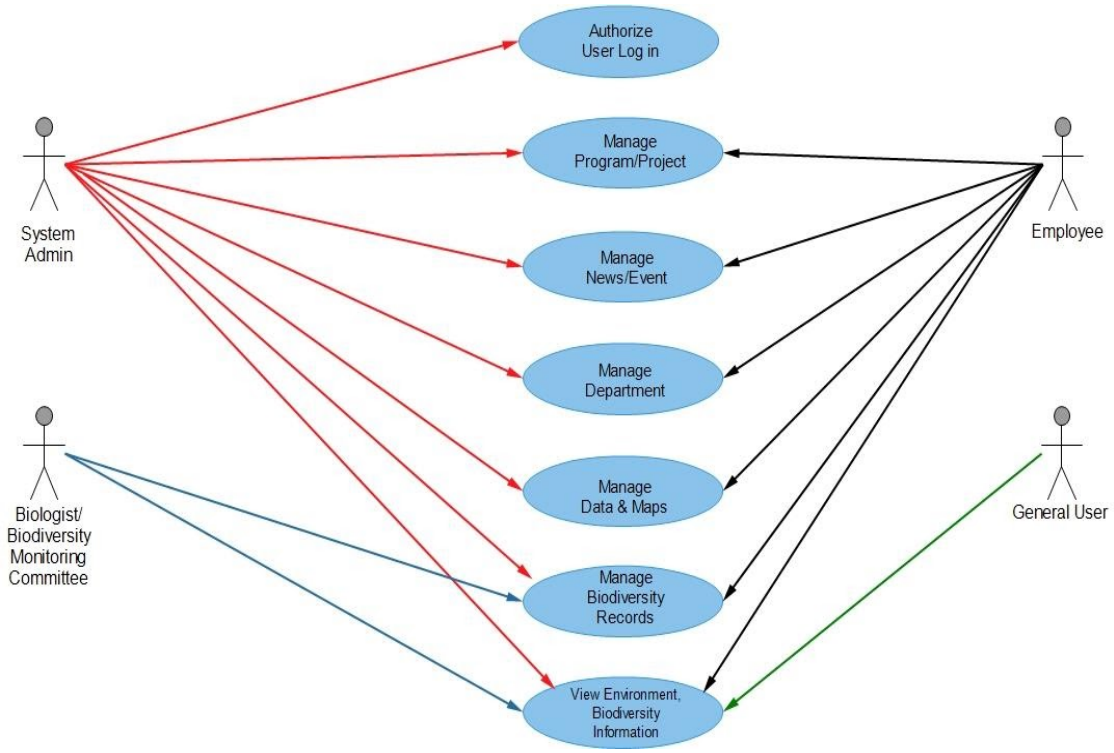
Use Case Diagram

Figure 2 shows the use case diagram, which is a visual representation of the relationships between actors, and use cases together that document the system's intended behavior as stated by Visual Paradigm (2020). The System Admin is responsible for the upkeep, configuration, and reliable operation of the information system. The Employee could manage various environment-related information, while the Biologist/Biodiversity Monitoring Committee is involved only in managing biodiversity (species) data. The General User is an actor that uses the web-based and mobile application for online viewing of various environment and biodiversity data.

Figure 2

Use Case Diagram



System Architecture Diagram

Figure 3 shows different technologies that were implemented to the system and the communication between them. Based on the figure, the web-based application could communicate directly with the public server (web server). This approach can secure application and database servers separately, which provides an extra layer of protection. On the other hand, the mobile client is talking to the web service API to be able to contact and obtain a response from the private API server (independent server).

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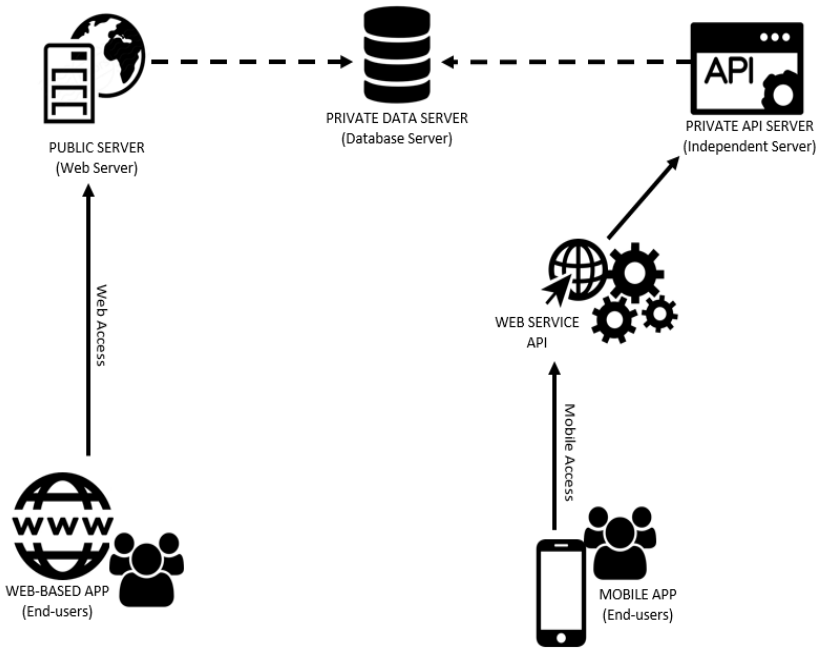
Figure 3

System Architecture Diagram



System Development

The Internet-based Geographic and Environment Biodiversity Information System is composed of four main modules, namely Login Page; Content Manager (Program/Project, Department, News/Event, and Species/Biodiversity); Data and Maps Manager; and environment and biodiversity information viewing.

The Login page of the system is the first line of defense or security of the system. User security levels are strictly implemented in the three user levels, namely Employee, Biologist/Biodiversity Monitoring Committee, and System Admin. The user security level determines the privilege of the users in accessing the system resources.

The Content Manager Module is used for adding, and updating of environment and biodiversity records. Data and maps manager module is used in setting up the visual representation of various environment and biodiversity data. Its purpose is to integrate provincial-wide efforts in environmental information collection, storage, retrieval, and dissemination to all concerned entities (Ministry of Environment, Forest and Climate Change of the Government of India, n.d.). It includes interactive maps management, maps, and geo-tagged photos management, charts, and graphs management and the information management to be displayed on tables.

The main feature of the web-based application is the Data and Maps page, which includes interactive maps (thematic maps), maps, and geo-tagged photos, charts and graphs, and tables. The researcher decided that the design should resemble the layout of the other pages of the website to enable the users to quickly familiarize themselves with the interface.

Figure 4 shows the final layout for the interactive maps (thematic maps), which displays coordinates for polygons and marker icons plotted on the map with the aid of Google Maps API. This gives the end-users idea about the geographic locations, to easily monitor the status for each program/project implemented by PENRO-Nueva Ecija.

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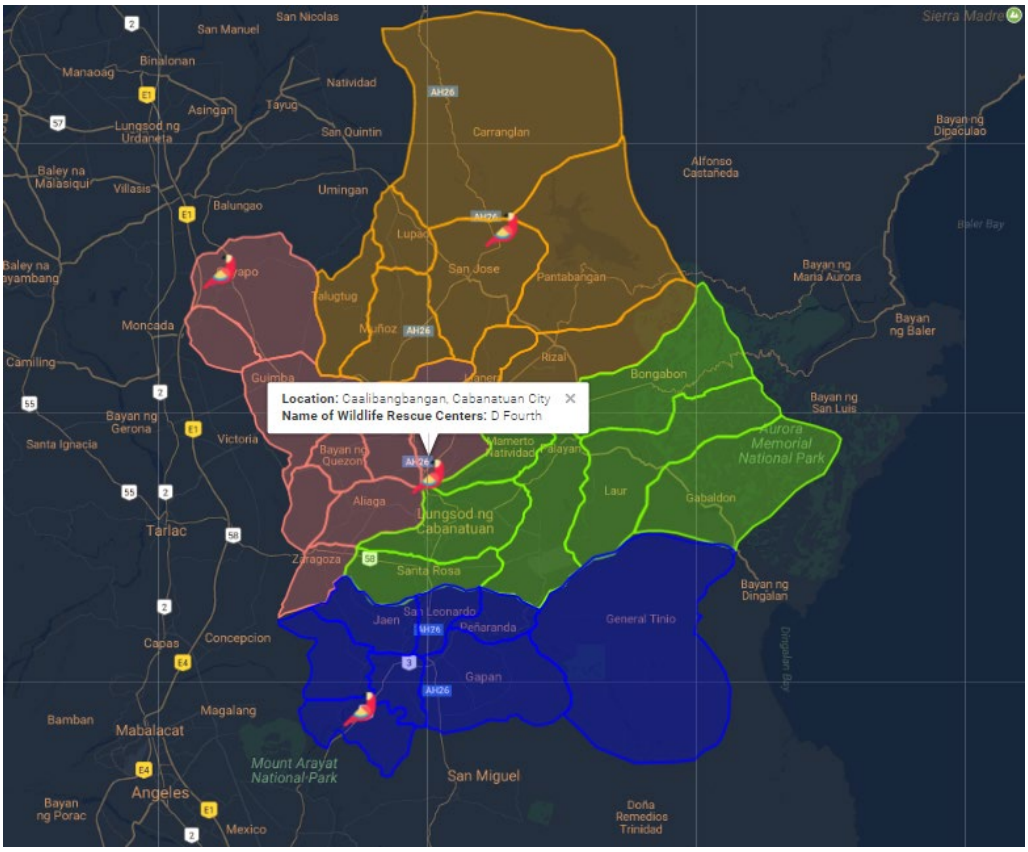
Figure 4

Data and Maps Page (Interactive Map)



Based on the figure, the polygonal maps used four (4) colors, which determine the division of four districts in the province of Nueva Ecija. The researcher also used different icons on coordinates for each project/program to easily differentiate information.

Maps and geo-tagged photos as shown on Figure 5 displays geo-tagged photos on the map with attached description. This is used by the researcher to readily view instant locational information on the map. This tool supported the finding of Chapman et al. (2005) that it can help increase data quality, thus making records more usable for environment and biodiversity research and in conservation decision-making.

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Figure 5

Data and Maps Page (Maps and Geo-tagged Photos)

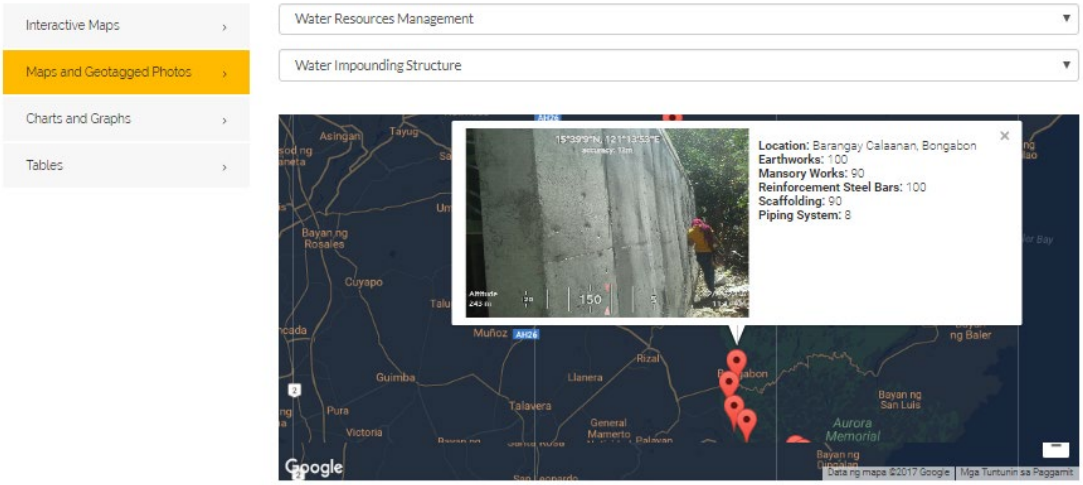
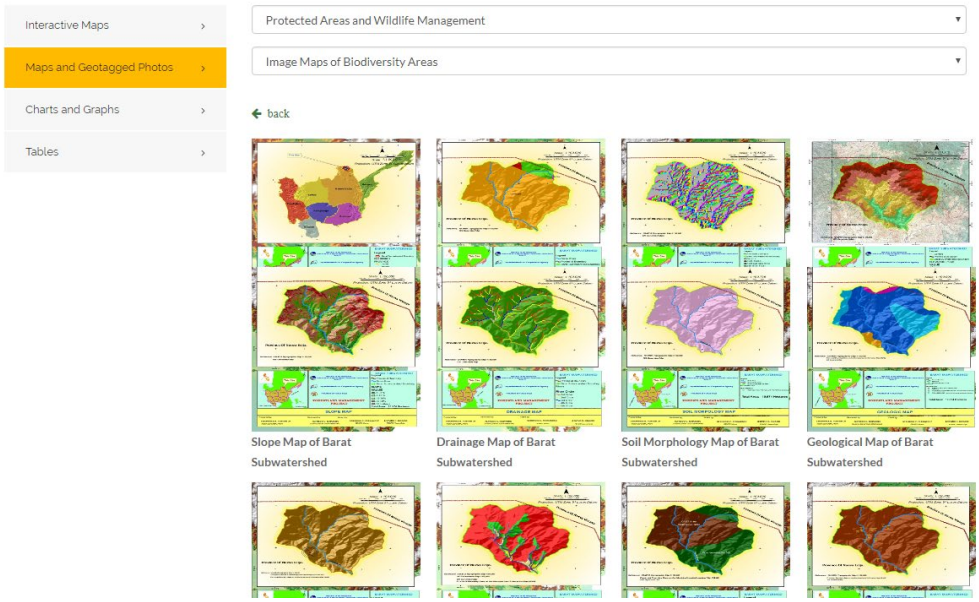


Figure 6 shows the ready-made image maps for a specific program/project. This provides the end-users means to quickly navigate topographic maps for specific location in the province.

Figure 6

Data and Maps Page (Maps and Geo-tagged Photos)



Charts and graphs are shown on Figure 7. This visual tool is used by the researcher to sum up the data for a specific program/project.

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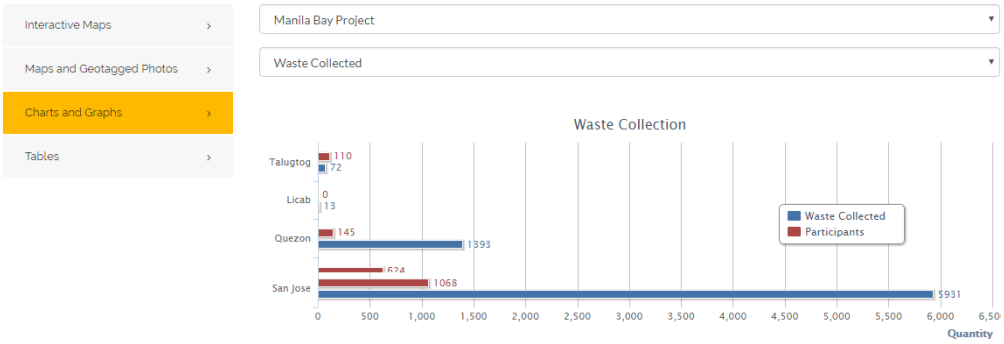
Figure 7

Data and Maps Page (Charts and Graphs)



The biodiversity/species information is made available with the use of mobile phones both on iOS and Android operating systems as shown on Figure 8. Through this, the community or interested individuals could easily access the information on the species found in the province of Nueva Ecija. It includes the full details for each species following the Darwin Core Archive format (Catalogue of Life, 2017) as shown on Figure 9.

Figure 8

Data and Maps Page (Charts and Graphs)

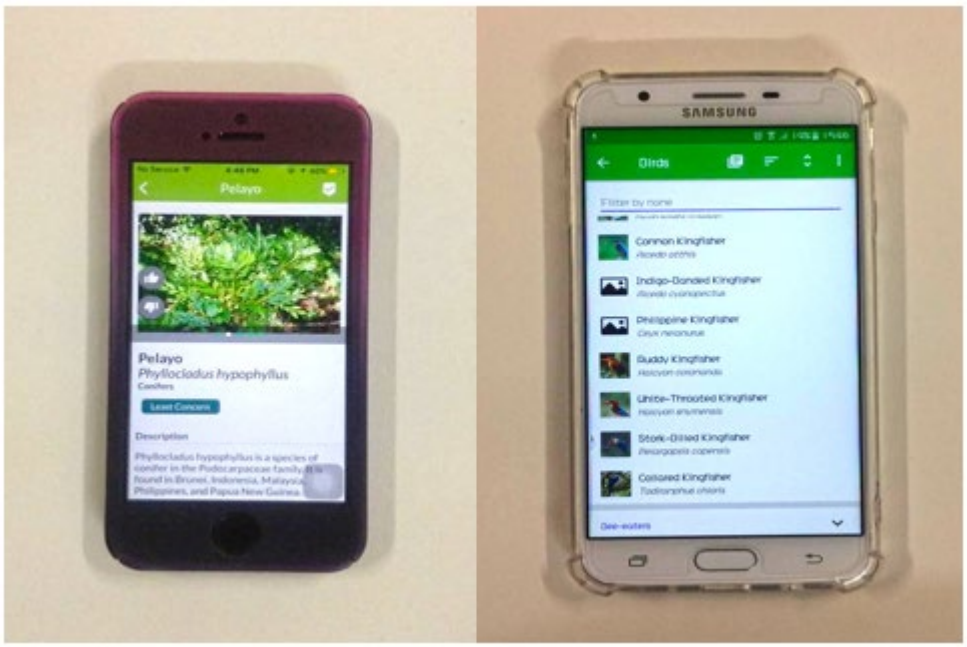


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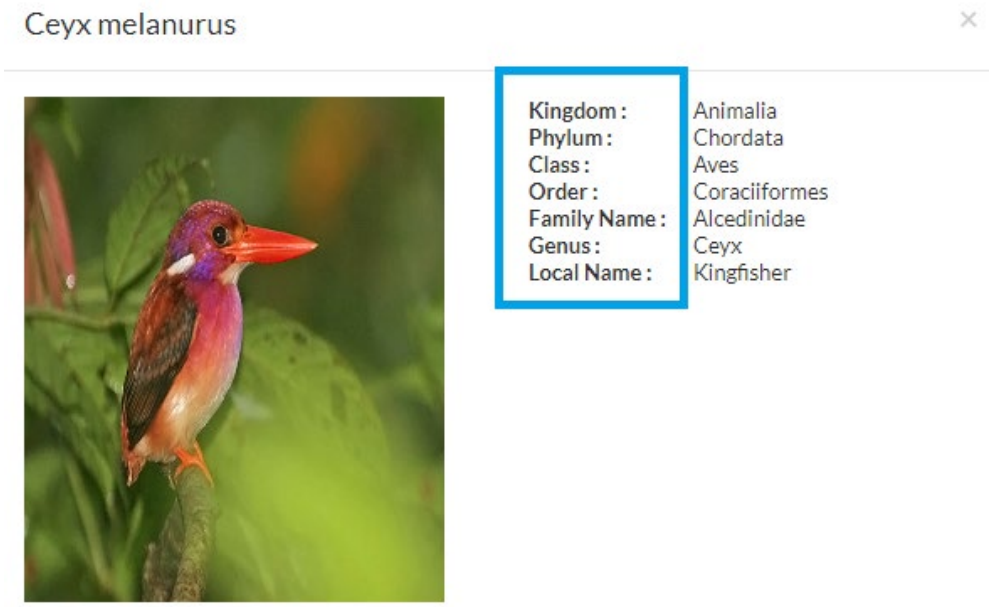
Figure 9.

Darwin Core Archive Format



Level of
Acceptability of the Internet-based Geographic and Environment Biodiversity Information System by Information Technology (IT) Experts and End-users

Level of Acceptability of the IT Experts

The IT experts evaluated the system based on the system features shown on Table 3. The system acquired an acceptable rating in five (5) evaluated areas with the total mean of 4.79. This affirms that the developed system is acceptable to replace the existing information management of the Provincial Environment and Natural Resources Office (PENRO) – Nueva Ecija.

Table 3

IT Experts' Level of Acceptability of the System

System Feature	Mean	Descriptive Rating
Database Design	4.67	Acceptable
Functionality	4.67	Acceptable
Maintainability	4.89	Acceptable
Security	4.89	Acceptable
User Interface	4.81	Acceptable
Overall Mean	**4.79**	**Acceptable**

Level of Acceptability of the End Users

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The end-users were categorized into two: 1) the employees and biologist/Biodiversity Monitoring Committee members, and 2) the general users or people of the community.

These end users, both employees and biologist/Biodiversity Monitoring Committee, evaluated the system for its usability, functionality, reliability (system and data), and user interface as shown on Table 4.

Table 4

Employees' and biologists'/Biodiversity Monitoring Committee' level of acceptability of the system

System Feature	Mean	Descriptive Rating
Usability	4.88	Acceptable
Functionality	4.63	Acceptable
Reliability	4.52	Acceptable
User Interface	4.92	Acceptable
Overall Mean	**4.74**	**Acceptable**

The overall rating of the employees and biologist/Biodiversity Monitoring Committee as end users in all the areas they evaluated shows that the system is responsible for all the current issues with the manual management of environment and biodiversity information of the Provincial Environment and Natural Resources Office (PENRO)-Nueva Ecija.

On the other hand, the evaluation of the system by the general users or people of the community are shown on Table 5. These end users are the ones who access/view the information about environment and biodiversity thereby increasing public awareness about its conservation and preservation.

Table 5

General users'/people of the communities' level of acceptability of the system

System Feature	Mean	Descriptive Rating
Usability	4.71	Acceptable
Functionality	4.80	Acceptable
Reliability	4.60	Acceptable
User Interface	4.81	Acceptable
Overall Mean	**4.73**	**Acceptable**

The total mean rating obtained from the general users/people of the community shows that the areas on usability, functionality, reliability, and user interface are acceptable with a 4.73 overall mean. This implies that the system addressed all the current issues on dissemination of environment and biodiversity information to the general public.

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Conclusion and Recommendations

The development of the Internet-based Geographic and Environment Biodiversity Information System of Nueva Ecija was accordingly developed based on the user requirements following the SCRUM Agile Methodology.

Over all, the system was acceptable to the IT experts for its database design was properly designed and implemented; the system had vital functionality; the system's maintainability was easy to configure and responsive in changing system settings; system vulnerabilities found it secured; and user interface was noted as user-friendly and intuitive.

The usability, functionality, reliability, and user interface of the system were acceptable to the end users and was deemed suitable to replace the existing management, collection, and dissemination of environment and biodiversity information of the Provincial Environment and Natural Resources Office (PENRO)-Nueva Ecija.

It is recommended that PENRO should migrate their traditional practice of management, collection, and dissemination of environment and biodiversity information into the system. Also, the web-based content manager module for environment-related and biodiversity/species information may incorporate location sensor to automatically determine the latitude and longitude of a specific location, so that the places will be instantly recorded once the sensor gets the data and every time the device's location is changed.

The information system may also possibly be linked to Department of Environment and Natural Resources (DENR) LAWIN Forest and Biodiversity Protection System to further assist environmental monitoring especially in the forest and biodiversity of high conservation value areas.

Acknowledgement

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