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Forest Management System using iD3 Decision Tree Algorithm for Department of Environment and Natural Resources

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ABSTRACT

Accuracy of decision is a significant factor for organizations to survive. Most organizations today are already using data warehouses for a data-mining strategy to extract data based on historical and transactional data to create meaningful decisions. This strategy creates an imperative business perspective to direct the organization's future. This study is a development of a forest management system for the Department of Environment and Natural Resources. The researchers integrated the use of an ID3 decision tree algorithm data mining in the development. ID3 decision tree algorithm is used as a data mining technique to identify suitable species of trees to be planted according to uses, tree type, soil type, and tolerance to different diseases and pests. On ISO 25010 Systems Quality Standards, the SFM received "Very Great Extent." This implies that the system is ready for deployment and utilization.

Keywords: *Algorithms, Categorical data, Data mining, Decision tree, Strategic management*

INTRODUCTION

Human actions are now a pervasive facet of life on earth. Biological diversity comes with myriad responsibilities in environmental protection for the consumption of human life to balance and sustain the needs of wildlife and human beings. Accountability for the protection of biodiversity should be from the people who are consuming natural resources. Therefore, environmental protection is a social responsibility. Preservation of natural resources and protection of wildlife habitats such as forest lands, rivers, plants, and trees should be treated more seriously as a global resource, and human beings must be consuming the ecological benefits from the environment. Environmental degradation has resulted in threats from people.

There are threats to biodiversity, including deforestation and habitat loss, overexploitation of wildlife animals, pollution, and other man-made catastrophes that destroy the world. Human beings cause most environmental degradation factors; soon, if it is continued, the world and its habitats will become precarious.

According to Hui (2013), “the loss of biodiversity has become a serious issue in many places around the world” (p.1). Additionally, the World Wide Fund for Nature (2010) reported: "the Millennium Ecosystem Assessment, released in March 2005, highlighted a

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substantial and largely irreversible loss in the diversity of life on Earth, with some 10-30% of the mammal, bird and amphibian species threatened with extinction, due to human actions" (para. 3).

Consequently, there is a need for myriad social responsibilities in preserving the environment for global resources and the economy.

The Philippines is considered the country as a biodiversity hotspot, which means the extinction of wildlife and natural habitats are in danger.

A study from the Convention on Biological Diversity Secretariat (2018) says that “the Philippines is one of 18 mega-biodiverse countries of the world, containing two-thirds of the earth’s biodiversity and between 70% and 80% of the world’s plant and animal species” (p.1).

The Department of Environment and Natural Resources (2018) explained that “the Philippines continues to experience an alarming rate of destruction of these important resources brought about by overexploitation, deforestation, land degradation, climate change, and pollution (including biological pollution), among others” (p.13).

Furthermore, Nicer (2017) explained that “environmental degradation, abetted by incorrigible criminals and corrupt public officials, exacerbates natural calamities causing greater damage and a higher number of casualties are present in the Philippine situation on biodiversity” (para. 1).

Thus, the Philippines should have a pervasive resolution in the conservation and preservation of the natural resources of the country.

'Forest is one of the natural biodiversity habitats in the Philippines, including trees, plants, and animals. Food and Agriculture Organization- United Nations (nd) defined forest as “land with tree crown of more than 10 percent and area of more than 0.5 hectares (ha)” (para. 1).

However, Muller (2018) stated that the forest comprises trees, plants, and animals that make up a complicated and productive system.

A similar study explains:

> *“Forest ecological services are those ecological or ecological processes that benefit people directly. Some of the most important ecological facilities are: energy storage and sequestration, hydrological function preservation and protection and biodiversity conservation. Preservation and conservation of biodiversity starts in community-based activities (Hasan, 2018)” (p. 4).*

Therefore, programs and trusts of the government, especially the aligned agency, should be a bottom-up approach because people in the community are the doers of the government programs.

> *The Philippine Government should address the environmental issues to maintain and preserve biodiversity and increase the country's economic status. As stated in the Philippine Constitution, Article XI, Section 1--"Public office is a public trust. Public officers and employees must always be accountable to the*

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> *people, serve them with utmost responsibility, integrity, loyalty, and efficiency; act with patriotism and justice, and lead modest lives".*

There are many ways of facilitating trusts and programs as initiated by the government, one of which is using Information Technology.

Google Trends (2018) identified "the Philippines as top 16 out of 89 regions in the world which mainly use Information and Communication Technology; and Quezon City, Philippines tops number 4 out of the 30 cities worldwide". This means that the Philippines is included in terms of technology. It is alarming that these technologies may also be destructive because they can be facilitated as mechanisms for cybercriminals to destroy the community and the world.

Moreover, Alasaas, J., Navarro, S., and Buen, D. (2021) stated that adopting information technology will boost agricultural productivity. Providing the most recent data and inputs they need for decision-making can increase their productivity.

Trusts and programs of the government-initiated integration of Information technology for the different agencies in the Philippines. One of those initiatives is the E-Government Master Plan (EGMP).

> *"Department of Environment and Natural Resources is one of the agencies responsible and strategy for the environmental protection and conservation of natural resources of the country. Some of those strategies isthe E-Filing & Monitoring System (E-FMS*)" (para. 6).

Nicer (2016) explains that the "E-Filing & Monitoring System (E-FMS) on Illegal Logging & Wildlife (ILLWIL) Cases is a web-based application intended to systematize the recording and storage of Illegal Logging and Wildlife Cases filed in the Department of Environment and Natural Resources (DENR), Department of Justice (DOJ) and the courts throughout the country" (p. 23).

There is a big impact of Information Technology in all aspects of the world because of the huge number of internet users. Thus the development of a web-based inventory system is a need for the stakeholders of the Department of Environment and Natural Resources, foresters, forest landowners, the management, and the people towards an eco-friendly and pollution-free environment for the sustainability of wildlife and forest lands.

The study aimed to develop, design, and test a Strategic Forest Management Using a Decision Tree for the Department of Environment and Natural Resource - Abra Forest Land. Specifically, it sought to identify the challenges encountered by the agency participants in the existing system of strategic forest management. The researchers also proposed an algorithm to address the identified challenges and limitations for designing and developing a system for the DENR. The system was also evaluated using the ISO 20510 Software Quality standards. In validation, the researchers considered identifying the significant difference in the extent of compliance of the developed application to ISO 25010 Software Quality

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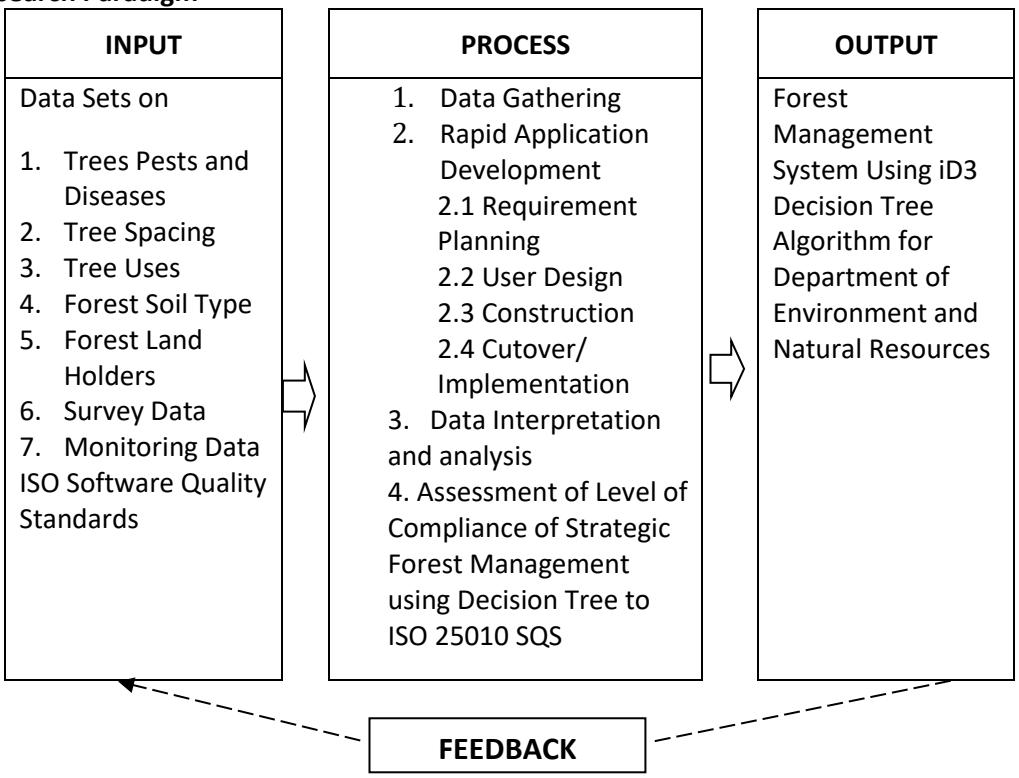
Assurance Standards as assessed by the IT Experts and users. Figure 1 shows the research paradigm.

Figure 1
Conceptual Paradigm of the Study

Research Paradigm



The researchers used the IPO model to represent the study's framework and realize the data needed for the study and the methodologies for data collection, development, and evaluation.

The input block contains the following: Data Sets on (1) Forest Land Owner, (2) Survey Data, (3) Monitoring Data, and (4) ISO Software Quality Standards. The data sets are gathered from the Office of the Provincial Environment and Natural Resources Office (PENRO) and the Community Environment and Natural Resources Office (CENRO- Bangued).

For the process, the researchers applied the phases of the Rapid Application Development methodology, which include requirements planning, user design, construction, and cutover phases.

Data Interpretation and analysis include getting the Mean of the gathered data from the Questionnaire on the Evaluation of the system using the ISO 25010 Software Quality Standards. Methods of Lamarca, Bryan Irvin & Ambat, Shaneth. (2018) is the same as the

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tool used for software quality assessment, the ISO/IEC 25010:2011, and the output of the study is Forest management using the decision tree.

METHODOLOGY

The researchers adopted the descriptive developmental type of research. They used this type of research because the instrumentation and data collection were done by employing interviews, questionnaires, and observation. The Systems Development Life Cycle served as a guide for the development of the system. It served as a blueprint for the study to answer the problems encountered in the operations and processes of the Department of Environment and Natural Resources. The Rapid Application Development (RAD) methodology was used for the study. Rapid Application Development suited the study because it is a user-centric software development life cycle and to accurately and quickly develop the system. It was used for the project because, among the other methodologies, it is the most appropriate one and could develop faster through more expedient processes. As stated by Quilon et al. (2019), RAD is best for the requirements of the development of web applications. The phases of RAD methodology are presented in figure 2. The presentation united distribution of the participants of the study is presented in table 1.

Table 1
Distribution of participants

Participants	Population	Percentage
PENRO	1	2.50
CENROs	2	5.00
Foresters	27	67.5
IT Experts	10	25.00
Total	40	100.00

Table 1 shows the distribution of participants, and convenience sampling was used to determine the participants. According to Lani (2018), the two most popular sampling techniques are purposeful and convenience sampling because they align the best across nearly all qualitative research designs.

Table 2
Numeric and equivalent rating for the evaluation of the deployed system

Numeric Value	Equivalent Rating
4.20 - 5.00	Very Great Extent
3.40 - 4.19	Great Extent
2.60 - 3.39	Moderate Extent
1.80 - 2.59	Little Extent
1.0 - 1.79	Very Little Extent

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The researcher identified forty (40) participants: PENRO (1), CENROs (2), Foresters (27), and IT experts (10) for the ISO 25010 Software Quality Standards Questionnaire with a numerical and equivalent rating, as shown in Table 2. The collected data were tabulated, analyzed, interpreted, and summarized using descriptive and inferential statistics. Weighted Mean and Independent Sample T-Test were used to help the researcher to get the independent sample T-test on the significant difference between IT experts and users on the ISO 25010 Software Quality Standards.

RESULTS AND DISCUSSIONS

Challenges Encountered by the Agency Participants on the Existing System regarding Strategic Forest Management.

Based on the interview conducted and observation, the researcher found four (4) significant challenges encountered by the agency on the existing system with regards to strategic forest management, which are (1) illegal activities, (2) monitoring and maintaining the project, (3) lack of trained personnel, and (4) manual record-keeping.

The ID3 Decision Tree Algorithm

The researcher utilized these tools to gather the most important data sets run on the ID3 decision tree algorithm. The researcher used an Informed Consent Form to ask for consent and approval for the data gathering of the study from the participants, who were the foresters, PENRO and CENROs.

From the decision tree analysis of the data gathered on diseases, uses, spacing, soil type, forest landholders, survey, and monitoring data, the researcher was able to derive important information such as suitable plants to be planted in a particular season or month, temperature, elevation and uses of trees. In this process, the researcher came up with the integration of machine learning because, based on the present data, the system can analyze output given to the foresters and the forest holders. Finally, these are used for the decision of both the CENROs and the PENRO of the province.

The researchers developed the forest management system by integrating the ID3 Decision Tree Algorithm. According to the study of Rakesh et al. (2011), ID3 has become a common factor for comparison in machine learning research because it produces good classifiers quickly. This study also mentioned that the ID3 works efficiently with non-numeric and categorical datasets. In another study by Venkatesan (2015), it was stated that implementing the ID3 algorithm using non-numerical and categorical datasets is easy to interpret and contributes to improved decision support. Based on these related works of literature of the study that the algorithm on ID3 is appropriate for the development of the system.

The researchers found problems with the office's record management and decision support. They decided to use the ID3 algorithm to help the office to solve the problems that the office is facing. The algorithm also helped the end user to make decisions based on their data. Using the algorithm provides a basis for them to formulate the much-needed situation.

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The researchers used the concept of the Decision Tree, particularly ID3. The Decision Tree algorithm is a member of the supervised learning algorithm family. In contrast to supervised learning algorithms, the decision tree algorithm can also solve regression and classification problems.

Inputs from users are stored in the system's database to be utilized for the decision tree algorithm of the system. ID3 (Iterative Dichotomiser 3) is used to ensure the quality output of the system. The decision tree output is shown employing the records extracted from the system, wherein the admin and user can view them. However, before the output is shown, the admin or the users must set the criteria for determining the nodes needed and identify the needed information for extraction. The system used these criteria to get the data from the database and show the result in tabular form so that the analysis and interpretation of the output would be easier. The output will then be the basis for making decisions like what species to be planted in particular soil types, uses, and even diseases or pests that might affect the trees.

Figure 2

ID3 decision tree algorithm system

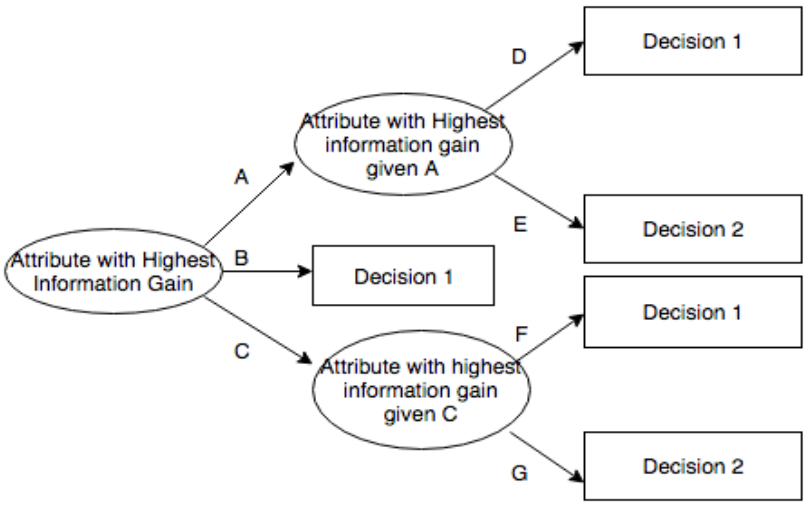

Figure 2 describes the ID3 algorithm of the proposed system. The records to generate the decision trees were based on the current record about different species of trees, what soil type to use, and what pest or disease might affect them in the future. This record was collected from the DENR Central Office and Abra office and stored in a database. The researcher also created a mechanism for adding or updating the records so that the algorithm will be more flexible when dealing with new data or changes.

To determine when to use the ID3, these are the following reasons:

1. The most common reason to use a Decision Tree is the realization that Naive Bayes does not satisfy one's goal. Everybody knows that it is naive to see all features as independent variables.

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2. If there are categorical data, for example, hot, mild, and cold.
3. If there are attribute-value pairs data, for example, an attribute 'temperature' may have some discrete values 'hot,' 'mild,' and 'winter.'
4. If the objective value has discrete output values, for example, 'yes' or 'no,.'

Table 3
Decision tree

No	Tree	Soil Type	Uses	Type	Decision to Plant
1	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	No
2	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Fruit Bearing	No
3	Marang	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	Yes
4	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Lumber	Yes
5	Apitong	Light to medium soil type	For Erosion control	Lumber	Yes
6	Apitong	Light to medium soil type	For Erosion control	Fruit Bearing	No
7	Marang	Light to medium soil type	For Erosion control	Fruit Bearing	Yes
8	Tagibokbok	Rocky thin material soils and alluvial soils	For Plywood	Lumber	No
9	Tagibokbok	Light to medium soil type	For Erosion control	Lumber	Yes
10	Apitong	Rocky thin material soils and alluvial soils	For Erosion control	Lumber	Yes
11	Tagibokbok	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes
12	Marang	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes
13	Marang	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	Yes
14	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Fruit Bering	No

The goal of the ID3 Decision Tree Algorithm is to produce new knowledge from the datasets which are available from the database.

Table 4 shows the following tree information about decision-making factors for planting trees in different soil types.

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ID3 algorithm can be summarized as illustrated below.

$$\text{Entropy}(S) = \sum - p(I) * \log_2 p(I)$$

$$\text{Gain}(S, A) = \text{Entropy}(S) - \sum [\, p(S|A) * \text{Entropy}(S|A)]$$

Entropy must first be calculated. The decision column consists of 14 instances and includes two labels: yes and no. There are 9 decisions labeled yes and 5 decisions labeled no.

$$\text{Entropy (Decision)} = - p(\text{Yes}) * \log_2 p(\text{Yes}) - p(\text{No}) * \log_2 p(\text{No})$$

$$\text{Entropy (Decision)} = - (9/14) * \log_2 (9/14) - (5/14) * \log_2 (5/14) = 0.940$$

(1)

Type factor on the decision

$$\text{Gain (Decision, Type)} = \text{Entropy (Decision)} - \sum [\, p(\text{Decision}|\text{Type}) * \text{Entropy (Decision}|\text{Type})]$$

Type attribute has two labels: lumber and fruit-bearing. We would reflect it in the formula.

$$\text{Gain (Decision, Type)} = \text{Entropy (Decision)} - [\, p(\text{Decision}|\text{Type=Lumber}) * \text{Entropy (Decision}|\text{Type=Lumber}] - [\, p(\text{Decision}|\text{Type=Fruit Bearing}) * \text{Entropy(Decision}|\text{Type=Fruit Bearing})\,]$$

Calculate (Decision|Type=Lumber) and (Decision|type=Fruit Bearing), respectively.

(2)

Table 4

Lumber type factor on decision

No	Tree	Soil Type	Uses	Type	Decision to Plant
1	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	No
3	Marang	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	Yes
4	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Lumber	Yes
5	Apitong	Light to medium soil type	For Erosion control	Lumber	Yes
8	Tagibokbok	Rocky thin material soils and alluvial soils	For Plywood	Lumber	No
9	Tagibokbok	Light to medium soil type	For Erosion control	Lumber	Yes
10	Apitong	Rocky thin material soils and alluvial soils	For Erosion control	Lumber	Yes
13	Marang	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	Yes

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There are 8 instances for the Lumber type. The decision of 2 items is no, and 6 is yes, as illustrated below.

1- Entropy (Decision|Type=Lumber) = – p(No) * $\log_2$p(No) – p(Yes) * $\log_2$p(Yes)

2- Entropy (Decision|Type=Lumber) = – (2/8) * $\log_2$(2/8) – (6/8) * $\log_2$(6/8) = 0.81128 (3)

Table 5

Fruit bearing type factor on decision

No	Tree	Soil Type	Uses	Type	Decision to Plant
2	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Fruit Bearing	No
6	Apitong	Light to medium soil type	For Erosion control	Fruit Bearing	No
7	Marang	Light to medium soil type	For Erosion control	Fruit Bearing	Yes
11	Tagibokbok	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes
12	Marang	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes
14	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Fruit Bering	No

Here, there are 6 instances for Fruit Bearing Type. Decision is divided into two equal parts.

1- Entropy (Decision Wind=Strong) = – p(No)* $\log_2$p(No) – p(Yes)* $\log_2$p(Yes)

2- Entropy (Decision Wind=Strong) = – (3/6)* $\log_2$(3/6) – (3/6)* $\log_2$(3/6) = 1

Now, turn back to Gain (Decision, Type) equation.

Gain (Decision, Type) = Entropy (Decision) – [p(Decision|Type=Lumber) * Entropy (Decision|Type=Lumber)] – [p(Decision|Type=FruitBearing)* Entropy (Decision|Type=Fruit Bearing)] = 0.940 – [(8/14) . 0.811] – [(6/14). 1] = 0.048

Calculations for the type column are over. Now, apply the same calculations for other columns to find the most dominant factor on decision.

Other factors on decision

Similar calculations on the other columns have been applied.

1- Gain (Decision, Tree) = 0.246

2- Gain (Decision, Soil Type) = 0.029

3- Gain (Decision, Use) = 0.151

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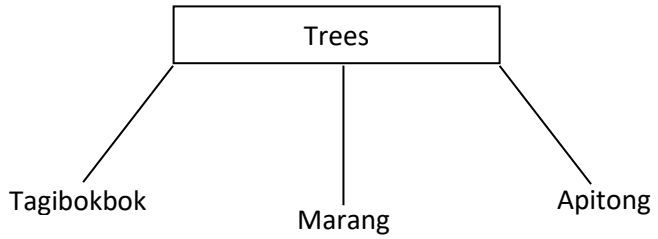
As seen, Tree factor on decision produces the highest score. That's why Tree decision will appear in the root node of the tree.

Marang Tree on decision



Basically, the decision will always be yes if Tree was Marang.

Table 6
Marang tree on decision

No	Tree	Soil Type	Uses	Type	Decision to Plant
3	Marang	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	Yes
7	Marang	Light to medium soil type	For Erosion control	Fruit Bearing	Yes
12	Marang	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes
13	Marang	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	Yes

Table 7
Tagibokbok tree on decision – Part 1

No	Tree	Soil Type	Uses	Type	Decision to Plant
1	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	No
2	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Fruit Bearing	No
8	Tagibokbok	Rocky thin material soils and alluvial soils	For Plywood	Lumber	No
9	Tagibokbok	Light to medium soil type	For Erosion control	Lumber	Yes
11	Tagibokbok	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes

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Here, there are 5 instances for sunny outlook. Decision would be probably 3/5 percent no, 2/5 percent yes.

1- Gain (Tree=Tagibokbok|Soil Type) = 0.570
2- Gain (Tree=Tagibokbok|Uses) = 0.970
3- Gain (Tree=Tagibokbok|Type) = 0.019
(4)

Now, Uses is the decision because it produces the highest score if Tree were Tagibokbok.

At this point, the decision will always be no if Uses were for Plywood.

Table 8
Tagibokbok tree on decision-Part 2

No	Tree	Soil Type	Uses	Type	Decision to Plant
1	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Lumber	No
2	Tagibokbok	Sandy clay loam and shallow alluvial soils	For Plywood	Fruit Bearing	No
8	Tagibokbok	Rocky thin material soils and alluvial soils	For Plywood	Lumber	No

On the other hand, the decision will always be yes if Uses were for erosion control.

Table 9
Tagibokbok Tree on Decision- Part 3

No	Tree	Soil Type	Uses	Type	Decision to Plant
9	Tagibokbok	Light to medium soil type	For Erosion control	Lumber	Yes
11	Tagibokbok	Rocky thin material soils and alluvial soils	For Erosion control	Fruit Bearing	Yes

Finally, it means that we need to check the Uses and decide if trees were Tagibokbok.

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Table 10
Apitong tree on decision

No	Tree	Soil Type	Uses	Type	Decision to Plant
4	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Lumber	Yes
5	Apitong	Light to medium soil type	For Erosion control	Lumber	Yes
6	Apitong	Light to medium soil type	For Erosion control	Fruit Bearing	No
10	Apitong	Rocky thin material soils and alluvial soils	For Erosion control	Lumber	Yes
14	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Fruit Bering	No

1- Gain (Tree=Apitong | Soil Type)
2- Gain (Tree=Apitong |Use)
3- Gain (Tree=Apitong | Type)

(5)

Here, wind produces the highest score if tree were apitong. That is why we need to check the type attribute in 2nd level if tree were apitong.

So, it is revealed that the decision will always be yes if type were lumber and tree were apitong.

Table 11
Apitong tree on decision

No	Tree	Soil Type	Uses	Type	Decision to Plant
4	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Lumber	Yes
5	Apitong	Light to medium soil type	For Erosion control	Lumber	Yes
10	Apitong	Rocky thin material soils and alluvial soils	For Erosion control	Lumber	Yes

The decision will be always no if type were fruit bearing and tree were apitong.

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Table 12
Apitong tree on decision

No	Tree	Soil Type	Uses	Type	Decision to Plant
6	Apitong	Light to medium soil type	For Erosion control	Fruit Bearing	No
14	Apitong	Rocky thin material soils and alluvial soils	For Plywood	Fruit Bearing	No

So, decision tree construction is over. The following rules for decision-making can be used. The algorithm helps the end user to make decisions based on their data. Using the algorithm will provide the needed basis for them to formulate the much-needed situation. The SFM in Addressing the Identified Problems and Issues in the Existing System With the challenges encountered by the researcher, a forest management system using the ID3 decision tree algorithm was developed to address the above-stated challenges of the existing system. The forest management system had undergone systematic development after thorough research on the related works of literature and interviews of the end users of the existing system. These guided the researcher in identifying features as well as algorithms of the forest management system. In the development of the system, Codeigniter Framework, Hypertext Mark Up Language (HTML)\Bootstrap, MySQL, and XAMPP were utilized. Logical design using the Unified Modeling Language (UML) diagrams to view the logical concept of the system.

Features of the Forest Management System

The features of the SFM include primary features such as (1) Security Mechanism, (2) Admin Dashboard, (3) Holders, (4) Tenure Class, (5) Holder Search, (6) Property, (7) Add Tree Disease, (8) Add Tree Uses, (9) Tree Information, (10) Tree Summary, (11) Tree Summary (12) Account Management, and (13) Accessibility.

Extent of compliance of the developed application to ISO 25010 Software Quality Standards

The summary of the evaluation of each factor given by the participants, both the Foresters and IT Experts evaluators garnered a descriptive evaluation of “Very Great Extent”. The extent of compliance to ISO: 25010 SQS is proven, and therefore, indicates the readiness of the system for deployment.

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Table 13
Summary of the system extent of compliance to ISO 25010: SQS

Factors	Mean		Desc
	Forester	IT Expert	
Functional Suitability	4.63	4.73	VGE
Performance Efficiency	4.57	4.63	VGE
Compatibility	4.67	4.70	VGE
Usability	4.63	4.53	VGE
Reliability	4.68	4.65	VGE
Security	4.68	4.70	VGE
Maintainability	4.74	4.90	VGE
Portability	4.78	4.67	VGE
Overall Mean	**4.67**	**4.69**	**VGE**

With an overall rating of 4.67 as evaluated by the Foresters and 4.69 as evaluated by IT experts, the developed system has an overall descriptive evaluation of "Very Great Extent". The extent of compliance to ISO:25010 SQS is proven, and, therefore, indicates the readiness of the system for deployment. The summary of the test results is shown in Table 14.

Table 14
Tagibokbok tree on decision

ISO 25010 Quality Standards	Participant	Mean	SD	T-Test Value	P-Value	Remarks
Functional Sustainability	IT Expert	4.73	.3784	.865	.393	NS
	Forester	4.63	.2949			
Performance Efficiency	IT Expert	4.63	.3991	.472	.640	NS
	Forester	4.57	.3831			
Compatibility	IT Expert	4.70	.4743	-.113	.911	NS
	Forester	4.67	.3790			
Usability	IT Expert	4.53	.3752	-.973	.337	NS
	Forester	4.63	.2453			
Reliability	IT Expert	4.65	.4116	-.285	.777	NS
	Forester	4.68	.2857			
Security	IT Expert	4.70	.4830	.665	.510	NS
	Forester	4.68	.5683			
Maintainability	IT Expert	4.90	.3810	-.512	.611	NS
	Forester	4.74	.4068			
Portability	IT Expert	4.78	.3094	.316	.754	NS
	Forester	4.67	.3147			

Significant Difference in the Assessment of the Participants on the Extent of Compliance of the SFM to ISO 25010 Software Quality standards as assessed by the IT Expert and Users

Table 14. T-Test for Significant Difference in the Assessment of the Participants in the Extent of Compliance of the Strategic Forest Management using Decision Tree to ISO 25010 Software Quality standards as assessed by the IT Experts and Users.

Table 9 reveals that in all the areas of the ISO 25010 Software Quality Standards, all of the probability values are higher than 0.05 level of significance, which means that there is no significant difference between the foresters' and the IT experts' evaluation of the developed system's extent of compliance with the eight attributes or requirements. In other words, their assessment of the extent of the Strategic Forest Management using decision tree compliance with ISO 25010 Software Quality Standards is the same regardless of whether they were IT experts or foresters.

Enhancement can be done to improve the proposed system.

Participants of the study gave feedback and suggestions for improving the SFM. The researcher recommends enhancing the network infrastructure so that the connectivity be improved to facilitate the needs of the SFM. Data on the monitoring, survey, and inventory should be recorded more on the database of the system so that the system will run effectively and efficiently because it needs more data for the accuracy of reports of the SFM. The researchers recommend purchasing a drone that can measure height, and width and has the feature of image recognition. This is, therefore, reconsidered to deploy the system soon. Those are some of the suggestions taken from the evaluation questionnaire by the researcher given by both users and IT experts.

CONCLUSIONS

The following conclusions were made based on the study's results. The Forest Management System was found to be ISO 25010 compliant by the end users and system evaluators and is ready for deployment. The features of the system are useful for the end users because of the data stored in the system, which they can manage to make important decisions like trees to be planted on different types of soil and providing important information about the different diseases that might affect the growth of the trees and how to avoid them. The system also provides a mechanism to notify the end users when they will be able to harvest the trees.

RECOMMENDATIONS

Based on the results presented and the conclusion drawn, the researchers offer the following recommendations: The Department of Environment and Natural Resources Provincial Office may adopt and deploy Strategic Forest Management using Decision Tree to boost the different processes done by the office. DENR employees may spearhead the conduct of seminar workshops and training to familiarize themselves with using the system. The DENR Provincial Office may also consider purchasing a drone that can measure the width

and has the feature of image recognition and sensor to evade obstacles. Lastly, the DENR Provincial Office may also acquire the latest model of computer and networking equipment to improve the performance of the developed system further.

ETHICAL STATEMENT

The University of Northern Philippines Ethics Review Committee reviewed and approved this study. Ethical principles observed in the study include the conflict of interest, the principle of informed consent, privacy and confidentiality, vulnerability, recruitment, benefits, compensation, and community considerations.

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