DEVELOPMENT OF SEMANTIC-WEB BASED FOREST RESOURCES DATABASE

Joseph Adeabah\textsuperscript{1} and Lanre Okoh\textsuperscript{2}

\textsuperscript{1}Affiliation not available
\textsuperscript{2}UE20005915

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DEVELOPMENT OF SEMANTIC WEB BASED FOREST RESOURCES DATABASE

BY:

LANRE OKOH

(UE20005915)

JOSEPH ADEABAH

(UE20000815)

KWOFIE BERNARD EDWINE

(UE20004915)

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DECLARATION
We, LANRE OKOH, ADEABAH JOSEPH, and KWOFIE BERNARD EDWINE declare that this, submission is our own work towards the award of a BSC. Computer Science degree, and that to the best of our knowledge, it contains no material previously published by another person nor any material which has been accepted for the award of any other degree of the university, except where due acknowledgement has been made in the text.

LANRE OKOH
(UE20005915) 
………..…….. 
(DATE) (SIGNATURE)

JOSEPH ADEABAH
(UE20000815) 
………..…….. 
(DATE) (SIGNATURE)

KWOFIE BERNARD EDWINE
(UE20004915) 
………..…….. 
(DATE) (SIGNATURE)

PROF. ADEBAYO FELIX ADEKOYA
SUPERVISOR
………..…….. 
(DATE) (SIGNATURE)

DR BENJAMIN ASUBAM WEYORI
(HEAD OF DEPARTMENT) 
………..…….. 
(DATE) (SIGNATURE)
DEDICATION

We dedicate this final year project work to the Almighty God who graciously granted us life, wisdom, knowledge, and inspiration to undertake this project. We also dedicate this work to our project supervisor. Again, to our parents and guardians; Mr. Anthony Okoh and Madam Suzie Arthur, Mr. Benjamin Ansah and Mr. Samuel Ansah Adeabah and Mr. and Mrs. Kwofie for their endless support and provision in terms finances, encouragement, love and support.
ACKNOWLEDGEMENT

We would like to express our great appreciation and gratitude to our supervisor Professor Adebayo Felix Adekoya for his valuable and constructive criticisms and suggestions during the planning and development of this research work. He generously gave us his time and we must say without him it would have been impossible to finish this work. His Contribution has been very much appreciated. We would also like express our profound appreciation to Pastor Anthony Baidoo of the natural Resource Department for his assistance in the gathering of information for our work.
ABSTRACT

There are some forest resources (such as Trees, Shrubs, and Water bodies) in the university main campus. These resources are used for various purposes ranging from teaching, researches medicinal and domestic purposes and among many others. However, there is no record of official documentation on them. Thus this study aim to provide a semantic-web based database system for efficient management of forest resources. We adopted the W3C semantic web framework in the design and development of this work. Specifically we focused on the layers 1 to 5 of the framework. The layers include; Resource Description Framework (RDF), Web Ontology Language (OWL), Extensible Markup Language (XML), User Interface). The Uschold’s and Kings’ method was applied in creating the ontology. The implementation process was carried out by populating the database with the Taxonomies of the Trees on University of Energy and Natural Resources (U.E.N.R) campus by means of creating an Ontology File using protégé. Some of the basic information that we provided by the proposed semantic web database include trees, their scientific name, geographical coordinate, physical location, medicinal value and other important data. We performed alpha test by involving six senior forest science students who used the application, evaluated it and came out with a good results which is shown in the chapter four of this documentation.
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CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND

A forest is a complex ecosystem which is predominantly composed of trees, shrubs and is usually a closed canopy. Forests are storehouses of a large variety of life forms such as plants, mammals, birds, insects and reptiles etc. Also the forests have abundant microorganisms, which do the important work of decomposing dead organic matter thereby enriching the soil. Nearly 4 billion hectares of forest cover the earth’s surface, roughly 30 percent of its total land area. The forest ecosystem has two components- the non-living (abiotic) and the living (biotic) component. Climate, soil type are part of the non-living component and the living component includes plants, animals and other life forms. Plants include the trees, shrubs, climbers, grasses and herbs in the forest. Depending on the physical, geographical, climatic and ecological factors, there are different types of forest like evergreen forest (mainly composed of evergreen tree species i.e. species having leaves all throughout the year) and deciduous forest (mainly composed of deciduous tree species i.e. species having leaf-fall during particular months of the year). Each forest type forms a habitat for a specific community of animals that are adapted to live in it. The word “Forest” can be described as a dense growth of trees and shrubs covering a large area. The definition of Forest is as ambiguous as its diversity in terms of types, species, Composition, goods and services it provides, etc. Forest types differ widely; they are determined by factors including latitude, temperature, rainfall patterns, soil composition and human activity. Forest are one of the dominant components of the natural environments with
a basic influence on the quality of the environment of the human population. However, their condition is not good. They are degraded and devastated by the effect of anthropic activities of society. The commercial production of wood was a priority for a number of centuries and forestry is ranked among industrial sectors. A modern ecosystem conception state that forest are on the level of natural systems, that is subsistence life-giving resources even for the human society. Forests hold great value in every local community and in the global world. A landscape without forests will greatly harm human health as one of the essential elements that take carbon dioxide from the atmosphere and produces oxygen for the living. Forest is not only vital to human life, but also important for the survival of other non-human lives and species that depend on the forest environment for survival. Forests should be looked upon not simply for its useful value but for it intrinsically value (Anthwala, 2010). With regards to Africa which has a tropical rain forest, its forest is in the low latitudes with heavy and regular rainfall and high temperatures (Anizoba, 2005). The African forest is filled with thousands of species ranging from trees, shrubs, parasites, animals, humans, other living organisms, and a gorgeous landscape. The forest is considerable value for Africa as other regions that have forests as it provides food resources, wood for various human ventures, abode for animals, leisure, temperature control, and improve climate change (Muck, 2005). Ghana, has a total land mass of 239,460 km2 lying between latitude 11.50N and 4.50S and longitude 3.50W and 1.30E. Ecologically, the country is made of three broad zones namely, the high-forest in the south (rain and deciduous forest), accounting for about one-third of the land area (8.2 million hectares), a savanna (15.7 million hectares – Coastal, Guinea and Sudan savannah), and a transition zone (1.1 million hectares1 mostly semi-deciduous forest in the middle belt(Oduro, Mohren, Peña-Claros, Kyereh, & Arts, 2015). Based on the global forest resource assessment
category, three land cover classifications are identified in Ghana as Forests, Other Lands, and Water. The forest area covers 39 percent of the landmass and it includes land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent or trees able to reach these thresholds insitu. It does not include land that is predominantly under agricultural or urban land use. The Other Lands cover 56 percent of the land area and is predominantly agricultural and/or urban land use and have patches of tree cover that span more than 0.5 hectares with a canopy cover of more than 10 percent of trees able to reach a height of 5 meters at maturity. It includes both forest and non-forest tree species. The water covers 5 percent of the landmass and it is made up of inland water bodies including major rivers, lakes, and water reservoirs. (Ghana Forestry Commission 2016-2036).

**FIGURE 1.0 Ecological Zones in Ghana**
Utilizing Landsat imageries over the last one and half decades, the land-cover map of Ghana shows an increasing forest cover of 0.3 per cent annually as summarized in Table 1 (FPP Report, 2015). The increasing forest cover may be the results of national afforestation program, natural regeneration, and significant reduction in the incidence of forest fires. However, the increase in forest cover cannot be translated to mean improved quality of the forest since deforestation rates and illegal forest operations are seemingly high.

Table 1: Land cover classification of Ghana (1990 -2015)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>8,627,401.9</td>
<td>8,908,607</td>
<td>9,053,360</td>
<td>9,195,137</td>
<td>9,294,349</td>
</tr>
<tr>
<td>Other land</td>
<td>14,126,598.1</td>
<td>13,845,393</td>
<td>13,700,640</td>
<td>13,558,863</td>
<td>13,459,651</td>
</tr>
<tr>
<td>Water</td>
<td>1,100,000</td>
<td>1,100,000</td>
<td>1,100,000</td>
<td>1,100,000</td>
<td>1,100,000</td>
</tr>
<tr>
<td>Total</td>
<td>23,854,000</td>
<td>23,854,000</td>
<td>23,854,000</td>
<td>23,854,000</td>
<td>23,854,000</td>
</tr>
</tbody>
</table>

Source: Global Forest Resources Assessment (2015)
1.1 PROBLEM STATEMENT

There are some forest resources (such as Trees, Shrubs, and Water bodies) in the university main campus. These resources are used for various purposes ranging from teaching, researches medicinal and domestic purposes and among many others. However, there is no record of official documentation on them. Thus this study aim to provide a semantic-web based database system for efficient management of forest resources data.

1.2 GENERAL OBJECTIVES OF STUDY

The general objective of this study is to develop a structured forestry database semantic web technology.

1.3 SPECIFIC OBJECTIVES OF STUDY

Developing a forest resource database using semantic web technology

- Creating taxonomy of trees in U.E.N.R forest resources database using ontological engineering.
- Design conceptual framework for forest resource database.
- Implement and evaluate the design.
1.4 SIGNIFICANCE OF STUDY

The semantic web base forest resource database will provide support for undertaken research and improve the teaching and learning of forest science.

The database will serve as a reference material for interested individuals who would want to acquire knowledge in the field of forestry and in the use of structured forest resource database.

Discoveries in this research will add to the body of knowledge in Forestry resources management.

1.5 ORGANIZATION OF WORK

This research work is categorized into five chapters. Chapter one deals with the introductory aspects of the research study, which includes the background of the study, objectives, statement of the problem, importance of the study, constraints of the study. Chapter two of the study is the review of literature written by the semantic web community. Chapter Three is methodology; it talks about the methods employed to design the project. This chapter also discusses the approach and some frameworks to be adopted in the project development. This chapter further explains the hardware and software requirement of the system. Chapter Four is implementation and testing of the project. This chapter will briefly summarize the proposed project. This chapter describes the architecture of the project. Chapter Five draws conclusions and summaries from the research work as well as suggest directions for future works.
CHAPTER TWO

LITERATURE REVIEW

2.0 OVERVIEW

The semantic web is now a new web technology that is massively evolving as a new web technology. It recently gained a lot of attention as a potential replacement for our traditional web pages. (Boer, 2012). In our research, we are looking into how linked Open data as a method can be used to interlink forest resources data to achieve the semantic web base database. This method (linked open data) will enable us to easily create a structured data that will be available in machine and human readable format. In other words, it will be useful, more convenient for human readability. The future result of our work is going to be an aggregated biological structured data that will store the linked dataset about the collective forest resources. Our application will allow other researchers and professionals to make a good meaning of forest resources typically on plants that exist in the forest areas.

2.1 Forest Resources

The word “Forest” can be described as a dense growth of trees and shrubs covering a large area. The definition of Forest is as ambiguous as its diversity in terms of types, species, Composition, goods and services it provides, etc. Forest types differ widely, they are determined by factors including latitude, temperature, rainfall patterns, soil composition and human activity. (Equatoria, 2008) Forest are one of the dominant components of the natural environments with a basic influence on the quality of the environment of the human population. However, their condition is not good. They are degraded and devastated by the effect of anthropic activities of society. The
commercial production of wood was a priority for a number of centuries and forestry is ranked among industrial sectors. A modern ecosystem conception states that forests are on the level of natural systems, that is subsistence life-giving resources even for the human society. (Equatoria, 1989)

2.1.1 Components of Forest Resources

A forest is made up of many layers. Starting from the ground level and moving up, the main layers of all forest types are the forest floor, the understory and the canopy. The emergent layer exists in tropical rainforests. Each layer has a different set of plants and animals depending upon the availability of sunlight, moisture and food (Carandang, 2005).

Forest floor contains decomposing leaves, animal droppings, and dead trees. Decay on the forest floor forms new soil and provides nutrients to the plants. The forest floor supports ferns, grasses, and mushroom and tree seedlings.

Understory is made up of bushes, shrubs, and young trees that are adapted to living in the shades of the canopy.

Canopy is formed by the mass of intertwined branches, twigs and leaves of the mature trees. The crowns of the dominant trees receive most of the sunlight. This is the most productive part of the trees where maximum food is produced. The canopy forms a shady, protective "umbrella" over the rest of the forest.

Emergent layer exists in the tropical rain forest and is composed of a few scattered trees that tower over the canopy. As the demand for natural resources increases, rain forests are cut down. The land is cleared for farming, mining, ranching, and timber projects. When the rain forest environment is
destroyed, the plants, animals, and people that live in the rain forests are also harmed. The rain forests have many valuable resources. (Strategy et al., 2004)

2.1.2 Types of Forest Resources

There are two major types of forests resources, classed according to latitude:

**Tropical:**

Tropical forests are characterized by the greatest diversity of species. They occur near the equator, within the area bounded by latitudes 23.5 degrees N and 23.5 degrees S. One of the major characteristics of tropical forests is their distinct seasonality: winter is absent, and only two seasons are present (rainy and dry). The length of daylight is 12 hours and varies little. Temperature is on average 20-25° C and varies little throughout the year: the average temperatures of the three warmest and three coldest months do not differ by more than 5 degrees. Precipitation is evenly distributed throughout the year, with annual rainfall exceeding 200 cm. Soil is nutrient-poor and acidic. Decomposition is rapid and soils are subject to heavy leaching. Canopy in tropical forests is multilayered and continuous, allowing little light penetration (Acheampong & Marfo, 2011). Flora is highly diverse: one square kilometer may contain as many as 100 different tree species. Trees are 25-35 m tall, with buttressed trunks and shallow roots, mostly evergreen, with large dark green leaves. Plants such as orchids, bromeliads, vines (lianas), ferns, mosses, and palms are present in tropical forests. Fauna include numerous birds, bats, small mammals, and insects. Further subdivisions of this group are determined by seasonal distribution of rainfall:

Evergreen rainforest: no dry season.
Seasonal rainforest: short dry period in a very wet tropical region (the forest exhibits definite seasonal changes as trees undergo developmental changes simultaneously, but the general character of vegetation remains the same as in evergreen rainforests).

Semi evergreen forest: longer dry season (the upper tree story consists of deciduous trees, while the lower story is still evergreen).

Moist/dry deciduous forest (monsoon): the length of the dry season increases further as rainfall decreases (all trees are deciduous).

More than one half of tropical forests have already been destroyed.(Acheampong & Marfo, 2011)

2.1.3 Temperature

Temperate forests occur in eastern North America, northeastern Asia, and western and central Europe. Well-defined seasons with a distinct winter characterize this forest biome. Moderate climate and a growing season of 140-200 days during 4-6 frost-free months distinguish temperate forests. Temperature varies from -30° C to 30° C. Precipitation (75-150 cm) is distributed evenly throughout the year. Soil is fertile, enriched with decaying litter. Canopy is moderately dense and allows light to penetrate, resulting in well-developed and richly diversified understory vegetation and stratification of animals. Flora is characterized by 3-4 tree species per square kilometer. Trees are distinguished by broad leaves that are lost annually and include such species as oak, hickory, beech, hemlock, maple, basswood, cottonwood, elm, willow, and spring-flowering herbs.(Ministry of Lands and Natural Resources, 2012) Fauna is represented by squirrels, rabbits, skunks, birds, deer, mountain lion, bobcat, timber wolf, fox, and black bear. Further subdivisions of this group are determined by seasonal distribution of rainfall:
Moist conifer and evergreen broad-leaved forests: wet winters and dry summers (rainfall is concentrated in the winter months and winters are relatively mild).

Dry conifer forests: dominate higher elevation zones; low precipitation.

Mediterranean forests: precipitation is concentrated in winter, less than 100 cm per year.

Temperate coniferous: mild winters, high annual precipitation (greater than 200 cm).

Temperate broad-leaved rainforests: mild, frost-free winters, high precipitation (more than 150 cm) evenly distributed throughout the year. Only scattered remnants of original temperate forests remain. The forests are used for variety of purposes like fuel, timber, pasture, shifting cultivation, shingles, splinters, medicine, dyes, water and religious activities. Forests are an extremely important natural resource that can potentially be sustainably harvested and managed to yield a diversity of commodities of economic importance. Wood is by far the most important product harvested from forests. The wood is commonly manufactured into paper, lumber, plywood, and other products. They help us breathe. Forests pump out oxygen we need to live and absorb the carbon dioxide we exhale (or emit). Phytoplankton are more prolific, providing half of Earth's oxygen, but forests are still a key source of quality air. Forests provide an array of benefits to human societies above and beyond their pivotal roles as habitat and environmental regulators in natural ecosystems. (Conservation, 2006) These benefits are often described as resources that people can draw upon for fuel, lumber, and recreational or commercial purposes. The perception that forests provide resources for people has been a prominent factor in spurring efforts to preserve forests.(N. Resources, 2016)
2.1.4 Harmful Effects of Deforestation

Deforestation is a global menace which has received much public attention in most countries in recent years. The international community, governments at national level, NGOs, and other such organizations are raising awareness about the dangerous consequences of forest loss to the environment and hence humanity. (Food and Agriculture Organization of the United Nations, 2015) The FAO 2010 report revealed an alarming rate of deforestation with a global loss of around 13 million hectares of forest each year in the last decade (2000 to 2010). This deforested area is more than half the total area of Ghana. The report indicated that Africa has the second highest rate of deforestation worldwide (with 3.4 million hectares of forest loss annually). The situation is not any different in Ghana where forest has been under pressure from human activities over the last century (Oduro et al., 2015).

This article seeks to highlight the state of Ghana’s forest resource, considering trends over the past 100 years. The article will also briefly discuss the causes of deforestation and present some suggested solutions.

Degradation and deforestation may be familiar to workers and students in forestry, but probably not to all. Deforestation is defined as the conversion of forest to non-forest land uses. (N. Resources, 2016) this means that if a land previously occupied by forest is cleared for agriculture or a building project, then deforestation would have occurred. Degradation however refers to any activity that affects the quality of the forest. For example, bush fires may cause degradation but may not necessarily result in deforestation. By FAO definitions, an area is considered to be forest if it covers an area greater than 0.5 hectares, and has 10% or more tree crown cover. In turn, trees can be defined as having a single stem and the potential to reach a minimum height of 2-5 meters.
at maturity. An alternative definition is that it is possible to climb a tree at maturity, in comparison to shrubs which cannot be climbed (Strategy et al., 2004).

2.1.4.1 Deforestation Rates

Total land area of Ghana is about 23.85 million hectares. At the beginning of the last century, about one-third (i.e. 8.2 million hectares) of the area was covered by high forest while the remaining two-thirds (15.7 million hectares) was savanna woodland (Ministry of Lands and Natural Resources, 2012). The area of high forest (off reserve) has drastically reduced and the only remaining portions today are mainly in protected areas. Records show that at the turn of the last century, Ghana had about 8.8 million ha of primary forest. By 1950, the area had been reduced to 4.2 million ha and further to about 1.5 million ha by 1999. This implies that from 1900 to 1950, the nation lost 50% of its primary forest cover and also lost 60% of it between 1950 and 1999. On a 100 year scale (1900 to 2000), the nation lost over 80% of the closed forest (a reduction from 8.8 million ha to 1.5 million ha). (Farrhead and Leach, 1998) Estimated the deforestation rate to be a massive 22,000 ha per year around the late 90’s. From some more recent trends, Mongabay.com reported that, between 1990 and 2000, the average annual deforestation rate was 1.82%. Also, between 2000 and 2005, the rate of forest change increased by 4.2% to 1.89% per annum. The recent FAO 2010 report has estimated Ghana’s deforestation at 135 395 ha per year. (N. Resources, 2016)
2.1.4.2 Causes of Deforestation

According to Nsenkyire (1998), the main causes in Ghana are:

i. Forest clearance for cocoa and food crop farms.

ii. Logging (both legal and illegal). Illegal logging is a major cause of deforestation, depriving the Ghanaian economy of fiber, legal employment and tax revenues. This is done by selfish people who try and keep all the benefits away from the nation. Legal logging could also still be harmful to forest if not done in environmentally friendly ways. Clearance of forest for agriculture is the leading cause of deforestation not only in Ghana but in the whole of Africa (National REDD+ Secretariat, 2017). Because of reducing soil fertility, an ever increasing area has to be planted in order to grow sufficient food. As a result, rural families clear portions of land yearly for crop cultivation. Other causes of deforestation are shifting cultivation, bush fires, harvesting of fuel wood, human settlements and overgrazing. Conversion of forest lands for industrial activities or infrastructural development is another cause of forest loss. Examples include forest clearance for mining, industrial development, building of stadia, schools and other large infrastructure projects (Oduro et al., 2015).

2.2 Forest Inventory Data Model (FIDM)

For example, entity sets for several types of compartments (soils, vegetation, administrational), sample plots (temporary, permanent), and trees (sample tree, tally tree, seedling count) are needed in a forest inventory to describe variation and hierarchy levels of target. Data models in forestry traditionally contain an entity set for each object type of real world. The uniform storage structure allows applications to use standardized input–output routines for data manipulation. Both
inventories and all the field data sets can be active in one system. (Connell et al., n.d.) The FIDM keeps the number of entity sets to the minimum, e.g., FIDM has only three entity sets for observations instead of the eight listed in the previous example. The three sets describe observed objects, values of these objects, and interpretation of the values. The storage structure is explained further in the section Observations. The data model allows storage and manipulation of any data that can be identified as an object and described with attributes. Furthermore, the data model can simultaneously support several inventories of the same geographical area. Regardless of the real-life interpretation of attributes, applications receive data always in the same format. Parameters (interpretations) is required for decoding the input as well as for encoding the output. A number of data producers and even a greater number of data users have created a need for data conversions between organizations. Also, varying nomenclatures of organizations and measurement practices cause difficulties in data conversions. In FIDM data are labeled with starting and ending dates and some entities are also labeled with calculation or updating dates. The analysis is not restricted to the past, since the data model supports scenarios into the future with the possibility of forecasting and economic calculations. As calculations are a part of FIDM, no external applications are required to process the forest measurements into final reports (Connell et al., n.d.).

2.2.1 Components of Forest Inventory Data Model

The General Structure of the data model consists of seven main elements:

1. Observations

2. Calculations,

3. Models,

4. Inventory and stratification,
5. Reporting,

6. Change management,

7. Data dictionary

Every main element consists of entity sets that have links within the main element and between them. In this paper the main elements are in single quotation marks and the entity sets are in italics. When applying FIDM in practice, every main element of the data model is represented by an element of database with the same name, and every individual entity of the data model is represented by a database table of the same name. In the database there are also some auxiliary tables defined to represent many-to-many relations, such as a relation between a sample plot and a forest stratum (Tokola, Turkia, Sarkeala, & Soimiasuo, 1997).

Fig. 2.0. Main elements of the FIDM. (Tokola et al., 1997)
2.3 Forest Resource Database

Compilation of the database began by first identifying suitable data via literature search (including the terms “fragmentation” and “forest” and “species abundance” and “biodiversity”). The dataset measured species responses in plots or along transect located within different habitat fragments. Certain essential criteria had to be met before inclusion of a dataset from these sources (Sivaram & Station, 2017). The dataset had to contain quantitative and therefore analyzable data for responses of species. The classification is then updated regularly to account for changes in species names or taxonomic groupings (Pfeifer et al., 2014).

2.3.1 Features of Forest resource Database

Datasets in the Forest database may contain measurements of response variables at different levels of ecological detail (i.e., presence or absence of species vs. abundance, relative abundance or percentage coverage). Measurements may reflect the response of single species (e.g., variation in population traits) or communities (e.g., community composition) that have been measured once (as temporal snapshots) or repeatedly (as time series). The database holds single- and multiple-species inventories collected from several fragmented forest vegetation (Sivaram & Station, 2017). The aim of the database is to assess biologic responses to habitat fragmentation rather than provide a complete collection of species records on the globe. Gap analysis, however, does highlight some of the major data gaps. Addressing the lack of data for indicator groups such as plants and trees in the subtropical/tropical moist forests (Connell, Program, & Forest, n.d.).
2.3.2 Structure of Forest resource database

The database was designed following normalization rules to minimize redundancy and dependency and to isolate data. This means that design changes (i.e., additions and modifications of a field) can be made in just one table, which then propagate through the rest of the database. Thereby, data are addressed by value rather than position and larger tables are divided into smaller ones with relationships defined among them. The standardization of data derives from the constraints of the fixed architecture of the database. The database is designed around a circular (and fixed) relation with nine central tables: SPECIES, GPS, FAMILY, BOTANICAL NAMES, PHYSICAL LOCATION, EDIBILITY, ECOLOGICAL IMPORTANCE, AGE and MEDICINAL IMPORTANCE. Three extra tables define entries in SPECIES and FAMILY. Further tables provide essential information for queries and analyses but not for the functioning of the database. SPECIES holds names of species recorded in at least one landscape and links to species taxonomy via tables GENUS, FAMILY, ORDER, and GROUP. Two extra tables define currently accepted names and synonyms as additional entries (The Database Support & Forest, 2014).

2.3.3 Limitation of the Forest Resource Database

Whilst the forest database represents an essential step toward improved analyses of biologic responses to fragmentation, it cannot directly address problems of suboptimal study design data limitation (e.g., information not measured or excluded from response analyses) or varying data qualities produced by heterogeneous field measurements and unequal sampling effort. Also, varying species detectability may confound inference in meta-analyses and metrics calculated from aggregated data may be biased by sample size (Pfeifer et al., 2014).
2.3.4 Suggested Solution for Deforestation

One would think that the solution to degradation and deforestation lies with stopping the direct causes of deforestation. I agree with this only to some extent. In my opinion, halting forest loss should rather tackle both the direct causes and indirect causes, i.e. both prevention and cure. For example, one direct cause of deforestation is illegal logging. In trying to fight deforestation, we may not go very far if we are merely trying to stop illegal logging. (Food and Agriculture Organization of the United Nations, 2015) We might be better off solving the underlying cause of illegal logging which may be weak institutions or corruption or both. Similarly, we can only stop deforestation triggered by poverty when we have been able to tackle and deal with the poverty problems. Poor families who cannot afford alternative energy sources for cooking cannot be stopped from harvesting fuel wood since this will lead to hunger. In developed countries, the majority of people do not directly depend on the forest for energy to cook, hence it is easier to conserve forests.

The Ghana forestry commission is committed to tackling deforestation. Their efforts will not be successful until they are complemented with efforts of forest fringe communities. These groups often know of illegal activities in their local forests but tend to condone these activities. It is common recently to find chain saw operators even in northern Ghana selecting and cutting the few economic trees left in the area. Local people are those who help these illegal people to locate such trees in order to make their own gains at the expense of the whole of the nation. These rural dwellers may not be well informed about the benefits of preserving trees and even if they know, they value the money they get from chain saw operators much more than allowing the tree to stand.
There should be more training given to forestry officers to enable them to deal with the challenges of forest management in current times, in particular their ability to work together with forest fringe communities. With the advent of climate change for example, foresters must be equipped with necessary skills and technologies to be able to adapt to the anticipated changes. They should also be trained to understand and implement forest management approaches such as reduced impact logging, sustainable forest management, multiple use forest management, participatory forest management, and community forest management among others which have been found to be useful in other countries.

In addition, just like many crime related issues, Forestry officials need the support of other state security agencies to deal with these illegal activities. The police, customs, and military all have a role to play in the campaign against deforestation and illegal logging. I observed that most logs illegally cut in Upper West Region of Ghana were being transported across to Burkina Faso, through the borders. Training border officials in the identification of illegal logs is required. Government must step up forest protection by ensuring a multi-sectoral approach. Government should also review existing laws to ensure that punishments for illegal logging activities are severe enough to discourage people. The only way to regain lost forest is by reforestation or afforestation. Reforestation is to plant trees on land which carried forest within the previous 50 years or within living memory. Afforestation on the other hand is to plant trees on land devoid of forest or land that was deforested in the distant past. The Ghanaian government has been making great efforts to increase the nation’s forest cover through plantations. Since 2000 the Forestry Commission of Ghana has embarked on a national plantation development program with a target of 20 000 ha a year (FAO 2010). This is to be applauded but should also be done with more participation from local dwellers. Successful schemes such as joint forest management, participatory forest
management and community forest management should be introduced and studied. Tree planting could be made easier by encouraging local people to get involved through provision of incentives. Initiatives such as ‘Tree Aid’ provide an example of how such aspirations can be realized (Boakye and Baffoe, 2006). The protection of the nation’s forest is a collective responsibility of every Ghanaian. Hence every citizen should be a guardian of the remaining trees and be inspired and encouraged to plant trees. Some people argue that trees take too long to grow but I say that it is better to plant today and have it in 50 years than not to plant today and be forced to plant it in 50 years and end up using it in 100 years or more from now.

2.4 The Semantic Web

The Semantic Web is a mesh of data that are associated in such a way that they can easily be processed by machines instead of human operators. It can be conceived as an extended version of the existing World Wide Web, and it represents an effective means of data representation in the form of a globally linked database. By supporting the inclusion of semantic content in Web pages, the Semantic Web targets the conversion of the presently available Web of unstructured documents to a Web of information/data.

For the semantic web to function computers must have access to structured collections of information and sets of inference rules that they can use to conduct automated reasoning. A mixture of mathematical and engineering decisions complicates this task. It contains the seeds of important applications, but to realize its full potential it must be linked into a single global system. Traditional knowledge-representation systems typically have been centralized, requiring everyone to share exactly the same definition of common concepts such as
"parent" or "vehicle". Semantic Web researchers, in contrast, accept that paradoxes and unanswerable questions are a price that must be paid to achieve versatility. Moreover, these systems usually carefully limit the questions that can be asked so that the computer can answer reliably—or answer at all. Adding logic to the Web—the means to use rules to make inferences, choose courses of action and answer questions—is the task before the Semantic Web community at the moment. But central control is stifling, and increasing the size and scope of such a system rapidly becomes unmanageable. Artificial-intelligence researchers have studied such systems since long before the Web was developed. The challenge of the Semantic Web, therefore, is to provide a language that expresses both data and rules for reasoning about the data and that allows rules from any existing knowledge-representation system to be exported onto the Web. These triples can be written using XML tags. If we want to find people living in a specific zip code, we need to know which fields in each database represent names and which represent zip codes. RDF can specify that "(field 5 in database A) (is a field of type) (zip code)," using URIs rather than phrases for each term. Fortunately, a large majority of the information we want to express is along the lines of "a hex-head bolt is a type of machine bolt," which is readily written in existing languages with a little extra vocabulary. The logic must be powerful enough to describe complex properties of objects but not so powerful that agents can be tricked by being asked to consider a paradox. Two important technologies for developing the Semantic Web are already in place: extensible Markup Language (XML) and the Resource Description Framework (RDF). Scripts, or programs, can make use of these tags in sophisticated ways, but the script writer has to know what the page writer uses each tag for. Using a different URI for each specific concept solves that problem. XML lets everyone create their own tags—hidden labels such as or that annotate Web
pages or sections of text on a page. Meaning is expressed by RDF, which encodes it in sets of triples, each triple being rather like the subject, verb and object of an elementary sentence.

### 2.4.1 Semantic Web Technology

Semantic Web refers to a growing field of technology that continues to be the highlight of much focused research. Its foundational text introduces the standardized knowledge representation languages for modeling ontologies operating at the core of the semantic web (Chapman and Hall, 2009). This is not an exhaustive review, but aims to show the core capabilities and positions the technology in the overall web architecture. We now briefly review and highlight the key features of the Semantic Web family of technologies.

![FIGURE 2.1: W3C SEMANTIC WEB LAYER CAKE](http://www.w3.org/2001/sw/)

Cited: (Hogan, n.d.)
Web Ontology Language (OWL)

The Web Ontology Language, informally OWL, is a declarative knowledge representation language for the Semantic Web with formally defined meaning for creating ontologies. Property Hierarchies - allows for when property relationships implies reciprocal equivalence. Domain and Range Restrictions for Object Properties (similar to RDF). All the atomic constituents of statements, be they objects (Garden St), categories (Road) or relations (Intersection) are called entities. An OWL ontology is essentially a collection of basic “pieces of knowledge.” Statements, such as in RDF, that are made in an ontology are called axioms in OWL, and the ontology asserts that its axioms are true. RDF provides a core set of primitives for semantic modelling, but does not address some of the more advanced requirements. OWL also includes a number of advanced relationships for complex class and property restrictions, including:

- Class intersections
- Class unions
- Class complements (logical negation)
- Existential Quantification (defines a class as the set of all individuals that are connected via a particular property to another individual which is an instance of a certain class)
- Universal Quantification (defines a class of individuals for which all related individuals must be instances of a given class)
- Property Cardinality Restrictions
- Enumeration of Individuals
- Inverse, Symmetric, and Asymmetric Properties
- Reflexive and Irreflexive Properties
- Functional and Inverse Functional Properties
Transitive Properties (interlinks two individuals A and C whenever it interlinks A with B and B with C for some individual B) OWL is a very expressive and complex language, both for users and computationally (Rashid, Chastain, Stingone, Deborah, & Mccusker, n.d.).

**SPARQL Query Language**

The Semantic Web, typically represented using the RDF data format, requires a specific query language to make it possible to send queries and receive results. This is provided by the SPARQL query language and the accompanying semantics and protocols. SPARQL queries are similar in syntax to SQL but are based on the RDF triple models and provide patterns against such relationships in which some resource references are variables. A SPARQL engine would return the resources that match these patterns for all triples. SPARQL offers a complete set of read-only query semantics for operators, regular expressions, pattern matching, ordering, etc., that are framed around the RDF triple model. Under current development are a SPARQL Update language, SPARQL HTTP bindings, and discovery mechanism for describing the capabilities of a SPARQL endpoint (Identity, 2014).

**RIF**

The Rule Interchange Format (RIF) family of specifications focuses on exchange rather than a single one-fits-all rule language but even rule exchange alone is a complex and daunting area. The core idea behind rule exchange through RIF is that different rule systems will provide syntactic mappings from their native languages to RIF’s dialects and back. Rule systems fall into three categories; first-order, logic-programming, and action rules, and these paradigms share little
syntax and semantics. The “RIF-RDF and OWL Compatibility” specification defines how RIF uses its frame syntax to map onto RDF triples and joint semantics are defined for the combination. Obviously RIF’s rules should be able to interface with RDF and OWL ontologies even though they are languages with dissimilar syntaxes and semantics. RIF is a family of languages, called dialects, with rigorously specified syntax and semantics designed to be uniform and extensible (Raggett, 2009).

Semantic Data Model.

An SDM database is a collection of entities that are organized into classes. The structure and organization of an SDM database is specified by an SDM schema, which identifies the classes in the database. Multiple synonymous names are also permitted. Each class name must be unique with respect to all class names used in a schema. A class name identifies the class. A name class in SDM is a collection of strings, namely, a subclass of the built-in class STRINGS (which consists of all strings over the basic set of alphanumeric characters). In the real world, entities can be denoted in a number of ways; for example, a particular ship can be identified by giving its name or its hull number, by exhibiting a picture of it, or by pointing one’s finger at the ship itself. Entities are application constructs that are directly modeled in an SDM schema. However, one cannot enter or display a real entity on such a terminal; it is necessary to employ representations of them for that purpose. Operating entirely within SDM, the typical way of referencing an entity is by means of an entity-valued attribute that gives access to the entity itself. A name is any string of symbols that denotes an actual value encountered in the application environment; the strings are all names (Maryanski & Peckham, 1988)
ATTRIBUTES

As with class names, multiple synonymous attribute names are permitted. An attribute name must be unique with respect to the set of all attribute names used in the class, the class’s underlying base class, and all eventual subclasses of that base class. This means that attribute names must be unique within a “family” of classes; this is necessary to support the attribute inheritance rules. The attribute has a value which is either an entity in the database (a member of some class) or a collection of such entities. The value of an attribute is selected from its underlying value class, which contains the permissible values of the attribute. Any class in the schema may be specified to be the value class of an attribute. The attribute is specified as either single valued or multivalued. The value of a single-valued attribute is a member of the value class of the attribute, while the value of a multivalued attribute is a subclass of the value class. Thus, the SDM database manipulation facility strongly resembles the facilities described above for computing non-base classes and derived attributes. In the design of SDM, we have sought to provide a higher level and richer modeling language than that of conventional database models, without developing a large and complex facility containing a great many features (as exemplified by some of the knowledge representation and world modeling systems developed by the artificial intelligence community. We have also avoided the introduction of a huge number of attribute derivation primitives, limiting ourselves to the ones that should be of most critical importance. We have sought a middle road between these two extremes, with a relatively small number of basic features, augmented by a set of special features that are particularly useful in a large number of instances. Among other beneficial consequences, this duality allows for a natural evolution of the semantic schema to reflect changing patterns of use and access: As certain kinds of requests become more common, they can be incorporated as derived data into the schema and thereby greatly simplify their
retrieval. Such special cases would be most usefully handled by means of a general-purpose computational mechanism (Maryanski and Peckham, 1988).

**Ontology**

Ontology is a logical theory accounting for the intended meaning of a formal vocabulary, i.e. its ontological commitment to a particular conceptualization of the world (Verweij, Randen, Verhelst, Lokers, & Janssen, 2013). The intended models of a logical language using such a vocabulary are constrained by its ontological commitment. Ontology indirectly reflects this commitment (and the underlying conceptualization) by approximating these intended models. Ontology is a text file containing structured knowledge about a particular subject domain, and this file is used as a component of a so-called ‘intelligent’ information system. Ontologies have been, and are being, used to solve data integration problems by providing the common, agreed-upon vocabulary which is then used in a way so that the software understands. For instance, a question-answering system that lets the scientist chat with a library chatterbot to more easily find relevant literature (compared to string and keyword matching), automatically find a few theoretically feasible candidate rubber molecules out of very many (compared to painstaking trial-and-error work in the laboratory), and automated discovery of a new enzyme (outperforming the human experts!). In computing and intelligent software development, it is an object one can play with and manipulate. The actual artifact can appear in multiple formats that are tailored to the intended user, but at the heart of it, there is a logic-based representation that the computer can process. The most widely-used ontology is the Web Ontology language OWL format.(Web, Bechhofer, Madrid, & Gangemi, 2006) Other formats include (OBO format, Common Logic, etc.). For example: Two databases may use different identifiers for what is in fact the same concept, such as zip code. An ontology may express the rule "If a city code is associated with a state code, and an address uses that city code, then that
address has the associated state code”. If city codes must be of type city and cities generally have Web sites, we can discuss the Web site associated with a city code even if no database links a city code directly to a Web site (Berners-lee et al., 2001). The taxonomy defines classes of objects and relations among them. A program that wants to compare or combine information across the two databases has to know that these two terms are being used to mean the same thing. Inference rules in ontologies supply further power. More advanced applications will use ontologies to relate the information on a page to the associated knowledge structures and inference rules. The most typical kind of ontology for the Web has a taxonomy and a set of inference rules (Raggett, 2009). The meaning of terms or XML codes used on a Web page can be defined by pointers from the page to an ontology. Of course, the same problems as before now arise if I point to an ontology that defines addresses as containing a zip code and you point to one that uses postal code.

**Some Uses of Ontology**

Ontologies for information systems were first proposed to contribute to solving the issues with data integration: an ontology provides the common vocabulary for the applications that is at one level of abstraction higher up than conceptual data models such as EER diagrams and UML Class Diagrams. Ontologies have been shown to be useful in a myriad of other application scenarios; among others, negotiation between software services, mediation between software agents, bringing more quality criteria into conceptual data modelling to develop a better model (hence, a better quality software system), orchestrating the components in semantic scientific workflows, e-learning, ontology-based data access, information retrieval, management of digital libraries,

**Some useful Terms**

Syntax- has to do with what ‘things’ (symbols, notations) one is allowed to use in the language and in what way; there is/are a(n): – Alphabet – Language constructs – Sentences to assert knowledge.

Semantics – Formal meaning, which has to do what those sentences with the alphabet and constructs are supposed to mean.

**Ontology (OWL) and the Semantic Web**

OWL does not exist in isolation, but is part of the Semantic Web stack—also called the (in)famous ‘layer cake’—to make the Semantic Web work. This layer cake is shown in the Figure below. Stepwise working our way up from the bottom layer, there is XML, which is a surface syntax that has no semantics, and then XML Schema, which describes structure of XML documents. RDF is intended for describing data and facilitating data exchange; it is a data model for “relations” between “things”, which also has a RDF Schema and an RDF Vocabulary Definition Language. RDF data can be queried with the SPARQL query language (one can draw an analogue with SQL for relational databases, but then tailored to the Internet)(Berners-Lee & Chen, 2006). One of the central nodes in the Linked Data cloud is DBpedia, an RDF-based version of Wikipedia’s info boxes. Such systems may be users of lightweight ontologies or structured controlled vocabularies. The reason for lightweight is because the RDF store tends to be large with a lot of data stored in triples(Raggett, 2009). On top of that, we have the ontology language for the Web, OWL, to handle the knowledge and reasoning, and rules. RIF does not seem to be used much. There are many user
interfaces for the whole range of Semantic Web applications. The details of the “trust” and “crypto”, on the other hand, are still sketchy. Perhaps the “crypto” will receive more attention with the increasing popularity of Block Chain. Also, as there are several Block Chain systems, and they will need to interoperate at some point. Finally, several directions for extensions to OWL proposed. These include the ‘leftover’ from OWL 1’s “Future extensions”, such as the unique name assumption, closed world assumption, making parthood a primitive object property alike subsumption is, syntactic sugar for, e.g., ‘macros’ and ‘n-Aries’, a better integration with rules (RIF, DL-safe rules, SBVR), some orthogonal dimensions such as temporal, fuzzy, rough, and/or probabilistic, and better support for multilingual ontologies. Most of these desires were known during the standardization of OWL. Regardless, OWL itself has a life of its own, where OWL files are integrated into a wide range of applications on and off the Web in standalone ‘intelligent’ applications.

2.4.2 Semantic Web Database

Rosenthal defined data semantics as a connection from a database to the real-world outside the database. In the information systems context, semantics can be viewed as a mapping between an object modeled, represented and/or stored in an information system (e.g., an "object" in a database) and the real-world object(s) it represents. Semantic databases combine the characteristics of database management systems (DBMS) and inference engines. Benchmarking semantic databases is very complex. One major difference to DBMS is that semantic databases use ontologies as semantic schemata, which allows them to automatically reason about data. They provide storage, querying, and management of structured data. Another major difference is that they work with generic physical data models (e.g. in the current implementation of the data layer, inference is performed during loading and affects its performance. Typically the following
tasks are benchmarked: data loading - including parsing, persistence, and indexing; query evaluation - including query preparation and optimization and fetching; data modification - which may involve changes to the ontologies and the schemata; inference (not a first-level activity) - depending on the implementation, it can affect the performance of the other activities.

As a result, the semantic databases offer: easy integration of multiple data-sources - once the schemata of these sources is semiantically aligned, the inference capabilities of the engine support the interlinking and combination of facts from different sources; easy querying against rich or diverse data schemata - inference is applied to match the semantics of the query to the semantics of the data, regardless the vocabulary and the data modelling patterns, used for encoding data; great analytical power semantics is applied even with recursive inferences on multiple steps; facts are uncovered (based on interlinking long-chains of evidences), the vast majority of which would not be spotted in DBMS; efficient data interoperability - importing RDF data from one store to another is based on the use of globally unique identifiers. However, the best way to evaluate a semantic database is to use a methodology that provides a complete picture of the performance with respect to the full "life cycle" of the data within the engine.

In the data structure (Gandon, 2018).

The Semantic Web is based on the idea of a common and minimal language to enable large quantities of existing data to be analyzed and processed. This triggers the need to develop the database foundations of this basic language, which is the Resource Description Framework (RDF).

We’re looking at addressing this challenge by:

1. Developing an abstract model and query language suitable to formalize and prove properties about the RDF data and query language
2. Studying the RDF data model, minimal and maximal representations, as well as normal forms

The Semantic Web is a proposal to build an infrastructure of machine-readable semantics for the data on the Web. In fact, several languages for querying RDF were developed in parallel with RDF itself. All these developments have triggered the need of a more systematic research on formal aspects of the RDF database model, that is, its data model and query language. In 2008 the RDF Data Access Working Group (part of the Semantic Web Activity) released the standard of a query language for RDF, called SPARQL which address the basic needs of querying RDF, leaving several issues open for the future: inclusion of RDFS vocabulary, paths, nesting, premises, etc. Simultaneously to the release of data model, the natural problem of querying RDF was raised. Particularly, the RDF model was designed with the following goals: simple data model; formal semantics and provable inference; extensible URI-based vocabulary; allowing anyone to make statements about any resource. In 1999 the W3C issued a recommendation of a metadata model and language to serve as the basis for such infrastructure, the Resource Description Framework (RDF). As time passed, RDF evolved and increasingly gained attraction from both researchers and practitioners as a data model apt to represent the first layer of semantics on the Web (Identity, 2014).

2.4.3 Semantic Data Model

A specification of the Semantic Data Model
The following general principles of database organization underlie the design of SDM.

1. A database is to be viewed as a collection of entities that correspond to the actual objects in the application environment.
2. The entities in a database are organized into classes that are meaningful collections of entities.

3. These facilities integrate multiple ways of viewing the same basic information, and provide building blocks for describing complex attributes and interclass relationships.

4. Database entities and classes have attributes that describe their characteristics and relate them to other database entities.

There are several primitive ways of defining interclass connections and derived attributes, corresponding to the most common types of information redundancy appearing in database applications. (Maryanski & Peckham, 1988)

2.5Semantic Web Forest Resource Database

Semantic web forest resources database are management systems, capable of handling structured data about forest, taking into consideration their semantics. The Semantic Web represents the Web of Data, where information is published and interlinked in a way, which facilitates both humans and machines to exploit the structure and meaning of the forest data.

To foster the realization of the Semantic Web databases, the World Wide Web Consortium (W3C) developed a series of metadata, ontology, and query languages for it. Most of the semantic repositories are database engines, which deal with data represented in RDF, support SPARQL queries, and can interpret schemas and ontologies represented in RDFS and OWL. Naturally, such engines take the role of Web servers of the Semantic Web.
The advantages and the typical applications of semantic web forest resource database are the: reasoning with and the management of linked data (a popular trend in the Semantic Web) and enterprise data integration.

2.6 Case Study

UENR is a state owned university located in the Brong Region of Ghana, Sunyani. The university is made up various schools and departments in various academic disciplines of studies and one of such departments is the forestry department. There is no official document database that stores data about forest resources specifically tree and other important resources of the forest on and around campus. This in a way impedes upon teaching and learning when a student or lecturer wants to research on a specific forest resource (tree). Students and lecturers would have to rely on the general library to carry out their research. This takes a lot of time and sometimes they end up not getting the relevant information they are searching for.

In our studies, we took data about the forest trees on UENR campus. We did the taxonomy of the trees and provided the results as in this project. The following are the samples taken.

**Table 2.0** The Sampled tree data.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Botanical Name</th>
<th>Family</th>
<th>GPS Coordinate</th>
<th>Physical Location</th>
<th>Medicinal Value</th>
<th>Edibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>Mangifera Indica</td>
<td>Fabaceae</td>
<td>7°20’57” N 2°20’32” W</td>
<td>In front of Administration</td>
<td>Cure diarrhea</td>
<td>Eaten</td>
</tr>
<tr>
<td>Musk Mallow</td>
<td>Abelmoschus moschatus</td>
<td>Malvaceae</td>
<td>7°20'57&quot; N 2°20'31&quot; W</td>
<td>Behind New Library</td>
<td>Cures wounds</td>
<td>Not edible</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------</td>
<td>-----------</td>
<td>------------------------</td>
<td>-------------------</td>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Mato Amarillo</td>
<td>Caesalpinia major</td>
<td>Fabaceae</td>
<td>7°20'58&quot; N 2°20'31&quot; W</td>
<td>School field</td>
<td>Treating rheumatism</td>
<td>None known</td>
</tr>
<tr>
<td>Cissus verticillata</td>
<td>Princess Vine</td>
<td>Vitaceae</td>
<td>7°20'57&quot; N 2°20'30&quot; W</td>
<td>Behind Cafeteria</td>
<td>The sap is applied externally as a treatment for gangrene</td>
<td>None Known</td>
</tr>
<tr>
<td>Wine Palm</td>
<td>Raphia vinifera</td>
<td>Arecaceae</td>
<td>7°20'47&quot; N 2°20'30&quot; W</td>
<td>Back of Sawmill</td>
<td></td>
<td>kernels of the fruits are eaten roasted</td>
</tr>
</tbody>
</table>

Based on this data, we created the visualization of the taxonomy by using the ontology.
CHAPTER THREE

METHODOLOGY

3.0 OVERVIEW

This chapter will cover all necessary details, explanations and everything in relation to the methodology that is applied to make this project complete and working as expected. The chapter explains visually how Data becomes Linked Data when it links to related resources (Berners-Lee & Chen, 2006) using the semantic web technology. Linked data promise a possibility to increase the visibility and usage of forestry resource data on the Web. The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Berners-Lee et al., 2001). To achieve this, we have outlined below the tools and methods to help us carry out the implementation.

Figure 3.0: The Conceptual Framework of the Semantic Web Based Forest Resource Database
3.1 Conceptual Framework

User: the user is any person who will use the system. They use the system whenever they want to quickly find and use forestry data or information.

User Interface: It is the surface of the system on the browser that provides interaction between the system and the user.

Figure 3.1 the wireframe of the system user interface containing the search bar where user makes query
FIG 3.2: A wireframe of the interface which shows the display of related information on trees.

SPARQL Query: the user searches for data by entering some keywords or information they need into the search box of the system and the system goes to fetch the information from the forest resource database. A typical SPARQL query syntax is illustrated below:

SELECT ?c ?trees (3 * ?family AS ?fa)

SELECT * SELECT DISTINCT ?family

Results: the search results then displays on the browser.

Forest resource database: it is the database that has all the taxonomic and ecological data and information about the trees we studied.
Taxonomy dataset: classifications and groupings of plants into their FAMILIES, BOTANICAL NAMES, LOCAL NAMES, MEDICINAL VALUE, and other taxa.

Ecological dataset: defines the data about our plants with regards to their PHYSICAL LOCATION, GPS COORDINATES and HABITAT on campus.

Ontological Engineering: is the methods and methodologies for building ontologies: formal representations of a set of concepts within a domain and the relationships between those concepts.

3.1.1 Method Used

We adopted the Uschold’s and Kings Method to create an ontology.

Figure 3.3 Diagram of the Uschold’s and king’s method

The Method describes that:

- Build the ontology
✓ Identify key concepts and relationships in the domain of interest; to produce precise and unambiguous textual concepts of the relationship.

✓ Identify the terms that refer to such concepts and relationships and thus to reach an agreement.

So with this, we referred to the Semantic web Layer Cake and chose three layers which would help us to build our ontology. These layers include:

i. The OWL (Ontology)
ii. The RDF
iii. The SPARQL
iv. The XML

These layers are themselves the tools for implementing the right syntax and semantics for the complete and working semantic web base database.

▪ Identify the purpose and the scope.

We studied and picked all our data on University of Energy and Natural Resources (UENR) Main Campus which then enabled us to create the taxonomy of the trees.
3.2 Taxonomy of the trees

Figure 3.4: the diagram showing the relationship of the taxonomy of the trees.

Figure 3.5: the diagram showing the relationship of the taxonomy of a sample mango tree
Figure 3.6: the diagram showing the relationship of the taxonomy of a sample Mato Amarillo tree.

Figure 3.7: the diagram showing the relationship of the taxonomy of a sample Musk Mallow tree.
3.2.1 Description of the taxonomy of the trees

Thing: it is the root of the tree that depicts the subject under study. In our case, it is trees. The Thing is then grouped into Classes, Objects and Properties that describes the trees.

The groups consist of the following major classes;

- Family
- Botanical Names
- Habitat
- Medicinal Value
- Edibility
- Geographical location
- GPS coordinates
- Age
- Height
- Environmental effect of trees

The Objects explains what was been studied. Which in our case are the various plants and trees on UENR main campus.

The attributes explains the relationships among the various trees. We describe them by the following;

- hasFamily
- isLocatedAt
- hasGPS
- hasBotanicalName
- hasMedicinalValue
- has Age
- hasHeight
- AtPhysicalLoc

Provide a consensual knowledge model of the domain that will be used by forestry Lecturers and students.

This is illustrated in our conceptual Model described above.

Evaluate

By evaluating, we made technical judgement of the ontologies, their associated software environment and documentation.

To document

We then provided the guideline example to locate similar definitions together or to create naming conventions and to write the terms of the ontology in our Chapter Four.

3.3 Development Tools Used.

Protégé -2000: identified trees on campus were fed into the protégé using their Botanical name, medicinal Value Physical location, DNA and GPS to develop the ontology.
INTELLIJ IDEA: this is a java based platform for java development and this tool will be one of our development tools. Protégé Libraries will be setup on this platform in other to read the .owl file (ontology from the protégé) which was in RDF format.

![Figure: 3.8 intellij idea interface](image)

JAVA: These programming tools will help us to wrt our codes by simply helping convert our algorithm into a working program.

RDF: A variety of data interchange formats (e.g. RDF Schema (RDFS) and the Web Ontology Language (OWL), XML, N3, Turtle, N-Triples) are intended to provide a formal description of concepts, terms, and relationships within a given knowledge domain.

PROTÉGÉ: is a free and open source Java framework which can present RDF data and answer SPARQL queries over HTTP.
XAMPP: A local sever that will enable us to host and view our web pages on the computer without the use of internet.

OTHER VARIOUS TOOLS USED

JAVA SCRIPT

PHP

HTML

CSS

BOOTSTRAP

JQUERY

BRACKET EDITOR: Bracket is a proprietary cross platform source-code editor. We developed a PHP application using bracket text editor and also connected our Protégé, the ONTOLOGY FILE and XAMPP local server to the application.

Hardware and System Specification

Computer with the following specifications:

✓ Laptop System Manufacturer and System Model: HP - HP Envy Notebook

✓ Laptop Processor: Intel(R) Core (TM) i5-6260U CPU @1.80GHz 1.80Hz

✓ Laptop Memory: 8192MB RAM and Laptop Hard Disk Drive: 1.2TB

✓ Laptop Operating System: Windows 10 Professional

✓ Any desktop browser specifically chrome or Firefox.
CHAPTER FOUR

IMPLEMENTATION AND PRESENTATION OF RESULTS

4.0 OVERVIEW

This chapter describes the implementation and presentation of result of the semantic web based forest resource database. The system was implemented using the forest resources available on of UENR campus.

4.1 Implementation

System Interface

To start the system two local servers must be started; the XAMPP server and PROTÉGÉ.

4.2 Classes and Class Hierarchy

The first step as illustrated in figure 9 gives the diseases related classes or concepts. All the concepts shows in the figure are mainly focus on age, botanical names, family names, medicinal values, geographical location and GPS coordinates.
Explanation of figure above:
We define object classes according to our relationship which we want to add between trees (as shown in figure 9). Which show the relationship between families to tree species.
Explanation of figure above:
We define object properties according to our relationship which we want to add between classes (as shown in figure 10). Which show the relationship between families to tree species.

4.2.1 Axioms of Ontology and the Axioms for Class

Axioms can be used to describe the relationship between classes, attributes and individuals. There are four axioms of classes, the existence of class, subclass, equivalent class and disjoint with all the axioms describe by language using rdf: id, rdfs: subClassOf, owl: equivalentClass and owl: disjointwith.

4.2.2 The Axioms of Instances

In OWL, there are two types’ axioms between instances. One is the composition of members and value of attributes, first classify the information, and then describe the composition of each class and the value of its attribute. The other is two instances are whether equivalent those descriptions related to it are: owl: sameAs, owl: differentFrom and owl: AllDifferent etc. We applies in our ontology mostly axioms for providing more clear result of the prevalent disease term by query search results. We apply characteristics functional property in object properties such as hasGPS, hasBOTANICAL_NAME, has AGE, hasMEDICINAL_VALUE, has member and teacher of etc. We know that is property is inverse of has property so is member object property are inverse functional according to rule. Teacher of object property are both functional and irreflexive characteristics because we know one object property may be one or more characteristics.

4.2.3 The Instance of Ontology

Defining the instance (individual), first you should select the right class, and then create its instances for the class. Use RDF: type to state its class, and one instance can belong to many classes or many class belong to same instances.

4.2.4 The Reasoning of Ontology

For building correct and consistent ontology, reasoning is the most important part. Reasoner checks consistency and finds the logic contradictions implicit in the definitions. The test of
knowledge consistency includes detecting its reflexive, transmission and redundancy of knowledge (Noy & McGuiness, 2000).

4.2.5 System Constraints

The semantic-web base forest database will have some constraints: Data stored in the database is data only about forest resources and not related to any other subject matter. The usage of the system can only be implemented by the use of a web browser as the user interface. System cannot function without access to internet so availability of bandwidth hence it is not a system that can be classified as a standalone usage.

4.3 Testing and Evaluation

System Testing is the testing of a complete and fully integrated software product. Usually software is only one element of a larger computer based system. Ultimately, software is interfaced with other software/hardware systems. System Testing is actually a series of different tests whose sole purpose is to exercise the full computer based system.

4.3.1 Testing

Testing entails all the testing activities that were carried out by the team while the system undergoes development. The following were some of the tests conducted on our system while developing it.

We performed alpha test by involving six senior forest science students who used the application, evaluated it and came out with a good results which is shown in the chapter four of this documentation.

Based on the table in the case study above, the taxonomy labeled Fig.3.5, Fig 3.6 and Fig3.7 below was generated.
Figure 4.2: User Login Page

Explanation of figure above:
The figure above shows the login page of the implemented semantic web based forest resource database. On this interface, user enters their email and password as text in the boxes provided, then clicks the login button to get logged into the system.
Figure 4.3: User Registration Page

Explanation of figure above:

The figure above shows the sign up page of the implemented semantic web based forest resource database. On this interface, user enters their email and password, first, middle and last names as text in the boxes provided, then clicks the sign up button to get logged into the system.

An authentication requires registered user who is then granted access to the dashboard. If user is not registered then the user is required to register with a valid email address, password and a username.

After the system has authenticated you and verified your credentials, you’re then granted access to the main dashboard of the application. The figure below displays the dashboard the application interface.
FIGURE 4.4: LANDING PAGE AFTER AUTHENTICATION AND AUTHORIZATION

Explanation of figure above:

The figure above shows the landing page of the implemented semantic web based forest resource database. This interface presents the button as text where the user then clicks to finally be on the main dashboard.

Results:

The figure below shows the result of our test.
Explanation of figure above: The figure above shows the main dashboard of the implemented semantic web based forest resource database. This interface presents links to various information on trees as well as search boxes for querying data/information on trees. The button as text where the user then clicks to finally be on the main dashboard.
The table below shows the Questionnaire about the system flexibility test;

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Semantic-web based forest resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module name</td>
<td>Login</td>
</tr>
<tr>
<td>Reviewed By</td>
<td>Test leaders/Peers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Case</th>
<th>Test steps</th>
<th>Preconditions</th>
<th>Steps</th>
<th>Expected result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter a valid username &amp; valid password</td>
<td>1. Enter valid user name.</td>
<td>Valid URL</td>
<td>Username:<a href="mailto:abcd@gmail.com">abcd@gmail.com</a></td>
<td>Successful login</td>
</tr>
<tr>
<td></td>
<td>2. Enter valid password</td>
<td>Test data</td>
<td>Password:Perfect20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. click on login button</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Enter valid username.</td>
<td>Valid URL</td>
<td>Username:abcd@gmail</td>
<td>A popup message to show an error “username/password”</td>
</tr>
<tr>
<td></td>
<td>2. Enter invalid password</td>
<td>Test data</td>
<td>Password:Perfect20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. click on login button</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Enter invalid username.</td>
<td>Valid URL</td>
<td>Username:abcd@gmail</td>
<td>A popup message to show an error “username/password”</td>
</tr>
<tr>
<td></td>
<td>2. Enter valid password</td>
<td>Test data</td>
<td>Password:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. click on login button</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Enter invalid username.</td>
<td>Valid URL</td>
<td>Username:abcd@gmail</td>
<td>A popup message to show an error “username/password”</td>
</tr>
<tr>
<td></td>
<td>2. Enter valid password</td>
<td>Test data</td>
<td>Password:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. click on login button</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Case</td>
<td>Test steps</td>
<td>Preconditions</td>
<td>Data Test</td>
<td>Expected result</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Enter a valid username & valid password | 1. select search space  
2. Input a plant family name.  
3. click search | Successful login | Fabaceae       | Show all plant with searched family name display other vital information on the plant. |
|                                | 1. select search space  
2. Input a plant species name.  
3. click search | Successful login |               | Show plant with searched species and display other vital information on the plant.  |
|                                | 1. select search space  
2. Input a plant common name.  
3. click search | Successful login | Wine palm      | Show plant with searched common name and display other vital information on the plant. |
| 1. select search space | Successful login | Mangifera Indica | Show plant with searched botanical name and display other vital information on the plant.
<p>| 2. Input a plant botanical name. | | | |
| 3. click search | | | |</p>
<table>
<thead>
<tr>
<th>Test Case</th>
<th>Test steps</th>
<th>Preconditions</th>
<th>Data Test</th>
<th>Expected result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter a valid username &amp; valid password</td>
<td>1.select search space 2. Input a plant family name. 3.click search</td>
<td>Successful login</td>
<td>Fabaceae</td>
<td>Show all plant with searched family name display other vital information on the plant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.select search space 2. Input a plant species name. 3.click search</td>
<td>Successful login</td>
<td></td>
<td>Show plant with searched species and display other vital information on the plant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.select search space 2. Input a plant common name. 3.click search</td>
<td>Successful login</td>
<td>Wine palm</td>
<td>Show plant with searched common name and display other vital information on the plant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.select search space 2. Input a plant botanical name.</td>
<td>Successful login</td>
<td>Mangnifera Indica</td>
<td>Show plant with searched botanical name and display other vital information on the plant.</td>
</tr>
</tbody>
</table>
### Table 3.1

**The Post-Study Usability QUESTIONNAIRE**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Questionnaire</th>
<th>strongly agree</th>
<th>strongly disagree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>Overall am satisfied with how easy it is to use this system.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>2 B</td>
<td>It was simple to use this system.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>3 C</td>
<td>I felt comfortable using the system.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>4 D</td>
<td>It was easy to learn to use this system.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>5 E</td>
<td>I believe I could become productive quickly using this system.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>6 F</td>
<td>The system gave messages that clearly told how to fix problems.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>7 G</td>
<td>Whenever I made a mistake using the system, I could recover quickly.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>8 H</td>
<td>The information (such as on-screen help messages and other documentation)</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td></td>
<td>provided with this system was clear.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 I</td>
<td>It was easy to find the information I needed.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>10 J</td>
<td>The organization of information on the system was clear.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>11 K</td>
<td>The interface, of this system was pleasant.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
<tr>
<td>12 L</td>
<td>I liked using the interface of this system.</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○ ○ ○ ○ ○ ○ ○</td>
<td>○ ○</td>
</tr>
</tbody>
</table>

3.click search
4.3.2 Results of Test

After testing the following were the final results;

Results data indicating Wood and Non Wood Product derived from the forest on UENR campus

Result of data indicating Social, Economic and Environmental Services Provided by the forest on UENR campus

<table>
<thead>
<tr>
<th>Services from Forest</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil and water conservation</td>
<td>85.29 %</td>
</tr>
<tr>
<td>Conservation</td>
<td>10.51 %</td>
</tr>
<tr>
<td>Grazing</td>
<td>1.24 %</td>
</tr>
<tr>
<td>Scientific studies</td>
<td>1.14 %</td>
</tr>
<tr>
<td>Wind-breaking curtains</td>
<td>1.02 %</td>
</tr>
<tr>
<td>Hunting</td>
<td>0.80 %</td>
</tr>
<tr>
<td><strong>100 %</strong></td>
<td></td>
</tr>
</tbody>
</table>

Result of data indicating Standing Volume Distribution of tree by Family in the forest on UENR campus.
<table>
<thead>
<tr>
<th>No.</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Family</th>
<th>Gross Vol./ Area/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mangifera Indica</td>
<td>Mango</td>
<td>Anacardiaceae</td>
<td>1800</td>
</tr>
<tr>
<td>2</td>
<td>Abelmoschus moschatus</td>
<td>Musk Mallow</td>
<td>Malvaceae</td>
<td>400</td>
</tr>
<tr>
<td>3</td>
<td>Caesalpinia major</td>
<td>Mato Amarillo</td>
<td>Fabaceae</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>Cissus verticillata</td>
<td>Princess Vine</td>
<td>Vitaceae</td>
<td>180</td>
</tr>
<tr>
<td>5</td>
<td>Raphia vinifera</td>
<td>Wine Palm</td>
<td>Arecaceae</td>
<td>500</td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td>Other family</td>
<td></td>
<td>3000</td>
</tr>
</tbody>
</table>

|                           |                        |              | 6,180 m²           |
The Pie Chart below shows the major distribution of Family of tree species on UENR Campus.

FIGURE 4.6 PIE CHART SHOWING PERCENTAGE OF TREE DISTRIBUTION ON CAMPUS

Elaboration of the Pie Chart above;

Total Percentage covered by each Family of Tree Specie on entire UENR campus is calculated by:

- Mango Tree = \( \frac{1800}{6180} \times 100 \)
  \[ = 29 \% \]
- Musk Mallow = \( \frac{400}{6180} \times 100 \)
  \[ = 6 \% \]
- Mato Amarillo = \( \frac{300}{6180} \times 100 \)
  \[ = 5 \% \]
- Wine Palm = \( \frac{500}{6180} \times 100 \)
  \[ = 8 \% \]
Princess Vine = $\frac{180}{6180} \times 100$

= 3%

The figure above is a histogram of Family of Tree per Area that describes the total area on UENR campus covered by each family of Tree Species.

On total area 180 m² Anacardiaceae is the most densely populated tree within the area followed by Fabaceae then Arecaceae, others, Fabaceae, Malvaceae respectively.

On total area 300 m² Anacardiaceae is the most densely populated tree within the area followed by Fabaceae, Others, Arecaceae, Vitaceae, Malvaceae respectively.

On total area 400 m² others is the most densely populated tree within the area followed by Anacardiaceae then Vitaceae, Malvaceae, Arecaceae, Fabaceae respectively.
On total area 500 m² Malvaceae is the most densely populated tree within the area followed by others then Anacardiaceae, Fabaceae, Vitaceae and Arecaceae respectively.

On total area 1800 m² others is the most densely populated tree within the area followed by Arecaceae then Fabaceae, Malvaceae, Vitaceae and Anacardiaceae respectively.

On total area 3000 m² Anacardiaceae is the most densely populated tree within the area followed by Arecaceae, Malvaceae, Others, Vitaceae and Fabaceae respectively.

The tables Below Shows the Results of the Questionnaire:

<table>
<thead>
<tr>
<th>No.</th>
<th>Satisfied</th>
<th>Unsatisfied</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>45</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>47</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>46</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>47</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>48</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>45</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>46</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>J</td>
<td>45</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>K</td>
<td>47</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>L</td>
<td>46</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>M</td>
<td>47</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>49</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Number of People = 50
Total = 648  Total = 51  Total = 1
<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Satisfied</th>
<th>Percentage (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47</td>
<td>7.3</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>6.6</td>
</tr>
<tr>
<td>C</td>
<td>45</td>
<td>6.9</td>
</tr>
<tr>
<td>D</td>
<td>47</td>
<td>7.3</td>
</tr>
<tr>
<td>E</td>
<td>46</td>
<td>7.1</td>
</tr>
<tr>
<td>F</td>
<td>47</td>
<td>7.3</td>
</tr>
<tr>
<td>G</td>
<td>48</td>
<td>7.4</td>
</tr>
<tr>
<td>H</td>
<td>45</td>
<td>6.9</td>
</tr>
<tr>
<td>I</td>
<td>46</td>
<td>7.1</td>
</tr>
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<td>J</td>
<td>45</td>
<td>6.9</td>
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<td>K</td>
<td>47</td>
<td>7.3</td>
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<td>L</td>
<td>46</td>
<td>7.1</td>
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<td>M</td>
<td>47</td>
<td>7.3</td>
</tr>
<tr>
<td>N</td>
<td>49</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Number of People = 50</strong></td>
<td><strong>Total = 648</strong></td>
<td><strong>Total = 100</strong></td>
</tr>
</tbody>
</table>


Figure 4.8. The percentage value score of people who strongly agree the statement in the questionnaire after testing the system.

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Strongly Disagree</th>
<th>Percentage (100%)</th>
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<tbody>
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<td>A</td>
<td>3</td>
<td>5.9</td>
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<td>B</td>
<td>7</td>
<td>13.7</td>
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</tbody>
</table>
The percentage value score of people who strongly agree the statement in the questionnaire after testing the system.

**Figure 4.9.** The percentage value score of people who strongly agree the statement in the questionnaire after testing the system.
Implication of the result.

According to the results 648 which is representing 93% of the entire results agree that the system gives them the results they require from the queries they made about a particular tree. The remaining 7% comprises of people who strongly disagree or people who were not satisfied with the use of the system. Comments made was addressing the complex interface and navigation the system provided. Therefore, it can be concluded that majority of users found the use of the system less complex and user friendly.
CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Overview

This chapter presents the summary, conclusions and recommendations of the project.

5.1 Summary

In summary, the purpose of this study was to design and implement a semantic-web based forest Resources database for UENR forestry department. There are some forest resources (such as Trees, Shrubs, and Water bodies) in the university main campus. These resources are used for various purposes ranging from teaching, researches medicinal and domestic purposes and among many others. However, there is no record of official documentation on them. Thus this study aim to provide a semantic-web based database system for efficient management of forest resources data. Primarily the use of ontology was used in the construction of an .OWL file that entails the taxonomy of forest Trees.

5.2 Conclusion

The Ontology-centric approach provides an innovative, effective and an efficient means of capturing and organizing knowledge domain for forestry management system. Some of the basic information that we provided by the proposed semantic web database include trees, their scientific name, geographical coordinate, physical location, medicinal value and other important data. These data captured helped in efficient design and implementation of the semantic-web based forest resources database.
5.3 Recommendation

We recommend our Semantic web based forest resource database to all lecturers and students in the forestry department, and as well as the entire staff and students of University of Energy and Natural Resources. It is expected that they will find this application system useful in their teaching and learning of forest science. Likewise, we hope that it will attract and stimulate the public and policy makers’ interest and hopefully leads to exciting development in forestry informatics in the country.
REFERENCES

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73

Opportunities, O. (2016). FORESTRY Multiple-use forest management in the humid tropics Opport n iti. *FORESTRY Multiple-use forest management in the humid tropics Opport n iti*, 118.

Overexploitation, I. (2013). 2 . 2 Component 2 : Management and conservation of forest and tree resources. 2 . 2 Component 2 : Management and conservation of forest and tree resources, 1168.


Appendices

Appendix I

The XML Code that we implemented for the Semantic web Based forest Resource Database

<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml"
xmlns:DC="http://purl.org/metadata/dublin_core_elements#" xml:lang="en"
lang="en">
<head>
<meta name="DC.creator" content="David Decraene" />
<meta name="DC.publisher" content="Ontology Online" />
<meta name="Keywords" content="OWL, Ubiquity, jQuery, jOWL, ontology,
semantic web" />
<meta name="Description" content="jOWL Ontology Browser, visualizes
ontologies loaded with the ubiquity command 'view_ontology'" />
<title>U.E.N.R Forestry Link Data</title>
<link rel="stylesheet" href="css/blueprint/screen.css" type="text/css"
media="screen, projection" />
<link rel="stylesheet" href="css/jOWL.css" type="text/css" />
<link type="text/css" rel="stylesheet" href="css/jq/custom-theme/jquery-ui-1.7.custom.css">
<style type="text/css">


var configuration = {
    ontology: "data/uenrforestontology.owl",
    owlClass: "PLANT",
    classOverview: true,
    propertiesTab: true,
    sparqdlTab: true
}
$(document).ready(function() {
    if (!configuration.propertiesTab) {
        $('#propertyPanel').remove();
        $('#tab2').remove();
    }
    if (!configuration.individualsTab) {
        $('#thingwidget').appendTo("body").hide();
        $('#individualPanel').remove();
        $('#tab3').remove();
    }
    if (!configuration.sparqldlTab) {
        $('#sparqldlPanel').remove();
        $('#tab4').remove();
    }
    
    "#tabs".tabs();

    jOWL.load(configuration.ontology, initjOWL, {
        reason: true,
        locale: 'en'
    });
});

function initjOWL() {
}
createOntologyWidget();
var conceptWidget = createConceptWidget();

if (configuration.classOverview) {
    jOWLBrowser.views.push({
        query: "Class(?x)",
        element: $('#classlist'),
        widget: conceptWidget
    });
}

if (configuration.propertiesTab) {
    var propertyWidget = createPropertyWidget();
    jOWLBrowser.views.push({
        query: "ObjectProperty(?x)",
        element: $('#OPlist'),
        widget: propertyWidget
    });
    jOWLBrowser.views.push({
        query: "DatatypeProperty(?x)",
        element: $('#DPlist'),
        widget: propertyWidget
    });
}
if (configuration.individualsTab) {
    var thingWidget = createIndividualsWidget();

    setTimeout(function() { //show individuals asynchronously
        var arr = new jOWL.Ontology.Array();
        for (key in jOWL.index('Thing')) {
            arr.concat(jOWL.index('Thing')[key], true);
        }
        showOverviewResults(arr, $('#thinglist'), thingWidget);
    }, 200);
}

if (configuration.sparqldlTab) {
    createSparqlDLWidget();
}

createOverviewWidget();

</script>
</head>

<body>
<div class="container">
A Link Data Database For U.E.N.R Forestry And Natural Resources Department using Open Link Data and Ontological Engineering

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</div>
<hr class="space" />

<div id="conceptwidget">

<form action="">

  Treeview: <input type="radio" name="visualisation" value="treeview" checked="checked" />

  Navigation Bar: <input type="radio" name="visualisation" value="navbar" />

</form>

<table id="browser" style="width:100%">
  <tr>
    <td style="width:50%;">
      <div id="treeview" class="ui-widget-content">
        <h4 class="ui-dialog-titlebar ui-state-default">Treeview</h4>
      </div>

      <div id="navbar" style="display:none" class="ui-widget-content">
        <h4 class="ui-dialog-titlebar ui-state-default">Navbar</h4>
      </div>

      <input id="owlauto" type="text" size="40" style="display:block;width:99%;margin:5px 0px;" title="enter a search term" />

      <div style="color:#DCDCDC" class="info">Enter Search Terms here</div>
    </td>
    <td>
      <div id="description" class="resourcebox ui-widget-content" data-jowl="owl:Class">

      </div>

      <input id="owlauto" type="text" size="40" style="display:block;width:99%;margin:5px 0px;" title="enter a search term" />

      <div style="color:#DCDCDC" class="info">Enter Search Terms here</div>
    </td>
  </tr>
</table>

</div>
<h4 class="ui-dialog-titlebar ui-state-default propertybox" data-jowl="rdfs:label">Description of $\{rdfs:label\}</h4>

<div class="jowl-content">
  <div class="propertybox" data-jowl="rdfs:comment">$\{rdfs:comment\}</div>

  <div class="propertybox">
    <b>Terms</b>: $\{term\}</div>

</div>

<div class="propertybox" id="disjoints">
  <b>Disjoint With</b>: $\{owl:disjointWith\}</div>

<div class="propertybox">
  <b>Relations</b>
  <ul>
    <li data-jowl="sparql-dl:PropertyValue(owl:Class, ?p, ?t)">
      $\{?p}\n      $\{?t\}
    </li>
  </ul>
</div>

<div id="individualsPropertyBox" class="propertybox" style="padding:5px;">
  <b>Instances</b><br />
</div>

83
<span class="valuebox" data-jowl="sparql-dl:DirectType(?i, owl:Class)">${?i}</span>
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</div>
</div>
</div>
</div>
</div>
</div>
</div>
</div>
</div>
</div>
<div class="propertybox" data-jowl="rdfs:comment">${rdfs:comment}</div>

<div class="propertybox">
  <b>Terms</b>: <span data-jowl="term">${term}</span>
</div>

<div class="propertybox">
  <b>Domain</b>: <span data-jowl="rdfs:domain">${rdfs:domain}</span>
</div>

<div class="propertybox">
  <b>Range</b>: <span data-jowl="rdfs:range">${rdfs:range}</span>
</div>

</div>
</div>
</div>
</div>
</div>

<div id="tab3">
  <div id="thinglist"></div>
  <hr class="space" />
  <div id="thingwidget">
    <div class="resourcebox ui-widget-content" data-jowl="owl:Thing">
      <h4 class="ui-dialog-titlebar ui-state-default propertybox" data-jowl="rdfs:label">Description of <span>${rdfs:label}</span></h4>
      <div class="jowl-content">

      </div>
    </div>
  </div>
</div>
<div class="propertybox" style="margin-bottom:5px"><b>owl:Class</b> <span data-jowl="rdf:type">${rdf:type}</span></div>

<div class="propertybox" data-jowl="rdfs:comment">${rdfs:comment}</div>

<div class="propertybox" data-jowl="sparql-dl:PropertyValue(owl:Thing, ?p, ?t)">
  <span class="alt">${?p}</span>: <span>${?t}</span>
</div>

<h4>Enter a query:</h4>
<form id="sparql"><input type="text" size="100" /></form>
<hr class="space" />
<table style="width:100%">
  <tr>
    <td style="width:50%;"
    <h3>Results</h3>
    <div class="loader hide">
      <div style="color:black">Querying, Please Stand By</div>
      <img src="img/ajax-loader.gif" alt="Loading Image" />
    </div>
    <div id="sparqlresults" class="box"></div>
  </td>
</tr>
</table>
<h3>Syntax</h3>
<ul>
<li>PropertyValue(?a, ?b, ?c)</li>
<li>Class(?a)</li>
<li>ObjectProperty(?a)</li>
<li>DatatypeProperty(?a)</li>
</ul>
APPENDIX II

In accessing our System a questionnaire on Table 3.1 was given out to our testers to conclude the eligibility of our system.