

Semiotic Based Framework for the Development of Indigenous Knowledge Systems

By

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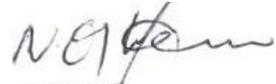
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A Thesis Submitted to the College of Science in Partial Fulfilment of the Requirements for
the Award of the **Degree of Master of Science in Computer Science** of BIUST

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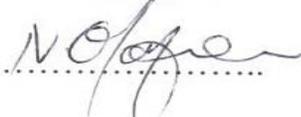
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Declaration

I **Naledi Kefitile** declare that this thesis titled “**Semiotic Based Framework for the Development of Indigenous Knowledge System**” has been prepared by me under the guidance and supervision of Dr.Hlomani Hlomani, **Department of Computer Science & Information Systems**. This Dissertation belongs to Botswana International University of Science, college of Science and fulfils the University regulations and Requirements for the award of Degree Master of Science in Computer Science and Information Systems. This thesis has not been submitted to any other university for the award of any degree or diploma.

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Certification

The undersigned certifies that, they have read and hereby recommend for acceptance by the Botswana International University of Science and Technology a dissertation entitled: **“Semiotic Based Framework for the Development of Indigenous Knowledge System”**, in fulfilment of the requirements for the degree of Master of Science in Computer Science of the Botswana International University of Science and Technology.

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Acknowledgement

I thank the Lord for giving me the opportunity to do my Master's Degree at Botswana International University of Science and Technology. I would like to thank the following for their encouragement in the preparation of my thesis. First, I would like to give gratitude to my supervisor; Dr. Hlomani Hlomani for being the supportive, showing leadership and supervising me through this research. I thank him for giving me direction and mentoring me every step of the way to the completion of this thesis. I would have not done this research without his leadership, as he gave me support, philosophies and encouraged me where I fell short. I dedicate this Thesis to my daughter "Amantle" and son for giving me motivation to complete my studies. I would like to express my thanks to my colleagues at Botswana International University of Science and Technology, BIOT (BIUST Intelligence and Ontology Team) for sharing ideas with me especially Mr Dylan Phefo who we had a mutual understanding of Ontologies and completed our first conference paper (Othusitse S.D. Phefo, Naledi Kefitile and Hlomani Hlomani Towards the Cultural Knowledge Ontology, 2015 IEEE. Computer Society Conference, 16th International Conference on Information Reuse and Integration, August 2015, page 526 – 533). I appreciate you all for your help.

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List of Abbreviations

IKS Indigenous Knowledge Systems

IK Indigenous Knowledge

IKMS Indigenous Knowledge Management Systems

ICT Information Communication Technology

IPR Intellectual Property Rights

OWL Web Ontology Language

DL Descriptive Logics

API Application Program Interface

DL Description Logics

ATM African Traditional Medicine

WWW World Wide Web

TCM Traditional Chinese Medicine

TK Traditional Knowledge

KM Knowledge Management

KR Knowledge Representation

KN Knowledge Engineering

IPR Intellectual Property Rights

ICT Information communication Technology

KR Knowledge Representation

WTMPD World Traditional Medicine Patent Database and its applications

MIHK Malaysia Indigenous Herbs Knowledge

TKDL Traditional Knowledge Digital Library

TKRC Traditional Knowledge Resource Classification

IPC International Patent Classification

ATM African Traditional Medicine

ANKN Native Knowledge Network

ODRL Open Digital Rights Language

OWL Web Ontology Language

API Application Programming Interface

SAW Additive Weighting Scheme

List of Appendices

Appendix A: Sample Questionnaire

Appendix B: Conference paper (Othusitse S.D. Phefo, Naledi Kefitile and Hlomani Hlomani. Towards the Cultural Knowledge Ontology, 2015 IEEE. Computer Society Conference, 16th International Conference on Information Reuse and Integration, DOI 10.1109/IRI.2015.85, August 2015, page 526 – 533)

Abstract

Indigenous cultures have encountered a renaissance throughout the years; this made indigenous groups to perceive the significance of recording and sharing their social legacy and history. However, the absence of procedural framework that can manage, formalize, preserve and disseminate Indigenous knowledge has become a problem in the modelling of indigenous knowledge management systems (IKMS). This research demonstrates an analytical framework using Ontologies and Semiotic Theory to understand, classify and formalize Indigenous Knowledge systems (IKS) in Botswana. The Semiotic theory is the production, interpretation of meaning of signs for communication; it has three branches, semantic, pragmatic, and syntactic. These branches are incorporated to develop the proposed framework. The framework developed is applied considering the issues of representation, acquisition, and creation in order to evaluate and determine how IKS should be preserved and disseminated throughout Botswana and possibly applied to other African countries and continents. The Semiotic framework provides a procedural guidance and a coherent way of identifying IKS by determining if it's still exists, relevant and known; then it classifies the knowledge domains that could possibly exist by developing IKS Ontology to impart the proof of concept for this research. The framework is formalized in the form of Ontology to make the domain knowledge explicit. The semiotic framework and the ontology are evaluated by conducting an empirical study of three groups of participants with regard to the relevance, existence and knowledge of IKS. The Ontology build with Protégé editor was evaluated for quality against a semiotic metric suite to determine the overall total quality of the ontology. An organizational framework based on semiotic suite for assessing the quality of ontology is developed consisting of four metric suites; Syntactic quality, Semantic quality, Pragmatic quality, and Social quality. The results reveal that upon empirical evaluation of the Ontology and Semiotic framework, Semantic quality is the most significant with a total of 57%, syntactic is 28% , Pragmatic is 14%, while social recorded is 1%.The Social recorded 1% because IKS is an innovative Ontology that is not yet accessed by agents.

Chapter 1

1. Introduction

1.1 Overview

Future directions are foundationally dependent upon the development of frameworks that improve and encourage perceptions about existing and emerging knowledge management approaches. Knowledge Management is concerned with representation, acquisition, creation, usage and development of knowledge in its numerous structures [1]. While building up new innovations for information based frameworks in endeavour to represent knowledge, we likewise need to construct tools which can adequately seek through databases, files, web sites, to extract information, capture meaning, organize and make it accessible.

Though IK is at the verge of extinction, the emergence of new technologies has come to the rescue of vanishing cultures, to preserve and disseminate the knowledge that exists. This can be achieved for example, via philosophies such as Ontologies. Ontologies are reusable artefacts that analyse and reuse the domain knowledge, and also separate domain knowledge from operational knowledge. With Ontology, it is clearly possible to explicitly represent the domain knowledge, as it allows sharing an understanding of the structure of information among people and software agents. According to the linguist, Gruber, ontology is defined as a formal and explicit specification of a shared conceptualization of a domain of interest to enable sharing and reuse [44].

For many years rural communities in Botswana have relied on their indigenous knowledge for survival and to sustain their livelihood. Indigenous Knowledge refers to the skills, knowledge, wisdom acquired by Indigenous people belonging to a particular ethnic community as cultural Knowledge. It can be understood as Traditional knowledge (TK) unique to a particular community. Indigenous Knowledge Systems include management of natural environment, learning systems, local classifications, human health, soil and agriculture [2]. Botswana is divided into ten districts, from which a pilot of the audit of Indigenous research has been conducted by the University of Botswana researchers through the Centre for Scientific Research, Indigenous Knowledge and Innovation (CesrIKi) from 2010 to current. One of the main aim being to identify the knowledge domains that exist in Botswana in order to draft the Intellectual Property Rights (IPR) Policy that protects the IK

patents and for documentation [58]. During the research, fourteen knowledge domains were discovered; namely; traditional food, medicinal plants, water prospecting (go dupametsi), traditional games, language, culture, Agriculture (temo), Dress (Kapari), weather forecasting, cosmetic and detergent, hunting and gathering and handcrafts. The aim of the research at CesriKi was to come up with indigenous rights for patents for the protection of their knowledge systems to be secured within an intellectual property regime or through some over- arching legislative or policy framework. Currently this information is documented, albeit without a knowledge base (or some formal representation) to store and disseminate the knowledge. The absence of the knowledge base hinders access of IKS as we move into new ventures of technology. This is to mean that, there is need to exploit ICT to preserve and disseminate IK before its extinction because it is transmitted orally from generation to generation and passed through shared practice, storytelling and will be lost with time as society changes. Numerous individuals particularly, the youthful age are entranced by the new undertakings of innovation which ought to be connected to safeguard IKS [3]. ICTs play a major role in preserving and spreading IK, it provides access to indigenous Knowledge information systems to all people for socio-economic development. It improves the availability of IK systems and it assist in blending modern scientific and technical knowledge [4]. This research proposes an organisational semiotics and ontology for IKS knowledge representation. It gives an outline of the basic concepts of semiotics, revealing that the long-term perspectives on preserving indigenous Knowledge still need a major work, as young generation move into the Technological Era and adopting popular culture.

Semiotic theory is the study of signs to express meaning between a sign and an object in the mind of an interpreter. This study introduced semiotic framework to understand the mechanism of how signs convey contextual information to knowledge representation and illustrate the framework by applying it in an analysis of the signs design in relation to Indigenous Knowledge Systems.

IK should be recognised as an informational activity. It is envisaged that Ontology, being the innovative technology that is used to model data from a specific domain, would support the representation of IK domains that exist in Botswana. We posit that, Ontology-driven systems are proficient in demonstrating a mutual comprehension of organized data within a specific

domain, therefore adopting Ontology technology to represent IK would assist to identify and classify the important concepts.

The main objective of this research is to establish an analytical framework based on the Semiotic Theory to understand, identify, classify, formalise Indigenous Knowledge System in Botswana, and resolve the problems that arise through the modelling of indigenous knowledge management system and knowledge preservation.

In our past research [3], we built up a Cultural knowledge ontology which is an knowledge base that formalizes the IK domain of "Culture" to contribute to the preservation and dissemination of the cultural Knowledge. The Culture domain comprises of subclasses to represent concepts that define the domain [3]. This past research inspired us to implement ICT advances specifically to preserve and disseminate cultural knowledge as people nowadays infrequently visit libraries, museums and government archives to learn and gain knowledge about specific cultural heritages.

As may be obvious, culture is only one small aspect of IK. Therefore a holistic approach that looks at the whole IK domain is needed. The preservation of IKS is a vital action in any society that desires to reflect meaningfully about its past, precisely evaluate its present and make educated decisions for the future. IKS preservation helps to maintain a sense of identity of traditions and heritage for future generation. IKS in Botswana revolves around people's livelihoods to sustain their lives. As echoed by Nfila [5], communities in Botswana highly depend on natural resources for their livelihoods and use their indigenous knowledge to ensure sustainability for their resources and they also use IK for poverty alleviation through communal fields, work parties, and share cropping, storage and protection of seed products, food preparation for nutritional value [5], [6] etc. From a global perspective,

IKS plays a fundamental role in development in African countries; the World Bank has launched the Indigenous Knowledge for Development Programme in 1998 and documented cases that show its importance [7]. This would include cases in Brazil where 47 traditional pharmacies and community-based organizations have been brought together to cultivate medicinal plants, to preserve traditional ecological knowledge and health traditions, and protect biodiversity [60].; In India there is a small tribal group called the Akas, living the sub-Himalayan part of India who owns indigenous knowledge system useful in the conservation of forest resources. Their traditional ways of food gathering like fishing hunting, fishing, and extraction of materials for construction of their houses are sustainable and conservative [61].

These do not exclude the North, East, West and Central African and Southern African Development Countries (SADC) region. The examples include: using local language to improve primary education as a way of instruction in West Africa [8]; Reducing child and maternal mortality in Eritrea and Uganda by providing primary health care [7]; facilitating the eradication of female circumcision by empowering women in Senegal; Helping and educating the communities in Mozambique on how to manage coastal natural resources; and treat malaria by using indigenous medicinal plants in Zimbabwe [7], [8].

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1.2 Research background

Indigenous knowledge systems (IKS) have received increased interest in recent years; however, they are often misinterpreted while they should be recognized like any other knowledge management systems in order to make most of the precious knowledge. In African cultures, specific developmental and environmental problems are solved by indigenous knowledge as people rely on the rich knowledge for sustainability. This has been a norm for many years though it is slowly vanishing as people adapt to modern culture. As proclaimed by the then U.N. Secretary-General Ban Ki-moon he said “their history, traditions, languages, and knowledge are part of the very bedrock of human heritage. Indigenous people can teach the world about sustainable lifestyles and living in harmony with nature” [11].

On the worldwide front, India has an inventive Traditional Knowledge Resource Classification System (TKRC), a organized classification framework, which is demonstrated on the WIPO Universal Obvious Classification (IPC). The TKDL is a interesting, restrictive database that coordinating assorted knowledge systems on Ayurveda, Unani, Siddha, cutting edge science and advanced pharmaceutical that is composed in diverse dialects counting Sanskrit, Arabic, Urdu, Persian, Tamil, English, Japanese, Spanish, French and German. It is based on 148 books of earlier craftsmanship relating to Indian Systems of Pharmaceutical,

accessible at a taken a toll of around US\$1,000. The TKDL interfaces obvious inspectors around the world with these books of knowledge [14] protecting Indian Traditional Knowledge from bio piracy. Australia is considering a few of the necessities for the security of indigenous knowledge and the requirement of tribal standard laws related with knowledge, which has been communicated by Australian Native and Torres Strait Islander communities. In Spain, Cantabria's Cultural Heritage Ontology employs semantic web technologies to make an explicit and brilliant integration of all the information approximately the cultural heritage of Cantabria. The point of the system is to spread cultural heritage of Cantabria by gathering all the data in one location, maintaining a strategic distance from the clients to spend exertion finding sources in registries, web destinations, catalogues, finding helps, inventories, etc.

In Asia indigenous people in Philippines, have thrived sustainable management practices in the woodlot and watersheds collectively known as *Muyongs* in Ifugao communities to help promote forest sustainability. *Muyongs* have remained intact as deemed to be major source of fuel wood, house construction and various edible fruits for the local people [58]. Malaysia also has indigenous based system called Indigenous Herbs Knowledge (MIHK) to preserve their medicinal plants.

Indigenous Knowledge Systems have revealed a positive impact on Africa's development. The World Bank group organization has developed indigenous knowledge database that only focus on Traditional medicine from Sub Sahara African countries waving the other domains of IK. These Sub Sahara African countries include Burkina Faso, Ghana, Kenya, Mali, Mozambique, Senegal, South Africa, Tanzania, and Uganda [7]. This database has a link to knowledge packs of each country for users to easily access indigenous knowledge as per country [7]. However this has become a gap as the focus is only on one domain of IK.

IKS serve as an imperative tool to help Africa in adapting with climate change. In Nigeria, for illustration, indigenous strategies of climate determining are utilized by farmers to complement crop-planning exercises [12]. Tanzania has taken several initiatives towards IK preservation and protection by developing database to enhance capturing, storing, sharing and dissemination of Indigenous knowledge. The Maasai people of Northern Tanzania are pastoralists and have acquired a great deal of knowledge on their environment by practicing

mobile grazing for their animals to utilize a wide variety of forage vegetation types dispersed in the wild. The pastoralists have knowledge and experience of supplementing their cows with diet minerals, to help and protect them from the outbreak of diseases and also improve their growth ,appetite, fertility and milk production [59].

In order to address these challenges, there do exist Institutional research centers in African Universities devoted to promote and manage IKS through different research focus and mandate. The University of Botswana, for example made aCentre for Scientific Research, Indigenous Knowledge and Innovation (CesrIKi) established in 2007, which endeavors to interface scientific research with IKS in collaboration with the Department of Computer Science. It has attempted a few overviews reporting IKS in the nation and advancing IKS among communities. The universty of North West, Limpopo and Venda in South Africa have moreover collaborated to set up a Centre of Excellence in Indigenous Knowledge Studies [13].CESRIKI and the Department of Computer Science at the University of Botswana have embarked on developing an expert system called “Matwetwe system” to preserve medicinal knowledge for traditional healers in Botswana. The main focus of this system is to automate the consultation, diagnosis, medicine dispensary and the medicine preparation process for human beings by the traditional healers [10]. Though the Government of Botswana saw the need to protect Botswana’s Indigenous Knowledge and hence the need for an expert system which will enable the preservation of Botswana’s indigenous knowledge there are still knowledge domains that need to be formalised and preserved.

There moreover exists a Botswana Portal called the society of Botswana accessible at www.botsoc.org.bw which is a non-governmental body, established in 1969, that propels knowledge of Botswana in all disciplines and on all perspectives of the nation's cultural, scientific and environmental legacy. The Botswana Society debates ,collates reports, and disseminate the discoveries of research on Botswana.The Society publishes journals on History of Botswana, language and culture, biography of Botswana leaders, and peoples of Botswana. There are also tourism sites such as <http://www.everyculture.com/Bo-Co/Botswana.html>, <http://www.botswana.co.za/> that disseminates some aspects of Botswana culture. Even though we have all these sites that disseminate our cultural heritage, it is not easy for one to access it as the knowledge is haphazard and the knowledge journals are not available online.

The most dominant aspect of Indigenous Knowledge around the Globe is Traditional Medicine because it plays a major role in global health care, nevertheless this creates a challenge as other domains of IK need to be captured and preserved. The absence frameworks that formalise the knowledge create a gap in the preservation and Dissemination of IK. The research also has found that captures the Indigenous Knowledge; however these ontologies also focus on Traditional Medicine and the Cultural Heritage. The proposed framework aims to identify and formalize the entire domains of IKS in the context of Botswana to close the gaps identified in the management and preservation of IK.

1.3 Main Theories- Ontologies and Semiotic Theory

1.3.1 Indigenous knowledge system Ontology

Ontology as defined by Gruber; *is a formal, explicit specification of a shared conceptualization to enable sharing of a domain* [44]. Ontologies are part of knowledge representation to also enable reuse and integration of a domain of interest. Ontologies have expanded their intrigue towards the preservation and dissemination of different domains and have seen a noteworthy development and broad application in numerous fields such as Knowledge Representation (KR), Knowledge Management (KM), Knowledge Engineering (KN), information retrieval, and semantic web. Ontologies define basic terms, relations of a domain of interest, and rules of inference. Indigenous Knowledge System ontology is reusable entity that would explicitly represent the domain knowledge of IK. Ontologies in knowledge management processes aid in knowledge creation, storage, retrieval, transfer, problem-solving methods, software agents and domain independent applications [9]. One of the objectives of this project is to represent indigenous knowledge by developing the IKS ontology that captures the knowledge domains, in pursuit to solve the problems that arise through the modelling of indigenous knowledge management system [10]. Ontologies are then an illustration of knowledge modelling which represent the explicit knowledge in a manner which a computer can facilitate. This thesis contributes to the cultural, indigenous communities and research scopes in providing evaluation procedures and process, communication techniques and methods in handling of indigenous information and traditional practice which adds to the body of knowledge for both ontology and semiotics.

1.3.2 Semiotic framework

Semiotics is a field of research that studies signs as an essential part of cultural life to express meaning for communication. A sign can be anything that springs immediately to the mind an interpreter in everyday life to make meaning. There are all kinds of signs such as drawings, paintings, photographs, star signs, pub signs, road signs etc.; this is why we say Semiotics is about all the signs. Knowledge is everything; adapting semiotic theory in this research would

assist in conducting empirical research and to provide profound methods, techniques and tools for the development of the envisaged Indigenous knowledge management systems. The Semiotic framework provides procedural guidance in the development of IKS to preserve and disseminate knowledge in Botswana. Since design is concerned with representation, semiotics provide tools for analysing these representations accordingly, providing useful analytical frameworks to model knowledge domains (Ontologies).

1.4 Problem Statement and Contribution to Knowledge

The management, formalizing, preservation and dissemination of Indigenous knowledge has become a problem as there's absence of procedural framework to solve the problems that arise through the modelling of indigenous knowledge management systems. The purpose of this research is then to propose a semiotic framework to understand, classify, and formalise Indigenous Knowledge Systems in Botswana, Such a framework should identify all the knowledge domains of IKS, generate ideas and evaluate answers to solve the problems that arise through the modelling of indigenous knowledge management systems as well as offer guidance in the development of IKS. The government of Botswana have embarked on many innovations such as portals, tourism sites, and also attempted to develop an expert system for traditional medicine to preserve the knowledge, however, there are only limited to certain subsets of the IKS domain, not covering the whole spectrum of the IKS domain [15], [5], [16], [17].

Contribution to Knowledge

This study contributes to the body of knowledge by integrating two knowledge disciplines; Semiotic Theory and the Semantic Web (particularly Ontologies) in order to aid the recognition, preservation and dissemination of IKS in Botswana. The resultant semiotic based framework is one of its kinds contributing to the knowledge of Computer science. This semiotic framework will be a guide to the developers who wish to develop IK management systems and promote IKS in Botswana. The semiotic framework will be a decision making tool for IK, it will be used to determine the significance of existing IK; it will bridge the gap by presenting useful knowledge that will help Indigenous people to empower and organize their knowledge to improve their lives in a conservative and sustainable management practices . The Semiotic framework helps to determine IK that is beneficial which can be improved and collaborated with scientific knowledge in order to pursue the developments of

Botswana. It will also help to regulate IK which can be improved and collaborated with scientific knowledge in order to pursue developments of Botswana. The IKS ontology integrates information from different sources and would structure knowledge data sources and formalises semantics of IKS concepts in order to represent the Indigenous knowledge domains. The ontology will enable effective acquisition of knowledge; it will formalise, capture and preserve the domains of IK in order to renew vanishing cultures.

1.5 Research Objectives and Questions of the study

The research addresses the objectives of the study and research questions as follows;

1.5.1 Research Objective

The main objective of this research is to develop a semiotic based framework to understand, classify and identify domains of IKS and formalise them with Ontology Technology which will serve as a knowledge representation because of its ability to identify classes or concepts, the properties of these classes and relationship that exists between these within a domain of discourse. The study embarks on developing a guiding framework and IKS ontology to preserve and disseminate knowledge with explicit contributions to the body of knowledge.

Specific Objective

- To identify the domains of Indigenous Knowledge Systems from literature as a springboard for developing the proposed semiotic framework.
- To develop a semiotic based framework for understanding, classifying, and understanding IKS in Botswana.
- To formalise the framework by developing the IKS ontology.
- To evaluate the semiotic framework and the IKS ontology

1.5.2 Research questions

- How can semiotic framework be applied to classify and identify Indigenous Knowledge System domains?
- How will establishing the analytical framework be useful in the preservation of IKS?
- What is the contribution of the ontology in the preservation and dissemination of indigenous Knowledge Systems?
- How does Semiotic framework contribute to the formalisation of Indigenous knowledge Systems?

1.6 Expected Outcome and the Significance of the study

This section outlines the expected outcomes of this research and the significance; the expected outcome are sectioned into ICT outcomes and social outcomes

1.6.1 Expected Outcome

ICT Outcome

The ICT outcomes of this research are driven by: (1) establishing the semiotic based framework that would aid in understanding, classifying and formalising Indigenous Knowledge System in Botswana. The framework should identify IKS domains, generate ideas and evaluate answers to solve the problems that arise through the modelling of indigenous knowledge management system as well as offer guidance in the development of IKS. (2) IKS ontology that represent and formalises indigenous knowledge domain. The ontology offers a computer readable formalization of the domain that can be reasoned with.

Social Outcome

The IKS Ontology will aid in the preservation and dissemination of Indigenous knowledge, it will encourage knowledge acquisition, and important knowledge will be accessible to those who want to reflect on their culture. The semiotic framework will act as guidance in the development of IKS and the modelling of indigenous knowledge management system; promote IK and also aide in the recognition of IK by communities in Botswana. The semiotic framework will also assist to identify IK that is present and effective that can in turn be promoted for sustainable developments in Botswana.

1.6.2 Significance of the study

This thesis has appended to two knowledge disciplines, Ontologies and Semiotic framework with explicit contributions to the body of knowledge. It contributes the IKS Ontology which serves as knowledge base for the preservation and dissemination of Indigenous Knowledge in Botswana. It also contributes a semiotic organizational framework based on semiotic suite for assessing the quality of ontology in order to identify, classify, formalise Indigenous Knowledge System.

1.7 Structure of Thesis

This thesis is structured in five chapters. The **first chapter** introduces the topic of discourse and identifies the problem, the objectives, research questions, the importance of the study and how it contributes to the body of Knowledge. The **second chapter** assesses the present status of the problem and identify the gaps that exist in relation to the methodologies used.

The **third chapter** introduces and implements the methods that can be used to solve the existing problem of the research.

The **fourth chapter** discusses the methods used to evaluate the proposed Semiotic framework and IKS ontology.

The **fifth chapter** discusses the evaluation results gained from the proposed framework analysis and summarizes the outcome of the research, recommendations and future work

1.8 Publications

This section indicates publications that contributed to the study of this research.

1. Othusitse. S. D. Phefo, Naledi Kefitile, and Hlomani Hlomani, towards the cultural knowledge ontology, in Information Reuse and Integration (IRI), 2015 IEEE International Conference on, Redwood City, San Francisco, CA, USA. Aug 2015, pp.526–533.9

Chapter 2

2 Literature Review

This section introduces the semiotic theory and IKS in order to comprehend the significance of both subject matter that have been ascribed, and also present the State of the Art on Systems that Manage IKS, and State of the Art on technologies applied for the management of IKS to identify what has been done regarding IKS and bridge the gap.

2.1 Introduction to Semiotic theory

Indigenous Knowledge signifies the technical, cultural, political and institutional aspects of knowledge and value systems within rural and urban communities [6]. According to semiotics theory, we can only know aspects of knowledge by means of signs, through the processes of signification. Semiotics is a field of research that reviews signs as a fundamental piece of social life and communication. Semiotics have two originators: the Swiss linguist Ferdinand de Saussure (died 1913) and the American rationalist Charles Sanders Peirce (passed on 1914)[18]. Semiotic theory is the study in which three types of imagery/signs, and can be categorized depending to how they allow for comprehension [3]. These three types of signs are icons, indexes, and symbols as proclaimed by Charles Sanders Peirce [3], [4]. Semiotics approaches meaning by studying the signs that make up the sign systems for meaningful communication. A sign is anything that can be utilized to express a meaning. As customarily examined by Ferdinand de Saussure [5], a sign is formed from the union of the signifier (the sound-image) and the signified (the concept it represents) [6]. As depicted in Figure 1, Ferdinand de Saussure represented meaning as how an abstract mental concept is expressed in material form through a "sound-image" (i.e., an utterance, a written word, a picture). The two elements are concurrently united, each inducing the recollection of the other. The mental concept is called the signified, and the material sound-image is better known as the signifier

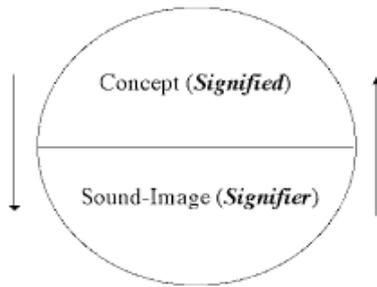


Figure 1 The Saussurian sign [19]

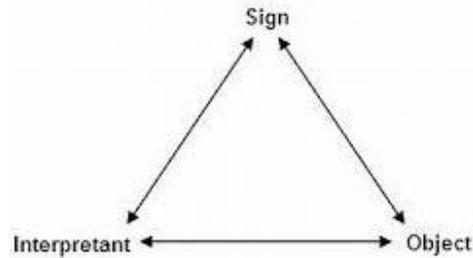


Figure 2 Charles Peirce's semiotic triangle [20]

Figure 2 depicts how Peirce broke the sign down into 3 parts: the representament (like the signifier), the object (the signified), and the interpretant (the sign that we used to translate the first sign). This emphasis on "translation" indicates that meaning always refers back to the signifying system [6]. Peirce referred to this endless chain as the process of "semiosis".

Semiotics is critical for architects as it permits us to get it the connections between signs, what they stand for, and the individuals who must decipher them (pragmatics) [7]. The standard translation of the sign is more often than not given by a semantic work, which allots a unique sentence structure sign to a point in some domain, as well as the variables of the sign to their meaning. Peirce's theory states that there are three branches of semiotics – *semantics* (relating signs to things in the world, coordinating designs of signs to related designs that happen among the things that the signs allude to "logic"), *syntax* (relating signs to one another, "vocabulary") and *pragmatics* (relating signs to the operators that utilize them to allude to things in the world) [8]. As echoed by linguistic C. W. Morris, semiotics is the umbrella beneath which syntax, semantics, pragmatics exist [21]. Semiotics is vital since it can offer assistance to not take "reality" for granted; it educates us that reality is a framework of signs. Studying semiotics can assist us to become more aware of reality as a construction and of the roles played by ourselves and others in constructing it. Semiotics has been used in a range of business areas to create brands. Companies such as Nike, Reebok, Apple and Microsoft etc. use semiotics to build a brand for their merchandise. Brands achieve everlasting presence in consumers through the action of signs. Semiotics can assist us to realize that data or meaning is not "contained" in the world or in books, computers or audio-visual media [9]. We learn from semiotics that we live in a universe of signs and we have no chance to get of understanding anything with the exception of through signs and the codes

into which they are organized out. Semiotics gives us with a possibly binding together conceptual framework and a set of strategies and terms for use over the full range of meaning practices, which incorporate gesture, speech, pose, dress, writing, film, photography, radio and television [9]. In the next chapter, a semiotic framework will be presented to provide the semiotic explorations to knowledge representation design in relation to Indigenous Knowledge Systems.

2.2 Introduction to Ontology

Ontology is a discipline that is part of the knowledge representation to enable knowledge sharing, reuse and integration of a domain of interest[40]. Ontologies have established themselves as one of the key pillars of the semantic web to enable knowledge sharing, and may be built to meet different resolutions for instance to support specification. The term ontology is widespread that few researchers use it in the knowledge engineering and representation field. Ontology has been widely used by academia to represent many real world cases, and emergent of applications have benefited from it. Ontologies play a key role on the semantic web, the development of Wikis and Ontology driven system more so that information is given a well defined meaning. In general terms an ontology is a framework for representing ideas, things we can call concepts and the relationship that exist between those concepts.. As analyzed by Gruber in more detail the three main concepts are central to the definition are “formal”, “domain conceptualization” and “explicit” [40]. “Formal” refers to knowledge representation that is mathematically described and machine readable. A “domain conceptualization” refers to the objects, concepts, and other entities that are assumed to exist within some domain of interest and the relationships that hold among those entities [45]. “Explicit” expresses clear and precise definitions of concepts and their relationships. Gruber puts further emphasis on ontology sharing, in Computer science, the primary goal of ontologies is to enable knowledge sharing that’s the reason why it is said to be a shared conceptualization. Conceptualization are specified by using particular semantic web modeling languages suitable for ontology representation; Examples of these languages include markup scheme to encode knowledge, most commonly with XML, DAML+OI, Ontology Inference Layer (OIL), Web Ontology Language (OWL), Resource Description Framework (RDF), RDF Schema (RDFS), SHOE and others such as , KIF, Ontolingua, UML, EER, LINGO, ORM, CML, DAML+OIL, and F-Logic etc.[61].Such modeling languages are used by researchers to develop the domain of interest using their desired

methodology for Ontology development. The ontology development process is taken into account to be a craft, instead of an engineering activity, and every development team sometimes follows its own design principles, criterion and phases in the development process [63]. However this research opts for a Systematic Ontological Modeling development approach in order to allow formalization to be accomplished progressively and Web Ontology Language (OWL) to model IKS ontology for the preservation and dissemination of the knowledge.

2.3 Introduction to Indigenous Knowledge System

Indigenous knowledge exists in many forms [22]. Indigenous knowledge is commonly understood as traditional/ local or knowledge of Indigenous peoples. IKS definition is hard to comprehend as there is no universal way of defining it. These definitional problems with ‘indigenous,’ ‘traditional’ and ‘local’ in-avoidable affects the classification and identification of the types of knowledge recognized leading to the debate regarding whether or not the term indigenous knowledge ought to be used interchangeably with the term traditional knowledge or whether not, it's more accurately a subset of the traditional knowledge category [23],[24]. However, consolidating all important components of IKS, a workable definition comes into view. IK is known as implicit or rather unstructured, and it is recognized as dynamic and changing because it is passed orally from generation to generation, mother to child, and father to son. IK is commonly tacit because it is stored in people's memory. First, knowledge is acquired through experience, observation or education by recognising, discovering, or learning from current and past generations. Knowledge can be implicit (as with practical skill or expertise) and explicit (as with the theoretical understanding of a subject). Definitions of IK, however, tend to reflect or include the particular focus of those who define it.

Martin Nakata and Marcia Langton define indigenous Knowledge with the same characteristics as IK in Botswana [24]. It is defined as:

“Traditional knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds.

Traditional knowledge is mainly of a practical nature, particularly in such fields as agriculture, fisheries, health, horticulture, and forestry” [6].

The World Bank defines indigenous knowledge as “*Local knowledge that is unique to every culture and society*”. IK is the premises for local-level decision making in: Natural-resource administration, Farming, agriculture, Food planning, Education, and have of other exercises in communities [25].IK is said to incorporate numerous forms. It incorporates cultural heritage in the form of traditional stories, dances, songs and ceremonies that reflect beliefs related to spirituality, family, social equity and land. It incorporates conceivably patentable knowledge about medicinal plants, farm practices, food, handicrafts, artwork, music design and development and agricultural practices. It incorporates knowledge about people, animals, plants, places, and historical occasions related with a specific community.

Indigenous people in Botswana value and appreciate indigenous knowledge because they depend on it for their daily lives. Tribes such as Basarwa and Communities in the Ngamiland around the Okavango Delta are still highly dependent on natural resources such as plant based medicines and cosmetics that are derived from traditional knowledge. IK is widely used to support livelihoods in the Okavango Delta through a range of strategies including fishing, basket making, cultural tourism, use and conservation of a range of natural resources, making and using mekoro (dugout canoes), water divining, and the use of fire – among many others [6]. Research centres at the University of Botswana such as Okavango Research Institute (ORI) and CesriKi have embarked on several surveys to document existing IK. IK as being implicit and of recognized significance, or rather seen as important to the developments motivate this research to identify and classify the knowledge domains in order to alleviate the preservation and dissemination for future generation. It aims to share the indigenous Knowledge with the communities, enrich, develop the knowledge, and aid the sharing of discoveries and innovation by scientists.

The management of Ik is a crucial activity as the bearers of the knowledge are old people should they die, the knowledge and wisdom will be lost forever. The World Bank launched the Indigenous Knowledge for Development Program in 1998 and came up with the stages that could be taken to assist communities and governments to integrate indigenous knowledge into the development process. The steps include recognition and identification, validation,

recording and documentation, storage in retrievable repositories, transfer and dissemination.

The six [4] essential steps are further elaborated as follows:

- **Recognition and identification:** Indigenous Knowledge can be capacitated a blend of advancements or in social esteems, interpreting them unrecognizable at first look to the viewer (specialized and social investigations may, subsequently, be required to distinguish IK)
- **Validation:** This includes an appraisal of IK's importance and significance (to solving problems), dependability (i.e., not being an incidental event), and usefulness (how well does it work?),
- **Effectiveness and transferability;** recording and documentation is a major challenge in light of the unsaid idea of IK (it is commonly traded through individual correspondence from ace to understudy, from parent to tyke, and so on.). Now and again, modern tools could be utilized, while in different conditions it might be fitting to depend on more customary techniques (e.g., taped narration, illustrations);
- **Storage in retrievable repositories:** Storage is not limited to text document or electronic format; it can comprise films' tapes, gene banks, storytelling, etc. .
- **Transfer:** This step goes past simply passing on the learning to the beneficiary; it likewise incorporates the testing of the information in the new environment. Pilots are the most fitting methodology in this step; and .
- **Dissemination** to a more wider group adds the formative measurement to the exchange of knowledge and could advance a more extensive and more profound swell effect of the knowledge transfer

The IK centres focuses to expand group based contribution to planning and development, additionally planning to oversee IK on technical base. For managing indigenous knowledge[26] and applying IK in development processes a framework for action revolving around four pillars is proposed including:

1. Disseminating information:

A database of IK can be developed containing IK, sources practices and lessons learned and partners;

- Testing instruments for the identification of IK to capture and disseminate it

2. Facilitating exchange of IK among developing countries:

- IK can be shared with the help of IK centres helping build local capacity.

- Identifying acceptable strategies of capturing, distributing IK among communities;
- Facilitating a worldwide network to exchange IK.

3. *Applying IK in the development process:*

- Raising awareness of the importance of IK among development accomplices; Communication and Management in Technological Innovation and educational globalisation
- Assisting countries to formulate national policies in support of indigenous practices;
- Integrating indigenous practices in programs/projects supported by partners.

4. *Building partnerships:*

- Learning from NGOs and local communities ;
- Leveraging restricted assets of accomplices to get superior impact on the ground;
- Addressing the intellectual property rights issue of indigenous knowledge.

2.4 State of the Art on Systems that Manage IKS

This section discusses the systems that manage IKS around the globe with regard to what has been done to promote Indigenous Knowledge. ICT plays a major role in the preservation and dissemination of IKS to protect endangered cultures. Indigenous communities are now realising the importance of preserving IK and beginning to realize the potential benefits which digital technologies play to disseminate. The expanded capacity to share data, including pictures, photos, movies and substantially more, effectively ensures the transmission of culture to future generation in the community of origin. The significant domain of IKS around the globe is the Traditional medicine, because it plays a major role in global health care. Traditional medicine is easily accessible, cost effective and because of its indigenous nature, every country and communities in the world find it imperative to preserve it.

The special developments in Indigenous Australia [32] incorporate the improvement of the Ara Irititja computer program and venture, created by Martin Hughes and John Dallwitz,

at first as a venture claimed by the Anangu individuals of the Pitjantjatjara communities. This computer program has been received in numerous parts of Australia, considering a few of the prerequisites for the security of indigenous knowledge and the authorization of tribal standard laws related with knowledge, which have been communicated by Australian Native and Torres Strait Islander communities. It surveys the capacity of the two major XML-based rights mark-up dialects XrML and Open Computerized Rights Dialect (ODRL) to fulfill these necessities and recommends expansions to these languages to make strides their support for indigenous knowledge protection. The system belonging to the aboriginal will support the customary laws with respect to gaining access to the Knowledge of Aboriginal indigenous groups. Indigenous groups have recorded and preserved important aspects of their cultures including ceremonies, artwork, stories, languages, dances, tools, songs, symbols, historical photographs, design, and costumes using multimedia technologies,. The designed extensions will in this manner empower input, feedback and proposals from indigenous communities. This will empower a clearer understanding of their differing necessities with regard to the protection of intellectual property and traditional knowledge and the advancement of a palatable solution through future collaboration. The system comprises of three major components: The Metadata Editor/Generator, The Database, The Look, Recovery and Introduction Interface [22], [23]

Canada's indigenous people are enhancing scientific research programs. For example, in a whale-labelling program including local, indigenous knowledge tackled issues with the techniques being utilized to label the whales. New labelling procedures created with local were extremely prosperous [62].

Tanzania has taken several initiatives towards IK preservation and protection. Development Gateway database of the Economic and Social Research Foundation (ESRF) has developed a database on IK to enhance capturing, storing, sharing and dissemination of Indigenous knowledge, experiences and practices in Tanzania and integrates it with modern science and technology to enhance dissemination [17].

2.4.1 Traditional medicine database systems

The World Bank group organization has developed indigenous knowledge database and practices with the objective to enable the development community to learn more about the

indigenous/traditional practices in local communities so as to better adapt global knowledge to local conditions, and to design activities to better serve the community needs [7]. The database have knowledge Packs which provide users with quick access to synthesis of country-specific cases of indigenous/traditional practices, in-country sources of knowledge, and Bank supported projects related to IK issues. Countries such as Ghana, Kenya, Mali, Mozambique, Senegal and Uganda have Knowledge Packs which contain Indigenous Knowledge cases and other useful information country related. The knowledge packs provides users with quick access to synthesized information by country or selected thematic area. This database encourages knowledge sharing worldwide. Users are allowed to comment and contribute to new cases however it is possible some contributed knowledge to be wrong. World Traditional Medicine Patent Database and its applications (WTMPD) is a bilingual (Chinese/English) natural/traditional medicine patent database which covers more than 200 traditional Chinese medicine formulas collected from 20+ countries [23]. The languages of the source patents include, Japanese, Korean, Russian, German, French and Spanish China. The database has different searches for retrieval of traditional medicine contents. It has natural medicine search, bibliographic data search, enhanced subject search, formula similarity search and chemical structure search. Querying information is efficient as it has a deep-indexed/precise search for traditional medicine compared with other databases. The limitation of these databases is that it focuses only on medicinal plants.

The Indian Systems of medicine, Traditional Knowledge Digital Library (TKDL) is an online knowledge repository for traditional medicine established by the government of India, and available in local language (Hindi, Arabic, Persian, Urdu,etc.). The knowledge repository contains definitions, principles, drug formulations and concepts of the traditional medicines of India. The knowledge of traditional medicine can be transcribed into 5 international languages (English, French, German, Spanish and Japanese). The TKDL repository venture built up a classification system, Traditional Knowledge Resource Classification (TKRC) in light of the International Patent Classification (IPC) structure [12].Traditional Knowledge is translated in TKRC images by utilizing Unicode, XML and Metadata procedure. TKDL stores knowledge in a content based database without formal ontologies.

So absence of ontologies or comparative formal structure decreases its degree. Another constraint is that TKDL is that it can't offer web-services, which are required for reconciliation with other programming applications. Third significant issue is that in TKDL

keyword based manual inquiries are permitted, however semantic questions are impractical. So in the present shape TKDL does not bolster semantic web, which expects ontologies to structure information for extendibility, reusability and automatic machine processing. To empower TKDL for semantic web, formal ontologies, web-services and semantic query support is required that fills in as a base for Unani medicine computerization [12]. A Malaysia indigenous herb is an Ontology driven representation of Herbs. The herbs knowledge mainly in preparation methods and plants part uses is collected from literatures and experts in herbal field.

In Botswana there's Dingaka database that stores information on medicinal plants, types of diseases, and traditional healers etc. The database has a search designed to extract both plant names and medicinal uses. It also then takes a plant name against medicinal uses, and gives the list of medicinal uses for a given plant. The database is fully functional and will be hosted soon at University of Botswana however it is not ontology driven.

2.4.2 Ontology-driven knowledge management systems

Ontology of Cantabria's Cultural Heritage system has adopted an ontology approach for the system. The aim is to utilize Semantic Web advancements for savvy incorporation of data about Cantabria region and heritage. It incorporates all sort of cultural heritages, from bibliographic things, to industrial patrimony, or to ancient excavations for this Spanish area. To accomplish this goal, the project will design, develop, sustain and exploit cultural heritage ontology. Its aim also is to build up a procedure for the ontology population and exploitation for different areas of Spain, or even outside Spain [27]. The system also gives rich route, semantic applications, including: Semantic Search Engine, which permits to discover data from the philosophy utilizing queries [28]. The objective of this a system was to gather all the knowledge in one site so users will spend less time and work to discover sources in web sites, directories, inventories, catalogues, finding aids etc. The Ontology decided to use RDF representation of CIDOC CRM in version 2, and combined it with FRBRoo and DUBLin Core which is a complimentary model for generic schema in order to represent knowledge in different domains.

The MIHK system uses an ontology approach [18]. The system uses Web Ontology Language (OWL) to capture and represent Indigenous Knowledge that focuses on the

preparation methods of medicinal herbs. Ontology-based knowledge representation model can be used to encode and store knowledge in a “Knowledge Base “such as repositories, libraries and databases. The Ontology-based knowledge representation model can also enhance search formulation to retrieve herbal knowledge fast, effortlessly and accurate.

The disadvantage of this model is that, the backend database that is grounded on OWL language needs to be transformed to the relational database format that is based on the OWL2DB algorithm.

African Traditional Medicine (ATM) is controlled by a multi-agent system for knowledge management system. The system was started by integrating some existing ontologies and part of modern medicine ontologies such as human disease, plant structure and disease transmission that could be used in the Ontology. Building an ATM knowledge management system required the initial a formalization of ATM concepts and their relationships [29].The concepts are structured to bring data into a well structure representation. The reason for building the ATM Ontology was predominantly to preserve the ATM information source.

In concrete, the subsequent ontologies are taken into consideration as a result of they are closed and may be thought-about additionally as a part of the domain, as medication issue not general: the employment of the ATM Ontology meant to market reprocess and integration of knowledge from numerous sources [29].

2.4.3 Library digitized knowledge systems

Traditional Knowledge Digital Library (TKDL) in Asian nation is made to systematise traditional knowledge on Indian Systems of medication, which are Unani, Ayurveda, Yoga, and Siddha. As in February 2009, eighty one thousand, three hundred formulations in Ayurveda, 1 09 000 formulations from Unani and twelve thousand, two hundred formulations from Siddha are completed and with reference to Yoga five hundred Postures are transcribed. Up to now a complete of 2 02 500 medicinal formulations are transcribed and therefore the info is gift in thirty million A4 sized pages [24]. Following the success of the Indian system, different South Asian countries (Bangladesh, Bhutan, Maldives, Nepal, Asian country and Sri Lanka) that square measure members of the South Asian Association for Regional Cooperation (SAARC), have set to make a composite digital library that may network the TKDL from every country [30]. The SAARC and TKDL can offer a standardized system for organising, distributive and retrieving traditional knowledge seamlessly across regions or

countries. Accessible via the web, the library can at the start contain info on ancient drugs including: materials used for treatment e.g., plants, animal merchandise, minerals, their generic or specific methodology of preparations or styles , their indefinite quantity, mode and time of administration, their therapeutic action or application

2.5 Literature Review Conclusion

Through the survey of literature, we have realised that the most dominant aspect of Indigenous Knowledge around the Globe is Traditional Medicine. The most literature reviewed focused on preserving one domain of IKS which is traditional medicine, except for Cantabria's Cultural Heritage which captures 11 types of culture, specifically for Cantabria and Aboriginal in Australia which preserve the important aspects of their cultures. The research also has found that ontologies that exist are of cultural domain knowledge. Ontologies reviewed in this study are the Traditional Medicine Ontology and the Cultural Heritage Ontology. In my last research I reviewed the agricultural ontology, food Ontology, and the Music & Art Ontology. The single most important gap in existing research is in providing a holistic view to IKS. This dissertation's proposed framework aims to identify and formalize the entire domains of IKS in the context of Botswana

Chapter 3

3 The Research Methodology and the Proposed Framework

Research methodology is an efficient way to solve a problem. Then again, it can be characterized as the methods by which researchers go around their work of portraying, explaining and anticipating a phenomena [33]. Using a software engineering methodology, we have adopted the Waterfall model as is best suited for Knowledge management systems as it focuses on knowledge processing. Knowledge management encompasses processing stages such as to; discover knowledge, Understand knowledge, ,acquire knowledge after obtaining it from different sources, Select, filter and classify the existing knowledge, outline storing structures for saving knowledge, Design ontology of knowledge, Generate, adapt or create new knowledge, Measure or evaluate knowledge, Envisage knowledge; Dispense or transfer knowledge to other individuals or organizations , Indorse, share, use/apply and sell knowledge, Preserve and sustain knowledge as an asset[65]. For the purposes of this research we covered some aspects of KM and phases which are beneficial for the development the research design and a springboard to design the Semiotic Framework as shown in figure 3.

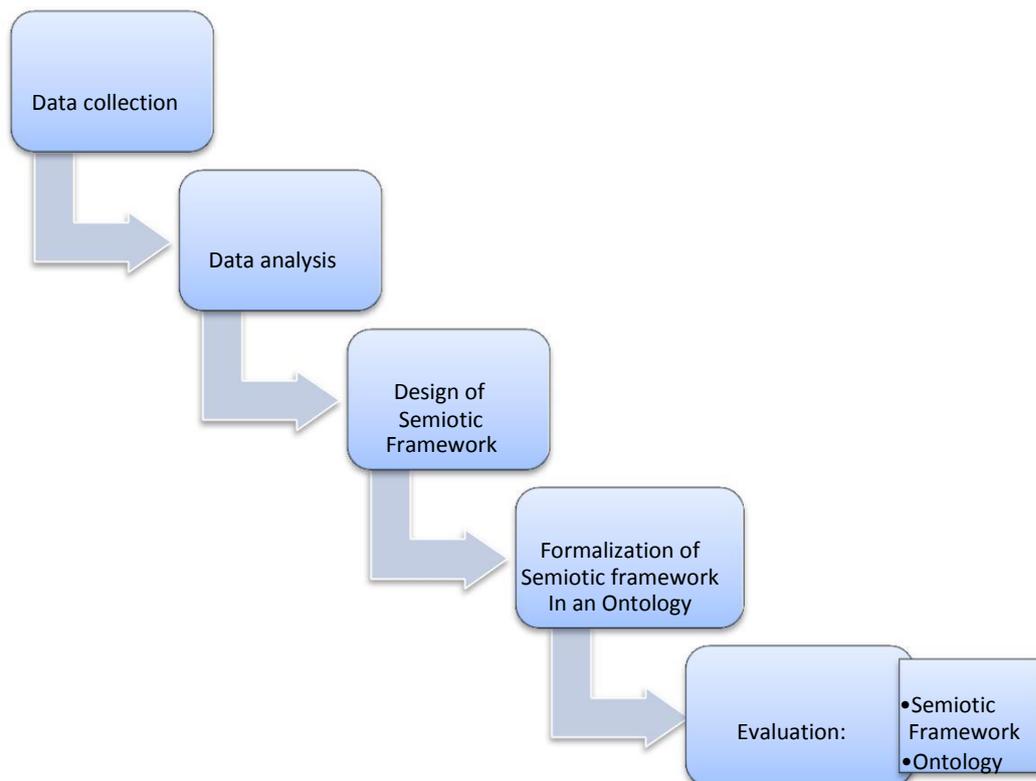


Figure 3 the Water fall phases established for the development of the research design.

3.1 Data collection

This research is based on secondary data as well as collecting primary data through documentation of what the respondents know and think about the IKS. The research questionnaire was developed as the primary data collection tool for the study, which was administered for the respondents during field work. The intended population for this research was the residents of Palapye in the Central district of Botswana from diverse backgrounds. The sample size is 31 participants divided into three groups to evaluate 120 Knowledge concepts. The individuals were recruited using random sampling. I Re-arranged. Secondary data was obtained through published information resources. These include journals, conference papers, books, government publications, museums, government policies and guideline plans, surveys, and seminar papers. Such resources have contributed reasonably diverse dimensions of the subject matter.

3.2 Data analysis

After the collection of Secondary data from different sources, conceptual maps were used to brainstorm and model the IKS domains. Fourteen knowledge domains were conceptualized and child concepts were derived from the domains. The Protégé ontology editor was used to construct the domain models and Develop IKS ontology. The Ontology was loaded in Net beans IDE to count the number of Axioms, Classes, and Object Properties in order to evaluate the quality of the Ontology. The primary data for this research was collected by conducting both qualitative and quantitate research methods; qualitative responses were quantified. A closed ended questionnaire was administered to respondents and statistically analysed with a Statistical Package for the Social Sciences (SPSS) to investigate the study

3.3 Design of Semiotic Framework

Semiotics is concerned with the creation, representation and interpretation of signs by utilising symbols to convey Knowledge. Knowledge can be represented by a variety of means, from plain natural language text to multimedia hypertext to executable rules and frames. While problem solving is a general principle of design plan, certain semiotics should be specified for better understanding to establish models. To design means to build or structure system of signs in such a way that communication is possible for achievement of human goals: knowledge engineering, architecture, art, education, etc. The design process is a

co-evolution of signs and concept. African cultures, or just any other cultures of the world, utilize symbols to express and convey meanings, verbally and nonverbally. In pursuit of developing a semiotic based framework and classifying IKS, first we need to know the prevalence of IKS in Botswana, Figure 4 depicts the process to reflect on. The prevalence of the knowledge ultimately leads to identifying the status of IKS which include defining the knowledge, relevance and existence. Determining the status of IKS is a prospect to represent and preserve the knowledge in a repository or rather Indigenous Knowledge management system (IKMS) for sustainable developments.

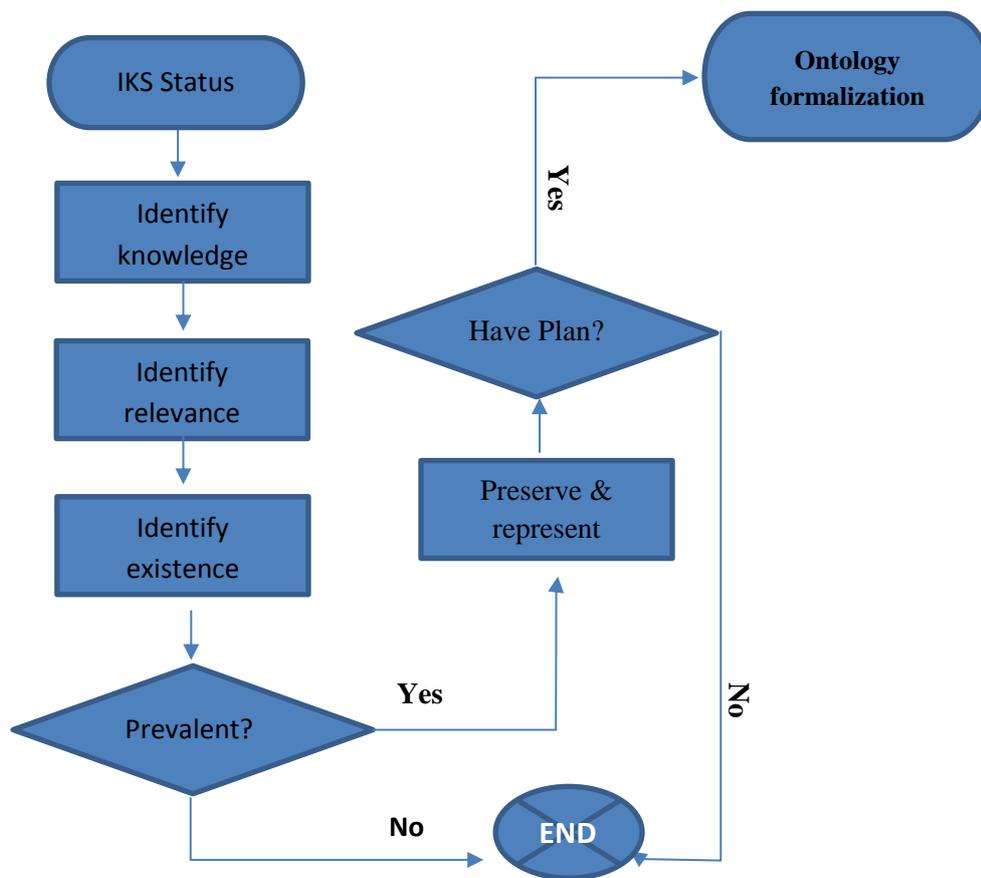


Figure 4 The process flow diagram indicating how to determine the prevalence of IKS in Botswana.

3.3.1 Semiotic Framework

The Table 1 presents the proposed framework to help understand, classify, formalise Indigenous Knowledge System in Botswana. The framework is informed by the social aspect of ontology quality and relatively covers the branches of semiotics, semantic, pragmatic and syntactic in order to assess the quality of the ontology [34]. The branches of semiotics (as

shown in Table 1), makes explicit reference to the IKS statuses of IKS as in depicted in Figure 4.

Table 1: The semiotic framework derived from the process flow diagram determining the prevalence of IKS in Botswana

<i>Branches</i>	<i>Statuses of IKS</i>	<i>Interpretations</i>
<i>Semantic</i>	Knowledge	Semantic (Can it be understood?). Knowledge is concerned with whether the society realizes, understand and acknowledge IKS.
<i>Pragmatic</i>	Relevance	Pragmatic (Is it useful?). Relevance is an aspect of determining the importance and usefulness of IKS with regard to the society's perspective.
<i>Social</i>	Existence	Social (Can it be trusted?). Existence of IKS is concerned with the awareness of IK domains that are practised, promoted and recognised.
<i>Syntactic</i>	Preservation and representation	Syntactic (Can it be read?). It is concerned with preserving IKS using different technologies like the semantic web, ontologies, video representations sessions, Indigenous Knowledge Management Systems and so on.

The Semantic Dimension of the Framework

IKs is understood as sign inventories and defining IKS domains as signs also allows us to analyse the relation of the domains and their respective context. Semantics is the study that expresses the meaning of signs or the mapping between signs and what they represent. The semantic branch of semiotics is concerned with the connotative or denotative meaning of a sign concepts, abstractions and interpretations. The status of IKS “knowledge” seeks to recognise, collect, document, restore and exhibit Indigenous Knowledge System (IKS), in order to protect, preserve and promote the existence. Recognition of IKS is an aspect of denoting the domains of IKs by classifying them first as depicted in Table 2.

Table 2: Classification of Indigenous domain and interpretation

Indigenous Knowledge System Domains	Interpretation
Culture	Is knowledge of a particular people who live in the same area and is characterised by language, livelihood, food, religion and social habits.
Traditional medicine	Traditional medicine is the sum total of the knowledge, skills, and practices based on the theories, beliefs, and experiences of indigenous to different cultures used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness. [35].
Traditional food	Traditional food alludes to foods and dishes that are passed through generations and also refers to foods devoured over the long-term length of civilization that have been passed through eras [36].
Language	Is a method of human communication by a particular community or country that can be spoken or written to relay the message or a system of signs that are used by particular people to express feelings and thoughts?
Music and dance	It is a traditional composition of music and dance specifically to facilitate dancing, to celebrate and relay historic events in the way people interact and communicate with each other.
Water prospecting	It is identifying the presence of ground water at a particular test site.
Hunting and gathering	It is surviving by hunting animals and gathering plants for subsistence, it involves fishing, gathering wild fruits, berries, nuts, and vegetables.
Traditional Games	Traditional games are motor activities of leisure and recreation which can have a ritual character practiced in an individual or collective manner, deriving from regional or

	local identity; they are based on rules accepted by a group that organizes competitive or non-competitive activities [37].
Weather forecasting	Weather forecasting is a prediction of what the weather will be like in an hour, tomorrow, or next week by applying science and technology to predict the state of the atmosphere for a given location.
Agriculture	Is the rearing of cattle and planting of crops to provide food and other products, is a practice that includes of farming, cultivation of the soil for the growing of crops.
Art and Hand crafts	It is a skilled activity for making decorative domestic or objects or craft (weaving or pottery making) that requires skill with the hands in a traditional way e.g. painting decorations, furniture, pottery ,woodworking, sewing etc.
Traditional dress	Is an outfit worn by a group of people who share a common background and heritage to identify their specific culture
Cosmetic and detergent	Cosmetics and detergent body products that are used to cleanse and protect of external parts of our bodies, while A detergent is a chemical compound or mixture of compounds used as a cleaning agent derived from plants and animals.
Wild fruits	Edible fruits harvested in the forest to sustain hunger and for nutritional deficiency in diets.

The Syntactic Dimension of the Framework

Syntactic dimensions of the framework represent the way to recognize signs and understand their relations. The preservation and representation of IKS embodies different methods like the semantic web, ontologies, video representations sessions, and Indigenous Knowledge Management Systems. Knowledge representation is expressed in relation to a specific language or tools for representing and manipulating signs. Examples of tools and representation languages are conceptual modelling languages, Web ontology Language

(OWL) and programming languages. Syntactically, a representation language is defined as a collection of symbols and rules for building formulas and equations. The Syntactic aspect is concerned with how things are formed, the syntax, rules, ideas, data, signals, documents, codes, and systems. The development tools and languages such as Protégé, Java, PHP, MySQL etc, lend a suitable syntactical basis in representation.

The Pragmatics Dimension of the Framework

Pragmatics is concerned with knowledge, beliefs, opinions and feeling of a person. In the context for understanding the principles of signs in pragmatic aspect, pragmatics realizes how signs make a difference and create an impact in people's social lives. Pragmatics is concerned with building up on the results of syntactic and semantic principle based on the knowledge. It is concerned with relationship between signs and behaviour of the responsible agents e.g. End users, administrator and developers. The society/ users of Indigenous Knowledge are the ones to determine the relevance of IKS and their perception is taken into consideration for the development of IKMS. Entities of knowledge that are defined as "pragmatics" represent personnel that are considered in the development of IKMS.

The Social Dimension of the Framework

Social semiotics is a branch of the field of semiotics which investigates human signifying practices in specific social and cultural circumstances, and which tries to explain meaning-making as a social practice [38]. Social semiotics focuses on social meaning-making practices of all types, whether visual, verbal or aural in nature thus making information (Semantic and Pragmatic) that becomes knowledge in the Social World. Social semiotics reflects the existence of IKS and is also concerned with the perception of IK domains that are recognised, practised, and promoted.

3.3.2 Application of the framework in knowledge engineering

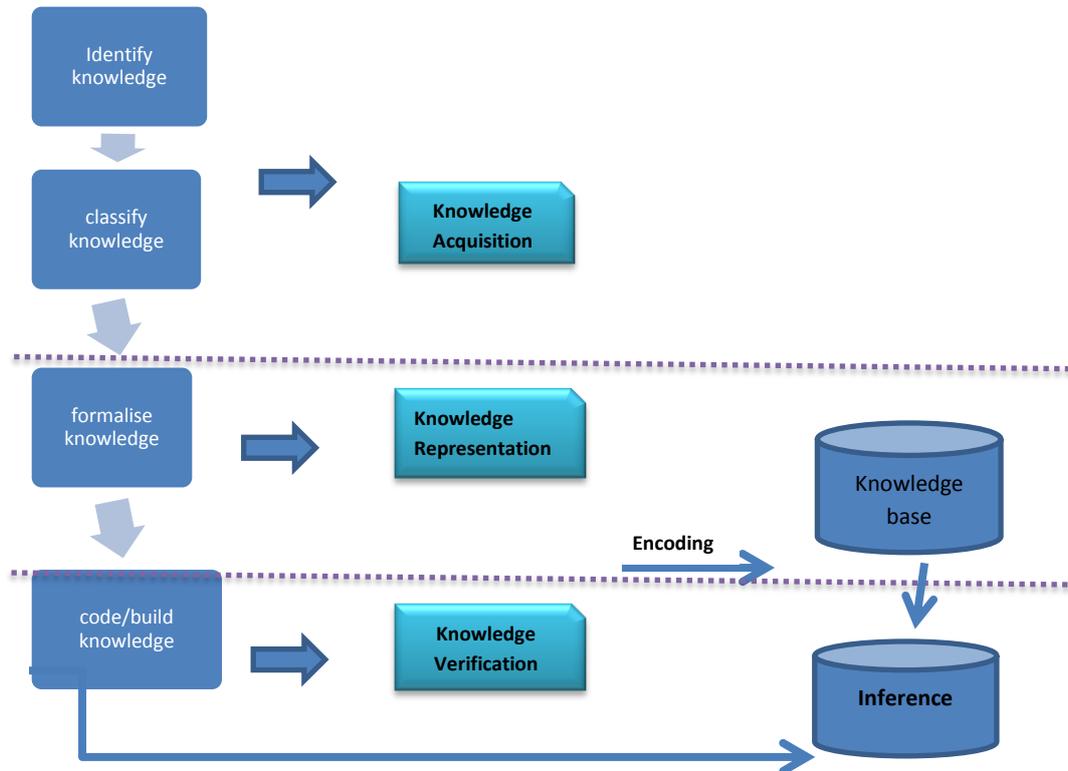


Figure 5 Application of the framework realised in Knowledge engineering Process

Knowledge engineering addresses the structuring and representation of knowledge [40], and it plays a very important role in the development of various information systems especially the knowledge based systems. Knowledge engineering is the first step taken to implement knowledge based system and a foundation to establish representation structures that classifies and formalise knowledge. It provides guidance about when and how to apply particular knowledge-presentation techniques for solving particular problems [39]. Based on the analysis of semiotic branches, there are four activities identified as being the most common in the knowledge engineering process, see Figure 5, and Table 3 for summaries of the semiotics framework's activities.

Table 3: Application of the semiotic framework summarised in knowledge engineering

Semiotic Branches	Activities	Descriptions
Semantics	Knowledge Acquisition	Knowledge acquisition involves elicitation of knowledge from human expert, books, records, documents, forums, collaboration, socialisation, observation and imitation.
Syntactic	Knowledge Representation	Acquired knowledge is organised so that it will be ready for use. This involves encoding the knowledge in a knowledge base e.g. ontologies thus become machine interpretable.
Pragmatic	Knowledge Verification	This involves validating the knowledge using test case until its quality is acceptable
Social	Inference	This involves the design of software to enable the computer to make inference based on the stored knowledge.

Knowledge acquisition is based on *Semantic*; knowledge representation is based on *syntactic* while knowledge verification is based on *Pragmatics* and inference based on *Social level*.

The Semantic

Knowledge acquisition is the process of getting knowledge from experts and once the knowledge is acquired it has to be represented by selecting the most appropriate structures to represent it. In pursuit of organizing knowledge and modelling for the management system, one may ask questions such as, what IKS is. How is it acquired? Where is it acquired and how is it preserved? Can computers understand the meaning from the information they process and create knowledge? Such questions give ideas on how semantic interpretation of a formal sign system can be made essential to the development of a system using our cognitive mind of modelling.

The Syntactic

Knowledge representation is the application of logic and ontology to the task of constructing computable models for some domain[40]. With regard to this research ontology is a representation scheme for acquired IK. Knowledge representation reflects *syntactic branch* of semiotics as it deals with the structure and tools for representing the knowledge. Ontologies and conceptual modelling languages lend the role of representing acquired knowledge. This involves encoding the knowledge in a knowledge base.

The Pragmatics

Knowledge verification is testing that the knowledge of a system is correct and complete. . For the development of IKMS pragmatics involves validating the knowledge using test case until its quality is acceptable. Many computer based information systems are designed without regard for pragmatics issues. The following pragmatic issues should be considered when developing a management system:

- Usability requirements of the system in terms of Effectiveness, Efficiency, Engaging, Error Tolerant, and Easy to Learn.
- The performance of the system in terms of capacity, availability and latency

3.4 Formalisation of Semiotic Framework in an Ontology

Having established the semiotic framework, it is now time to establish a method for formalizing the framework in the form of ontology.

3.4.1 Generic View to Ontology Development

It is a norm that the development of Ontology is done by a team of people such as domain experts and ontological engineers. There are phases that should be considered during the development of ontology. The main Objective of developing ontology is to share a common understanding of the structure of information among people or software agents, to enable reuse of domain knowledge. Figure 4 depicts the general phases in the design and development of the ontology. The ontology development process comprises of:

- Requirement Specification [Purpose and scope] - in this first phase, one should determine the source and what domain the ontology will cover. It is important to

address the purpose and scope to be clear about why the ontology is being built and what its intended uses is.

- **Ontology capture** – this second step ascertain the existing ontologies, if they exist then, they can be modified, reused and integrated with the new one. In this phase, the domain conceptualization is encountered based on the competence of the ontology.
- **Ontology formalization** - at this phase, conceptualization is captured in a formal language. As soon as the relevant concepts are identified, they should be classified in a hierarchy, the relations and properties of the concepts should be defined. There are different approaches that could be used when defining hierarchy of classes, one could use *top down approach* which defines the main concepts of the domain first then clustering them down specific ones, or the *bottom up approach* which entails defining specific concepts to form clusters of general concepts, or *iterative approach*.
- **Evaluation and Documentation** - the ontology should be evaluated to ascertain whether or not it satisfies the requirements specification. It ought to even be evaluated in regard to the ontology competence and a few style quality criteria , like those planned by Gruber and alternative authors[41], [42],[43].. Documentation is the last phase which entails documenting the purpose of the ontology, descriptions of the conceptualization as well as the requirement satisfied.

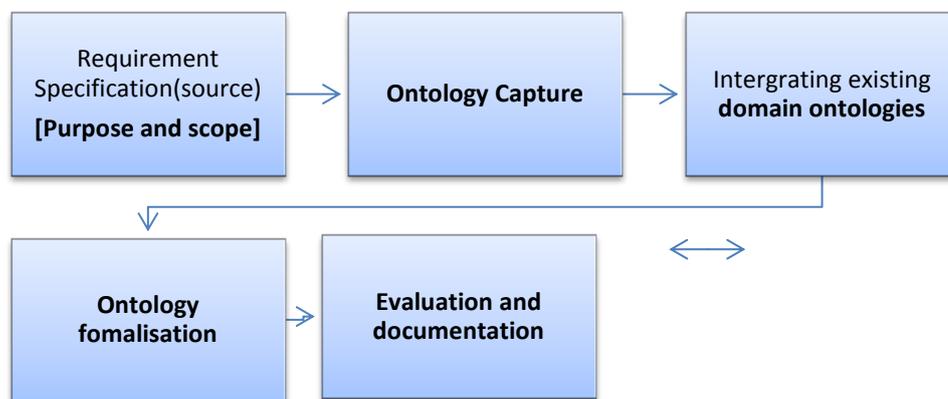


Figure 6: the general process for Ontology development

3.4.2 Specific view to Ontology Development

This section addresses the development steps taken to reach the research goal of developing the IKS Ontology .We go back to the proclamation of linguist Gruber defining the ontology *conceptualization*. The specification of a conceptualization involves the steps that should be taken when developing Ontology. The development of the ontology will entail the

requirement to identify the purpose, scope, the domain of the ontology as well as the source of the domain knowledge using a systematic approach. The ontology development process (see Figure 6) was refined and applied to the modeling of the IKS ontology in order to probe the research goal.

Purpose and Scope

The purpose of this research is to design and develop an ontology that formalizes indigenous knowledge domains with the motive to preserve and disseminate the indigenous knowledge. The research address the research question outlined in the beginning and aims to answer the third research question-*What is the contribution of the ontology in the preservation and dissemination of indigenous Knowledge Systems?*

The scope of the ontology addresses the fourteen knowledge domains of the IKS. In our previous research titled: *Towards cultural knowledge ontology* [3], the scope of the ontology was limited as it only addressed one domain of IKs “*Culture*”. In developing this ontology, we gathered information from rigorous review of the current literature to come up with relevant concepts for the cultural ontology. We then grouped the concepts in structured and workable corresponding subgroups in order to determine the relationship. The same methodology was followed for this research but covering a large scope of the IKS domain. In the context of this research, the first relationship determined is the *is_a_domain* and *consist_of* to express the semantics between the concepts.

Domain and Source

The domain of interest as mentioned before is IKS. Indigenous Knowledge Systems produce a large number of concepts and associated relationships and this could test the third question as it contributes to the body of knowledge- *What impact will the ontology have in the implementation of IKS Knowledge Ontology.* The top level concepts of the IKS ontology Are *Traditional_Food, Traditional_Medicine, Water_Propecting, Traditional_Games, Language, Culture, Agriculture, Traditional Dress, Art and Music, Weather_Forecasting, Cosmetic_And _Detergent, Hunting_And_Gathering, Wild_Fruit, Culture* and *Handcrafts*. These top level concepts were sourced from the IKS draft policy published by the Centre for Scientific Research, Indigenous Knowledge and Innovation (CeSriki) at the University of Botswana and some of the subclass were sourced from Literature[46]. We did not use any existing ontology the ontology was built from the ground up

A Systematic Approach to Ontological Modeling

The proposed methodology for ontology development in Figure 7, adapted from Sinead Boyce [45], comprises of a number of contextual, high-level choices that an associate ontology developer needs to build before selecting specific development.. The ontology development steps that were presented in Figure 6 extends a summarized methodology for IKS, the study used same way to collect and classify the key concepts of the domain of interest and additionally build partial taxonomies of the known concepts and outline some preliminary relationships in the ontology. A top down approach is used to build taxonomies and concepts are identified then advanced by presenting concept properties.

The identified concepts are further improved by presenting concepts properties and forcing important and adequate conditions on the concepts built on Description Logics (DL), [47] semantic model and Web Ontology Language (OWL) syntactic format. The output of this stage is thought to be the structural knowledge of the domain of interest.

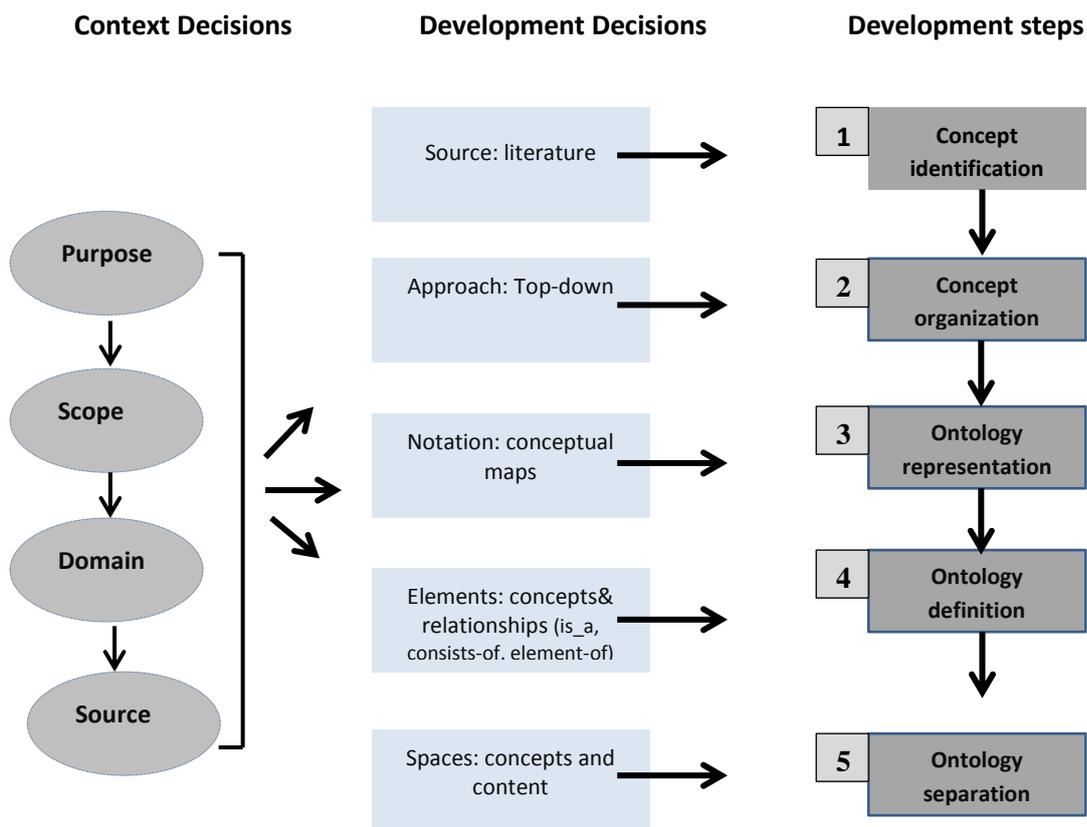


Figure 7: A summarized methodology of IKS ontology development adapted from source [45]

3.5 The Evaluation Approach

This section deliberates the Evaluation of Semiotics Framework and IKS Ontology.

3.5.1 The Evaluation of Semiotics Framework

Experiments regarding the evaluation of semiotic framework were conducted in three groups of participants.

Empirical Study

Group 1: Knowledge about IKS

Contributors/Participants

Ten students from The Botswana International University of Science and Technology (Biust) were recruited as knowledge participants, because they have internet access and acquire most of the knowledge from the web and they are familiar with technology. The students were divided into the groups of two, five boys and girls from different backgrounds to examine how well they know about the Indigenous Knowledge systems.

Method

The test was conducted by selecting 10 concepts/sign attributes of indigenous knowledge from each domain, a total of 140 concepts were used to test the IK in students. Five students were allowed to search the concepts they don't know from the internet while five were not allowed to do so. The Test was conducted to gather the interpretations of 140 signs and test their awareness regarding indigenous knowledge systems. The truth of their interpretation and the effort it took to decode the meaning of the concepts were registered on a questionnaire provided. For every sign attribute each participants were asked to provide the domain it falls under if they thought their prior interpretation was accurate. The sessions lasted 20 min and were time recorded. , qualitative and quantitative data were collected, through questionnaires. Qualitative data was analysed to classify attributes relevant to the evaluation of domains. Attributes which were misunderstood by participant, were indicated by using variables yes/No in questionnaire. Variables yes/ No were used to determine whether concept signs were interpreted accurately in order to find the states of IKS domains under study. For example, if a participant does not know what concept sign-**Serala** or **mosukujane was**, they must they respond with yes or No.

Group 2: Relevance of IKS

Contributors/Participants

Sixteen youth group were selected to determine if they think IKS is relevant or not. All participants were adolescent residing in Palapye village aged between 10 and 20 selected randomly from different households. Eight females and 8 males were test subjects.

Method

The same procedure was carried out as in group 1; the same 140 concepts were used to determine the relevance of IKS. The participants were not allowed to discuss the feedback and tick where applicable. The session lasted for 30 minutes the analyses were carried out after the survey.

Group 3: Existence of IKS

Contributors

Five experts were interviewed regarding the existence of IKS; one group participant included a doctoral researcher who is in traditional pharmaceutical at BIUST, a male traditional doctor and three elders residing in Palapye. The participants were all above the age of fifty six years

Method

A semi-structured interview was used to collect data. A total of 140 concepts were used to perceive the participant's perception regarding the existence of IKS. A brief introduction prior to the interview was conducted. The interview was conducted because three of the participants were illiterate and could not fill the questionnaire on their own, and was asked to answer questions for each concept. Analyses were made in regard to IKS existence. Qualitative analyses were used to analyse the data and identify the states of IKS that fall under the branches of semiotics; Semantic, pragmatic and social.

All the three groups who participated were asked to give their views on the preservation and representation of IKS. Analyses were made in regard also.

3.5.2 The Evaluation of the IKS Ontology

Ontology evaluation is the task of measuring the quality of ontology. Ontology evaluation is concerned with the approaches used which can be grouped into four general categories. The first approach [48] uses information about the class graph of an ontology to measure the complexity of the ontology. The second approach analyses the lexical or linguistic structure of the content of ontology to evaluate its quality characteristics, such as clarity, interpretability, and redundancy. The third approach exploits an outside evaluation mechanism and uses human reviewers and the positions of reviewers in a social or trust network to assess the quality of ontology indirectly. The fourth approach uses a combination of the three approaches[48]. The most important approach for ontology evaluation is the quality and correctness of the domain ontology which this research propose to use as imperative in ontology engineering and development of IKS.

As mentioned earlier, ontology is a semiotic object including graph objects, formal semantic spaces, conceptualizations, and annotation profiles [49]. In this regard an organizational framework based on semiotic suite for assessing the quality of ontology was developed and tested the researcher for the study. With such acknowledgement, an organizational framework developed is based on a metric suite consisting of four metric suites

- (i) Syntactic quality,
- (ii) Semantic quality,
- (iii) Pragmatic quality, and
- (iv) Social quality and eight internal attributes of ontologies including Richness, Cohesion, Consistency, Clarity, Conciseness, Completeness, Relevance and Authority. The proposed metric suite for evaluating the quality of the ontology is depicted in Table 4.

Table 4: Proposed metric suite for Ontology evaluation

Overall Approach	Metric suite	Attributes	Description
<i>Ontology Quality</i>	<i>Syntactic Quality</i>	Richness	Breadth of syntax used
		<i>Semantic Quality</i>	Cohesion
		Consistency	Consistency implies all definitions are reliable and no conflicting knowledge can be induced from display definitions and axioms
		Clarity	Recognition of all concepts, relationships, and their correspondences[51], Effectively measures how the ontology communicates the aiming meaning of the defined terms [35]. Clarity also is related to consistency of knowledge representation and determines if the terminology used is clear.
	<i>Pragmatic Quality</i>	Completeness	Is concerned with determining if the general concepts of the ontology are covered, sub concepts and relations are specified. Completeness refers to the domain of interest that is appropriately covered with all elements of an ontology that should are exist and fully described.
		Relevance	Relevance is whether the ontology

fulfills the agent's particular necessities. This requires a few knowledge of the agent's needs earlier to assessment [52].

<i>Social Quality</i>	History	
		It is concerned with how many of times concepts of the ontology have been used

The main goal is to evaluate the quality of the ontology is based on Metric suites which assess the ontology against linguistic dimensions: syntactic, semantic, pragmatic and a social aspect of ontology quality which ultimately answers the questions accordingly: Is the ontology syntactically correct? Does the ontology cover the domain of interest? Is the ontology comprehensible by the user?[53]. The quality of the Ontology is assessed by giving weights which sum up to the overall quality of the Ontology. The syntactic quality basically evaluates the ontology based on the correctness of the syntax. In most quality frameworks, the Syntactic quality is a fundamental aspect for evaluating the ontology. Richness refers to the relationship types other than subsumption (is-a) as well as axioms and restrictions that have been used in the ontology,[54].

Table 5: Determination of metric values

Attributes	Determination
Overall Quality (Q)	$Q = a_1 \times S + a_2 \times E + a_3 \times P + a_4 \times O$ <p>Where a_1 is value of syntactic quality metrics Where a_2 is value of semantic quality metrics Where a_3 is value of pragmatic quality metrics Where a_4 is value of social quality metrics</p>
Syntactic Quality (S)	$S = a_{s1} \times SR$
Richness (SR)	$SR \text{ will be } = \frac{x}{y}$ <p>Where x is the total syntactical features used in this ontology. Where y is the total syntactical features available in the ontology</p>
Semantic Quality (E)	$E = a_{e1} \times EH + a_{e2} \times EC + a_{e3} \times EA$
Cohesion (EH)	<p>Let $C_1, C_2 \dots C_m$ be the set of m classes explicitly defined in ontology. Let $P_1, P_2 \dots P_n$ be the set of n properties which work as relationship between the set of classes.</p>

	<p>Let $f_{c1}, f_{c2}, \dots, f_{cm}$, be the fanout of each class C_i in the set.</p> <p>Let O_i be OWL ontology of interest.</p> <p>Then $EH = \text{NoR}(O_i)$ and $\text{NoL}(O_i)$ [52].</p>
Consistency (EC)	<p>Let $I = 0$.</p> <p>Let C be the number of classes and properties in ontology. $\forall C_i$, if meaning in ontology is inconsistent, $I+1$. $\therefore I$ = number of terms with inconsistent meaning. $EC = I/C$.</p>
Clarity (EA)	<p>Let C_i = name of class or property in ontology. $\forall C_i$, count A_i ,</p> <p>Then $EA = A/C$.</p>
Pragmatic Quality (P)	$P = a_{p1} \times PR + a_{p2} \times PC$
Completeness(PC)	<p>Let PC be the measure for Precision and recall where</p> <p>TP = true positives , FN = false negatives , FP= false negatives and TN = true negatives</p> <p>Let F_1 = score for Precision (PRE) and recall(REC)</p> <p>Then $PRE = \frac{TP}{TP+FP}$</p> $REC = \frac{TP}{TP+FN} \quad \text{and} \quad F_1 = 2x \frac{PRE \times REC}{PRE+REC}$
Relevance (PR)	<p>Let NS be the number of statements in the ontology. Let S be the type of syntax relevant to agent. Let R be the number of statements within NS that use S. $PR = R / NS$[52].</p>
Social Quality (O)	$O = a_{o1} \times OH$
History (OH)	<p>Let the total number of accesses to an ontology be A. Let the average value for A across ontology IKS be H. Then $OH = A/H$.</p>

Semantic quality (E) evaluates the meaning of terms in the ontology. It covers four attributes being cohesion, consistency, clarity and clarity. Ontology cohesion refers to the of owl classes which are conceptually related by the properties. Ontology is said to have a high cohesion if the classes are strongly related therefore high cohesion is a desirable property. The idea behind this evaluation is that the concepts grouped in ontology should be

conceptually related for the domain and a sub-domain in order to achieve a common goal, Number of Root Classes (NoR) in the ontology. A root class in an ontology means the class has no semantic super class explicitly defined in the ontology. Consistency refers to the meaning of terms that are consistent in the Ontology. For instance, *Is_a* and *Is_an* are terms that can be used inconsistently thus destroying the semantic value of ontology. Ontology should have a semantic value with classes, sub-classes and properties with consistent meaning. Clarity refers to whether the context of terms is clear.

Pragmatic quality (P) refers to the practicality of the ontology, regardless of syntax and semantic as echoed by Chimienti et al (2009)[34]. For the evaluation it regards two measures, one of them is completeness which determine if important information regarding the concepts in an ontology is complete as they can sometimes be ignored thus leading to ambiguity and lack of reasoning mechanisms. The incompleteness errors of in ontology can be measured by using precision and recall metric. Precision is a measure of the ability of an ontology to present all relevant items and recall is a measure of the ability of an ontology to present relevant items[55].

Social quality (O) reveals the fact that agents and ontologies exist in communities. An attribute called History is used to determine how many times the ontology have been used or accessed. It is assumed that ontologies with longer histories are more dependable.

In conclusion to the determination of metrics; the formulas given to the metric suites, *Semantic quality (E)*, *Pragmatic quality (P)*, *Social quality (O)* and attributes that go side by side with the Metrics, aggregates to the Overall quality of the Ontology (Q). The overall quality (Q) is a weighted function of its syntactic (S), semantic (E), pragmatic (P), and social (O) qualities (i.e., $Q = a_1 \times S + a_2 \times E + a_3 \times P + a_4 \times O$) as shown in Table 5.

Chapter 4

4. Results and Discussion

In the previous chapters, we motivated for the creation of a framework that functions as a guiding principle for the development of IKS. We had set research objectives, research questions and went through literature to create a benchmark for the framework. We then in Chapter 3, presented the framework in two parts: the actual semiotic based framework and formalized it in an ontology. In the same chapter (Chapter 3), we established an approach through which the framework and the ontology will be evaluated. In this chapter, we present the results of the evaluation as stipulated in Chapter 3.

4.1 Semiotic framework evaluation results

The research starts by presenting the results of the framework, before discussing the components of the framework in greater detail and the ontology.

The Evaluation of Semiotic framework for IKS begins from semiotic branches as derived from the literature study. IKS is understood as sign inventories and defining IKS domains as signs also allows us to analyse the relation of the domains and their respective context.

On the foundation of data analyses for the three studies that were conducted, the status of IKS were identified and used to evaluate the domain signs. The states of IKS were mapped onto the four semiotic branches of the framework. The 140 sign attributes used to determine the status of IKS in the experiment are the concepts of Knowledge domains. Because IKS is often misinterpreted and misunderstood, in the experimental studies, the focus was on the interpretative process and on deriving the status and concepts associated with how it can be interpreted by people. The statuses of IKS can be used by experts to understand, classify and formalise the precious knowledge in Botswana. The *Knowledge* of IKS complements the semantic level, *relevance* is part of the pragmatic, and social touches the *existence* while syntactic on the *preservation and representation*. The four semiotic levels are discussed next in relation to the states of IKS and semiotic heuristics as depicted in Table 4.

Table 6: States of IKS as discussed in the three studies.

<i>Branches</i>	<i>Statuses of IKS</i>	<i>Group 1</i>	<i>Group 2</i>	<i>Group 3</i>
<i>Semantic</i>	Knowledge	X		
<i>Pragmatic</i>	Relevance		X	
<i>Social</i>	Existence			X
<i>Syntactic</i>	Preservation and representation	65%	85%	89%

(i) The semantic Level

Knowledge of IKS discusses how Group1 participants are knowledgeable and how they interpreted the concepts sign of the test subject with regard to referential meaning. Group 1 showed that 13 out of 20 participants managed to interpret the meaning of 96 out 140 domain signs properly. About 65% of participant in the group understand IKS concepts of the test study. As discussed, attributes relevant to the semantic level lead to a set of heuristics, such that perhaps the remaining unknown concepts signs, the participants are not familiar with because they are not in their cultural vocabulary or background.

(ii) The syntactic level

Is concerned with the relationship among signs including their formal logical arrangement, Participants of the study are from different background and they interpreted concepts according to their social background. The participants of the study were asked to give their view on the preservation and representation of IKS with regard to the technologies that could be utilised. Preservation and representation is concerned with protection of concepts according to how they contribute to the society. About 65 % of participants in group 1 feel IKS should be preserved while group 2 is 85%, and group 3 is 89%. They gave view based on the level of understanding of the concepts.

(iii) The pragmatic level

The pragmatic level deals with the relationship between a sign and the practical consequences of its interpretation because signs are analysed in relation to a human interpreter[56].

Relevance is concerned with importance of IKS and determining its practice. Group 2 were to determine if the concepts sign still apply to their social lifestyle. It was revealed that 120 out of 140 domain signs are still in practice and useful by 85%. The most practised concepts are from traditional food, traditional games, traditional medicine and traditional music.

(iv) The Social level

The status of IKS at the social level is derived from the empirical studies the social level deals with the meaning of domain signs in terms of their social contextualization. The social level focuses on domain signs with their meaning as embedded in a social context. **Existence** is actually the presence of Indigenous Knowledge domains that are practical to patents. Group 3 showed that 125 out of 140 domain signs are still useful especially from the traditional food domain.

To summarize, our analysis we expanded the evaluation of the framework by considering another branch of semiotics; the environmental level which deals with the surrounding factors that collectively affect participant's behaviour. The environment level represents the users' knowledge and memory, and frames their interpretations of referential meanings of signs[56] and it states that no sign can be interpreted outside its environment, because it provides the context for communication. To avoid miscommunication and misinterpretation of the domain signs, ontology is proposed as it holds indispensable traits to interpret the meaning of domain sign accurately. Hence Ontologies use symbols, or signs, to describe terms.

4.2 The resultant Ontology

IKS Ontology is a huge and it integrates all aspects of indigenous knowledge, the first design decision was to include all the fourteen knowledge domains of IKS. The ontology consists of concepts or terms that are linked by different relationships. The top level concepts of IKS ontology are traditional_food, traditional_medicine, water_prospecting, traditional_games, language, culture, Agriculture, Attire/dress, weather_forecasting, cosmetic_and _detergent, hunting_and_gathering, wild_fruit, culture , art & music and handicrafts. The ontology uses *consists_of*, and *domain_of*' and relationship to express the semantics between the top level concepts as depicted in figure 8, and later used other relationships such *as element_of*, *has_a*, *is_a*, *part_of*, *is_an*, *etc* to link the child concepts. The conceptual map has been used to show the relationship between the concepts of the Ontology, in which according to the illustrations

the main concepts are in **bold letters** while the relationships are written with an *italic underscore* ().

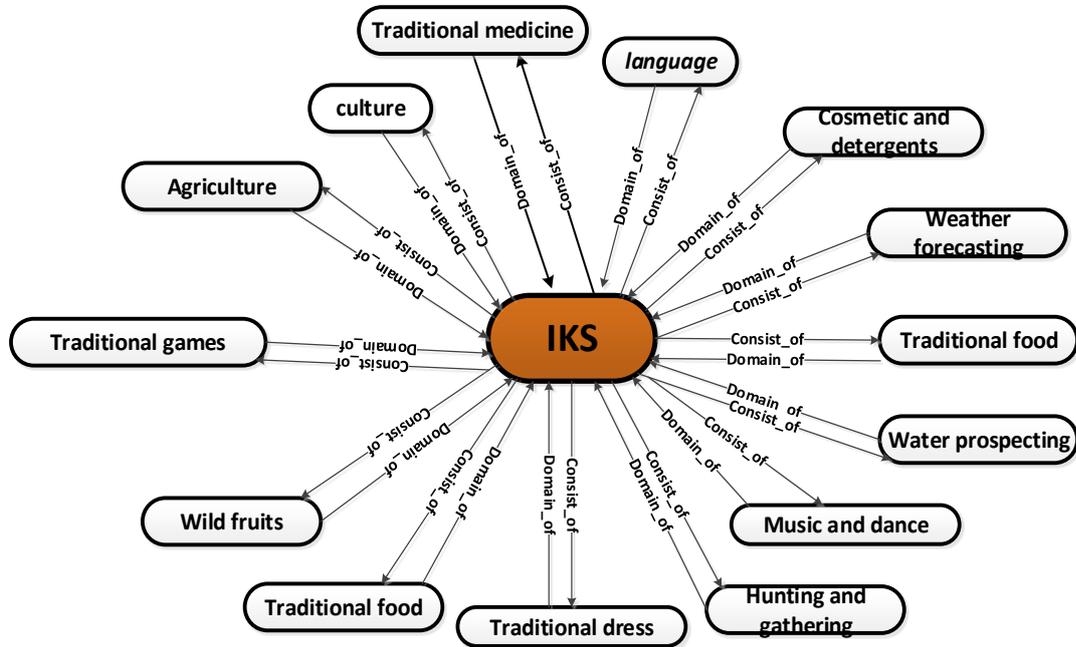


Figure 8: IKS ontology map using *consist_of* and *domain_of* relationships

The IKS domains are deliberated as depicted in figure 8. The *domain_of* and *Consist_of* relationships are used.

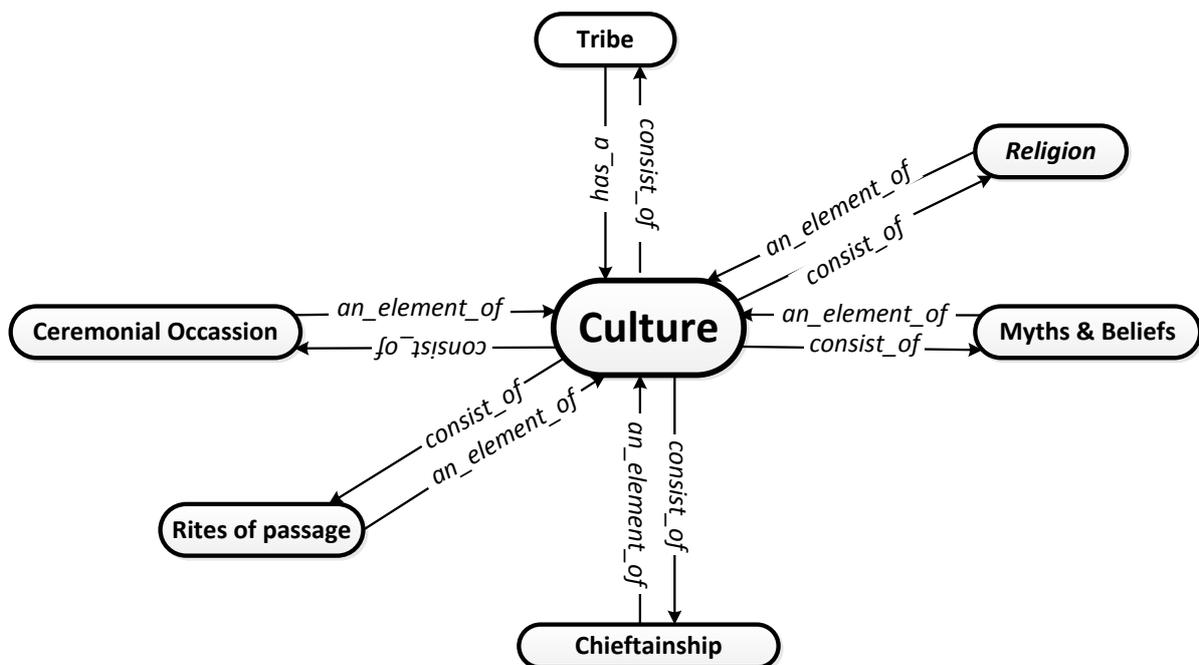


Figure 9: Conceptual map for Culture

Cultural knowledge *consists_of* ceremonial occasions, chieftainship, Circumcision, religion, rite of passage, religion, tribe, myth and belief. The relationships used are *consist_of* and *an_element_of*.

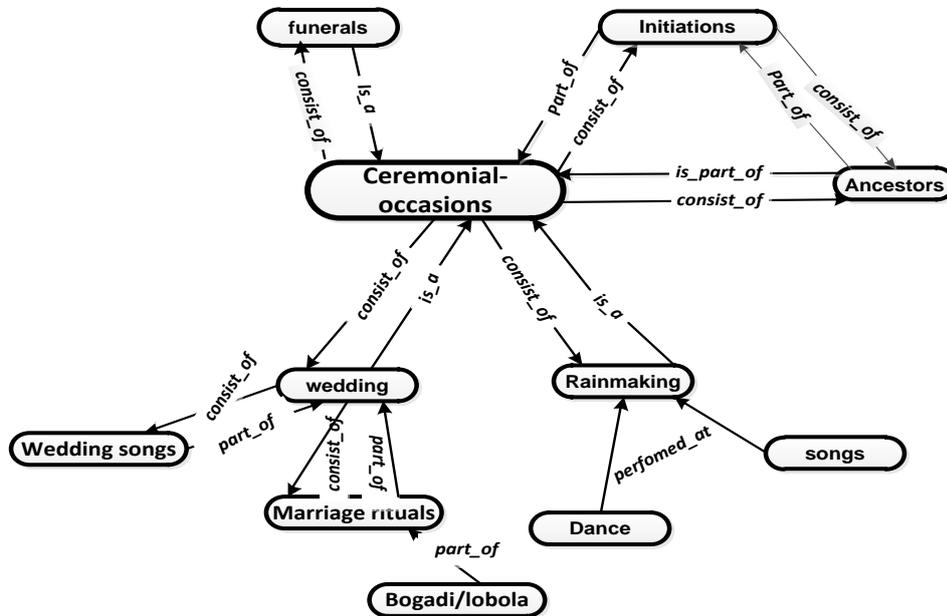


Figure 10: Conceptual map for Ceremonial occasion [Sub domain of culture]

Ceremonial occasion is an element of culture and it *consists of* **rain making** where different **Music and dance** is performed, **initiation**, **wedding** and **funerals**. **Wedding songs** and **marriage rituals** are performed of the wedding ceremony. **Dance** and **songs** are also performed during rain making

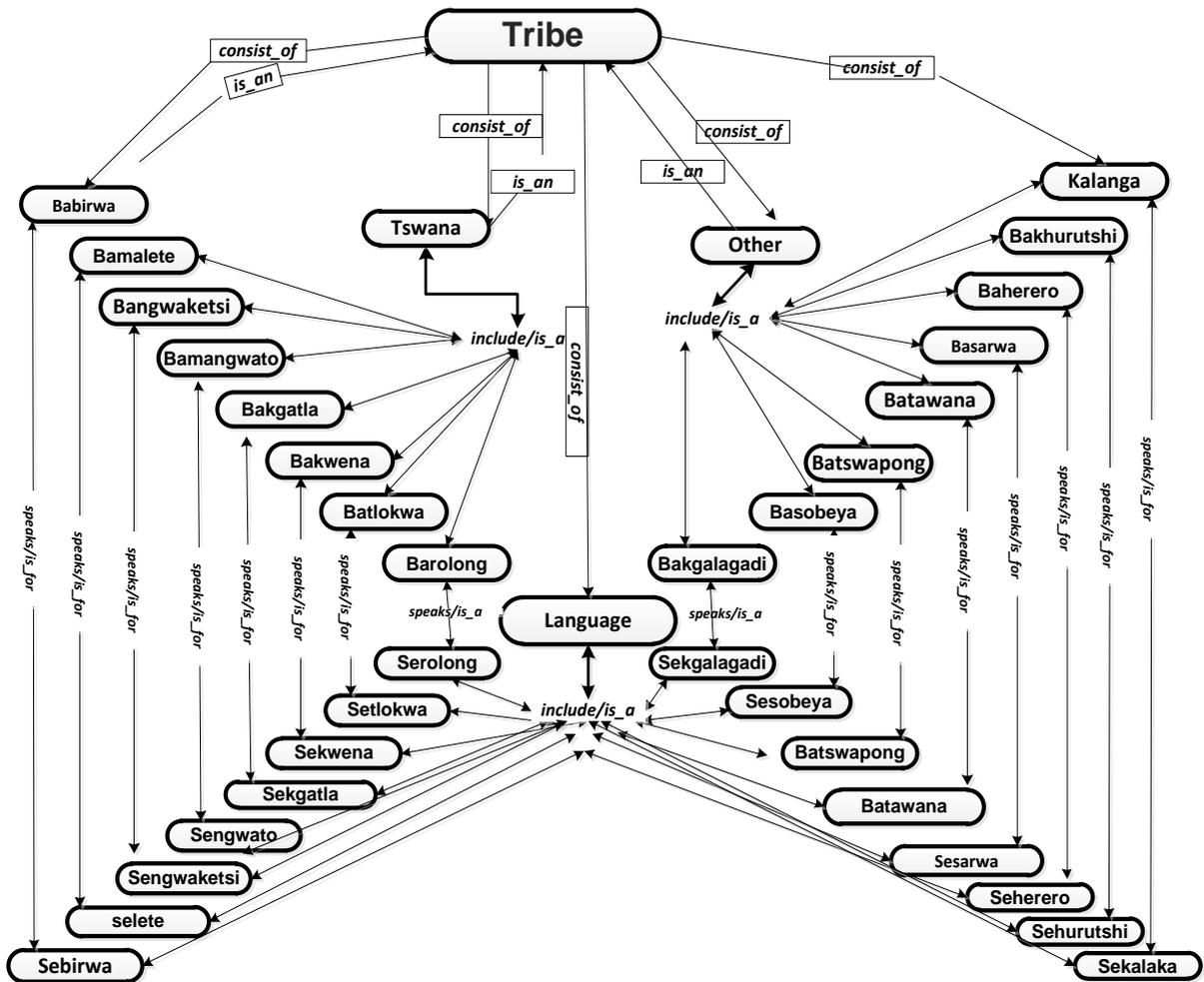


Figure 11: Conceptual map for Tribe/Language [Sub domain of culture]

In Botswana **Tribe** *consist_of* the **Language**, **Tswana** tribe and **other** tribe, Tswana includes **Bangwato**, **Bakwena**, **Bakgatla**, **Batlokwa**, **Bangwaketsi**, **Balete**, **Barolong** and **Babirwa**. **Other** tribe *Includes* **Basarwa**, **Bakgalagadi**, **Basobeya**, **Baherero**, **Bakalaka**, **Batswapong** and **Bahurutshe**. **Language** is spoken by a particular tribe belonging to the same community.

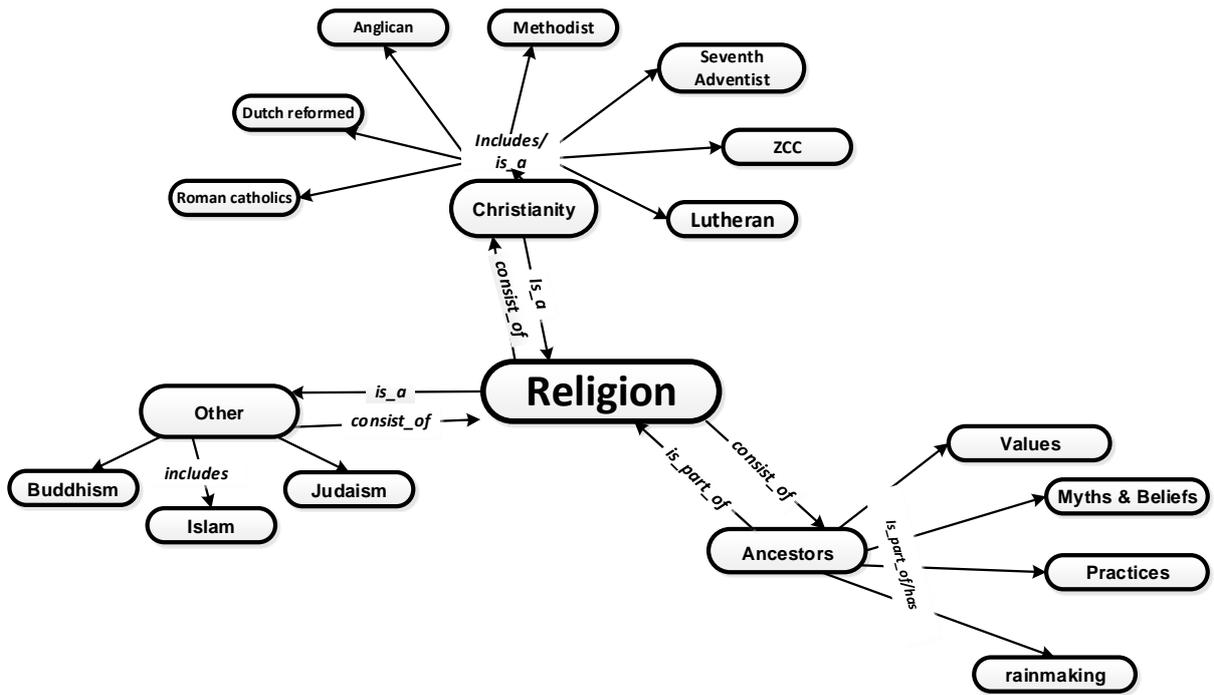


Figure 12: Conceptual map for Religion [Sub domain of culture]

Religion is the integral domain for different tribes in Botswana; it consists of ancestors, Christianity and other. Christianity dominates with concepts including Roman Catholic, Dutch Reformed, Anglican, Methodist, Seventh Adventist, Zcc And Lutheran. The relationships used are *Is_a*, *consists_of*, *part_of* and *Includes_a*.

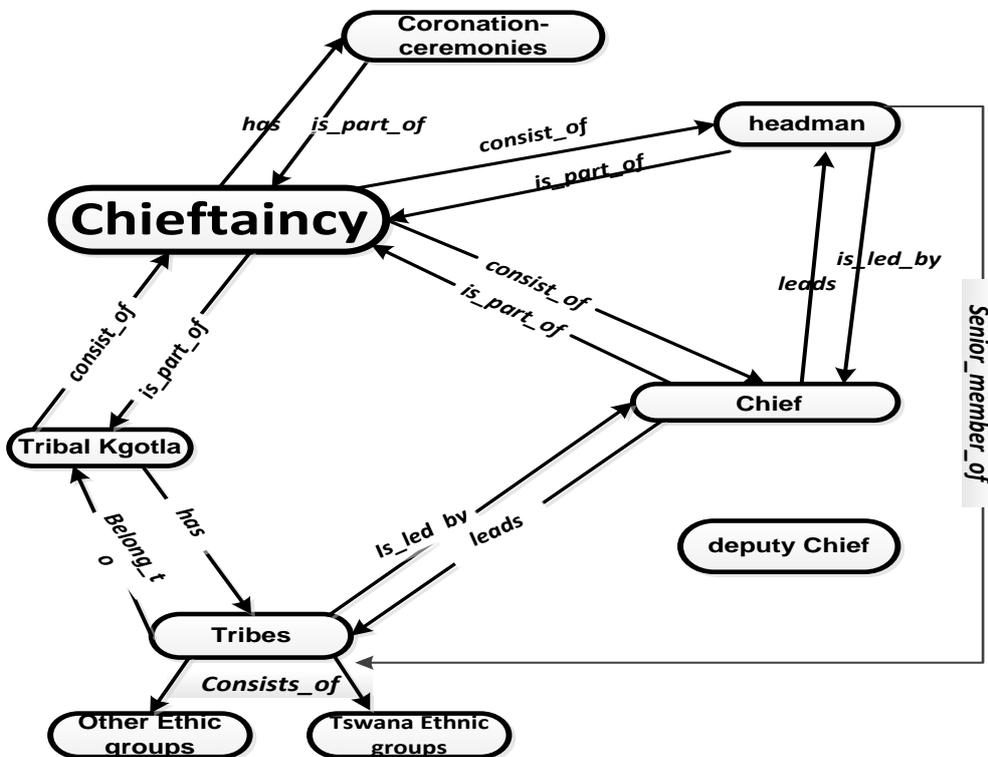


Figure 13: Conceptual map for Chieftaincy [Sub domain of Culture].

Chieftainship is the act of being the leader to a certain tribe, as depicted in the **figure 7**, it *consists_of* **coronation**, **Kgotla/ward**, and **chief**. Kgotla is a customary meeting of the tribe. **Headman** is the *senior_member_of* the **Tribe** which *has* **Tswana ethnic** and **Other ethnic groups**. Tswana ethnic group include *Bagwato, Bangwaketsi, Bakwena, Batlokwa, Batawana, Bakgatla, Balete, Barolong* and Other ethnic groups includes *Bakalaka, Basarwa, Babirwa, Basubiya and Hambukushu*

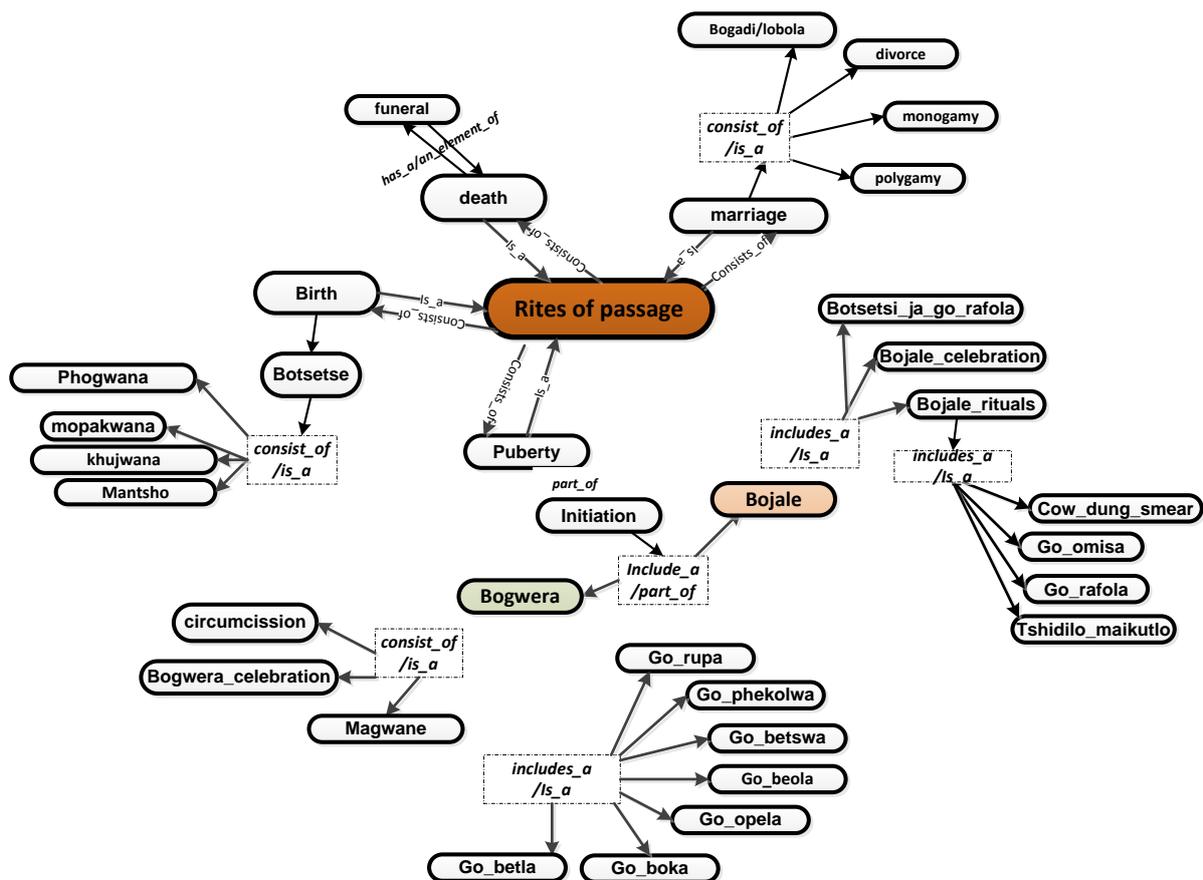


Figure 14: Conceptual map for Rites of passage [Sub domain of Culture].

Rite of passage is the act of being introduced into adulthood, the integral part of is **Initiation** which is very common among world communities. Initiation consist of **Bojale** and **Bogwera**, other concepts of rites of passage include **Puberty**, **Birth**, **Death**, and **Marriage**.

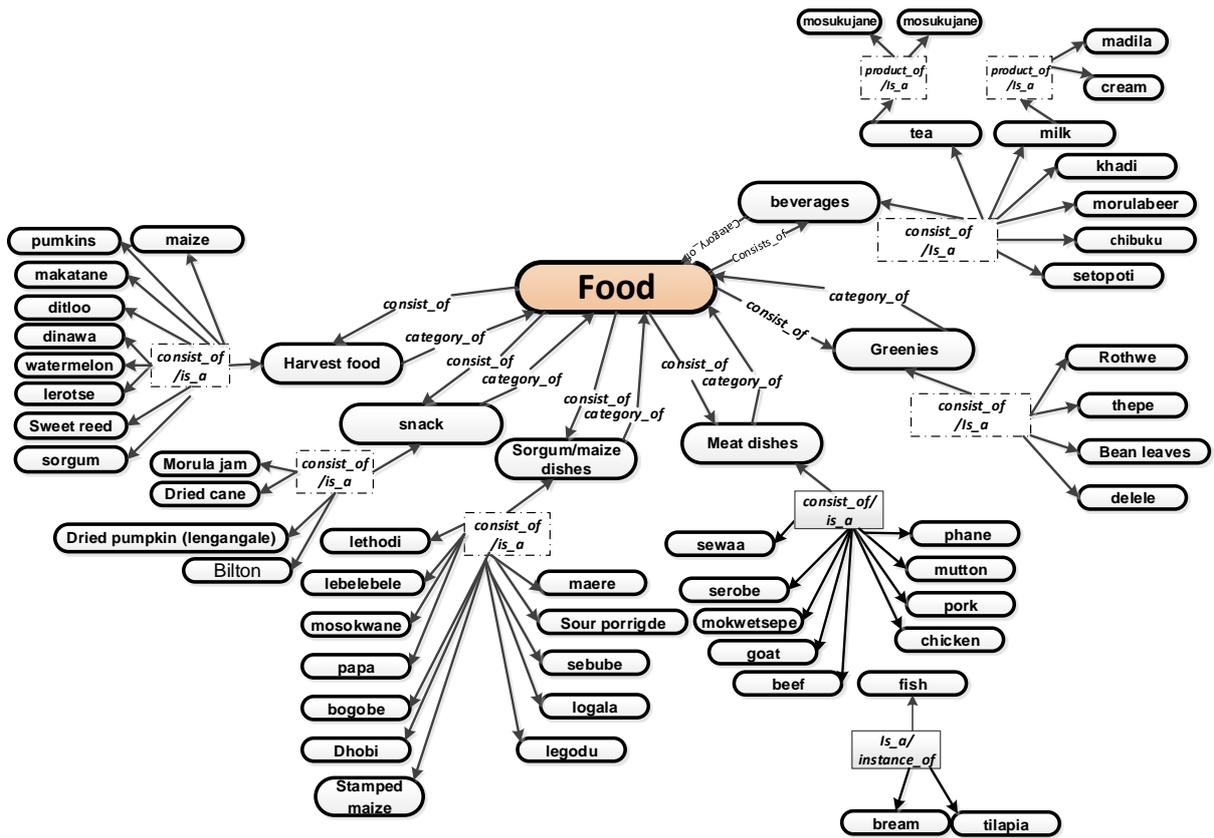


Figure 15: Conceptual map for Traditional

Food domain is classified into six main Concepts, Including Beverages, Greenies, Sorghum_Dishes, Snack and Harvest Food. Relationships are consistently used to associate the child concepts as depicted.

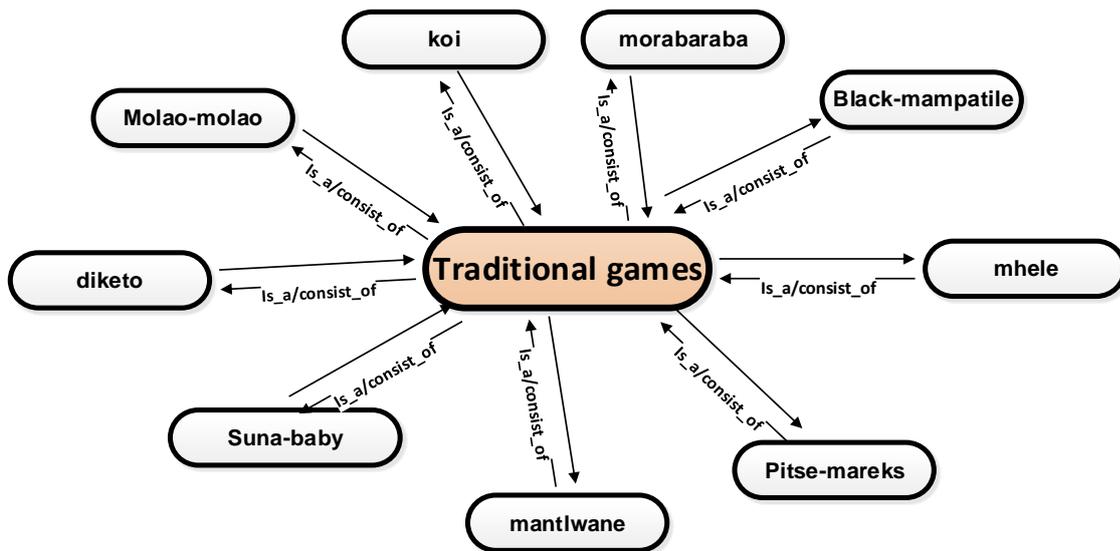


Figure 16: Conceptual map Traditional games

Traditional games include **Morabaraba, Koi, Black-Mampatile, Mhele, Pitse Mareks, Mantlwane, Suna_Baby, Diketo** and **Molao_Molao**. *Is_a* and *Consist_of* relationships are used to express the semantics.

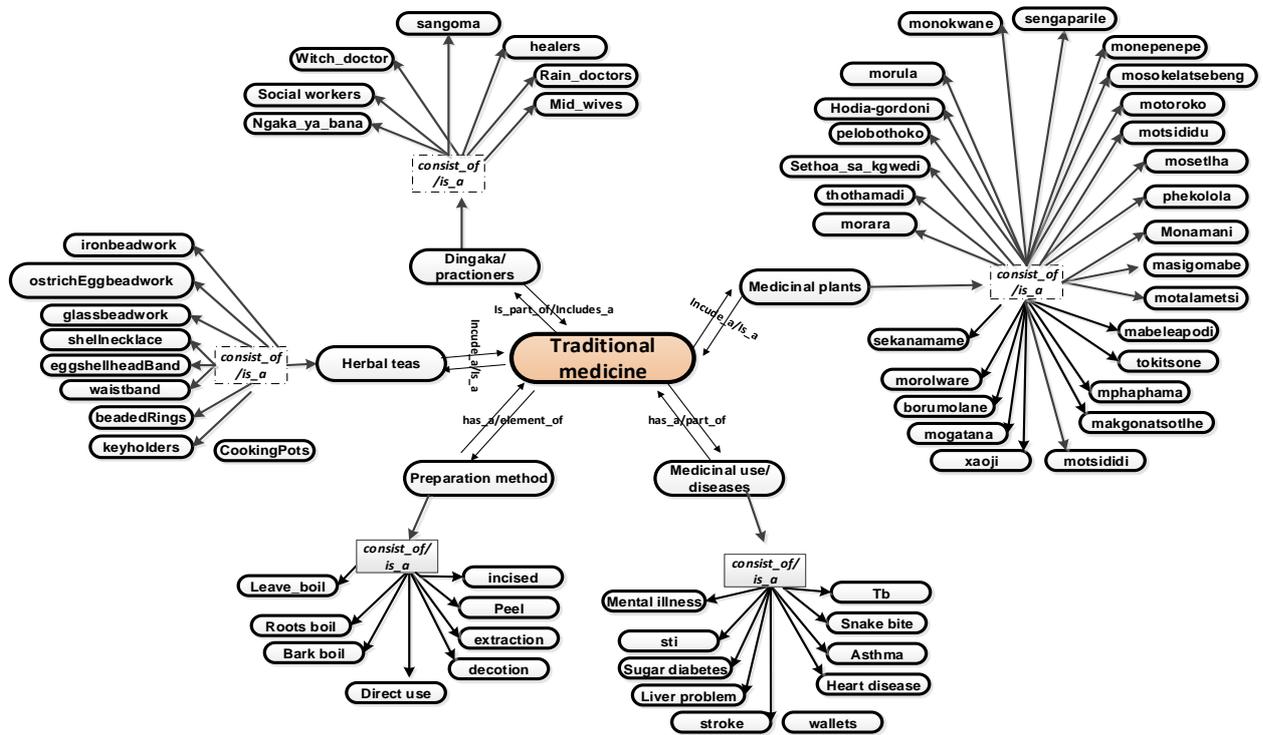


Figure 17: Conceptual map for Traditional medicine

Traditional medicine domain includes **Dingaka, Medicinal Plants, Medicinal Use, Preparation Method** and **Herbal Teas**. *Is_a* and *Consist_of* relationships are consistently used to express the semantics as depicted in figure 18.

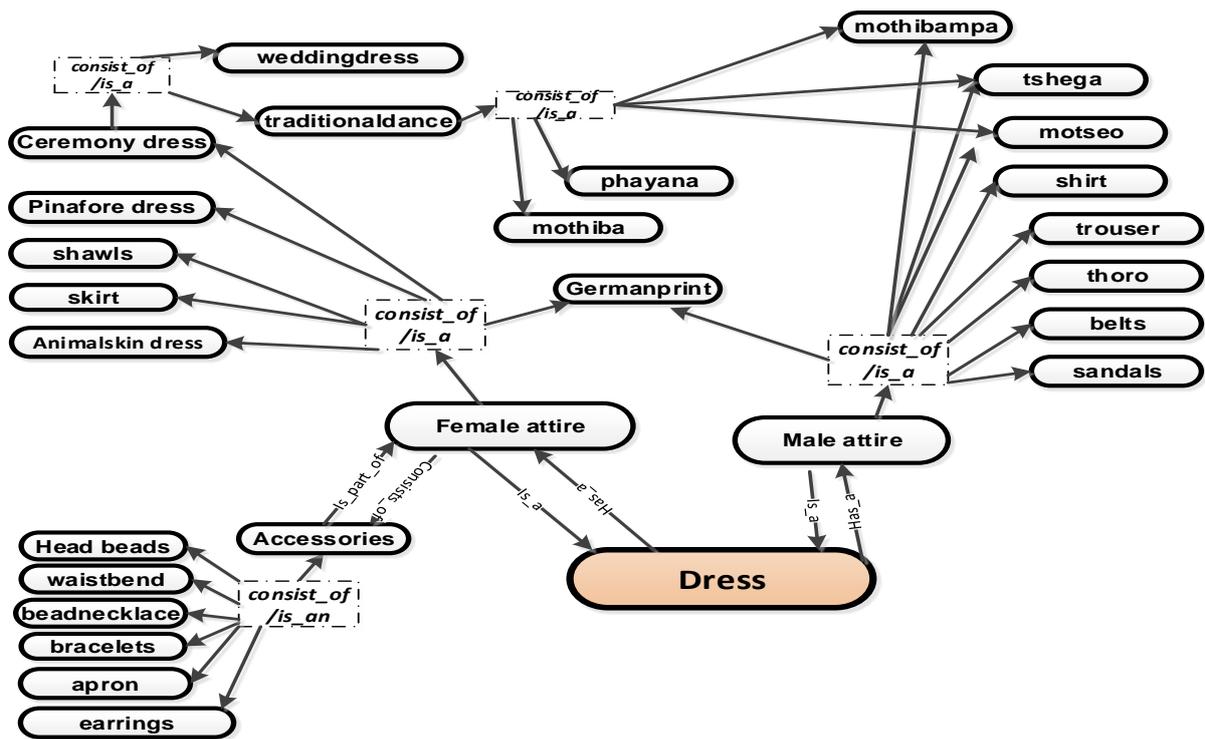


Figure 18: Conceptual map for Dress

Traditional dress domain has two sub concepts, **Male** and **Female** Attire; it used *Is_a*, *has_a*, *consists_of*, *is_part_of* to express the relationship between concepts.

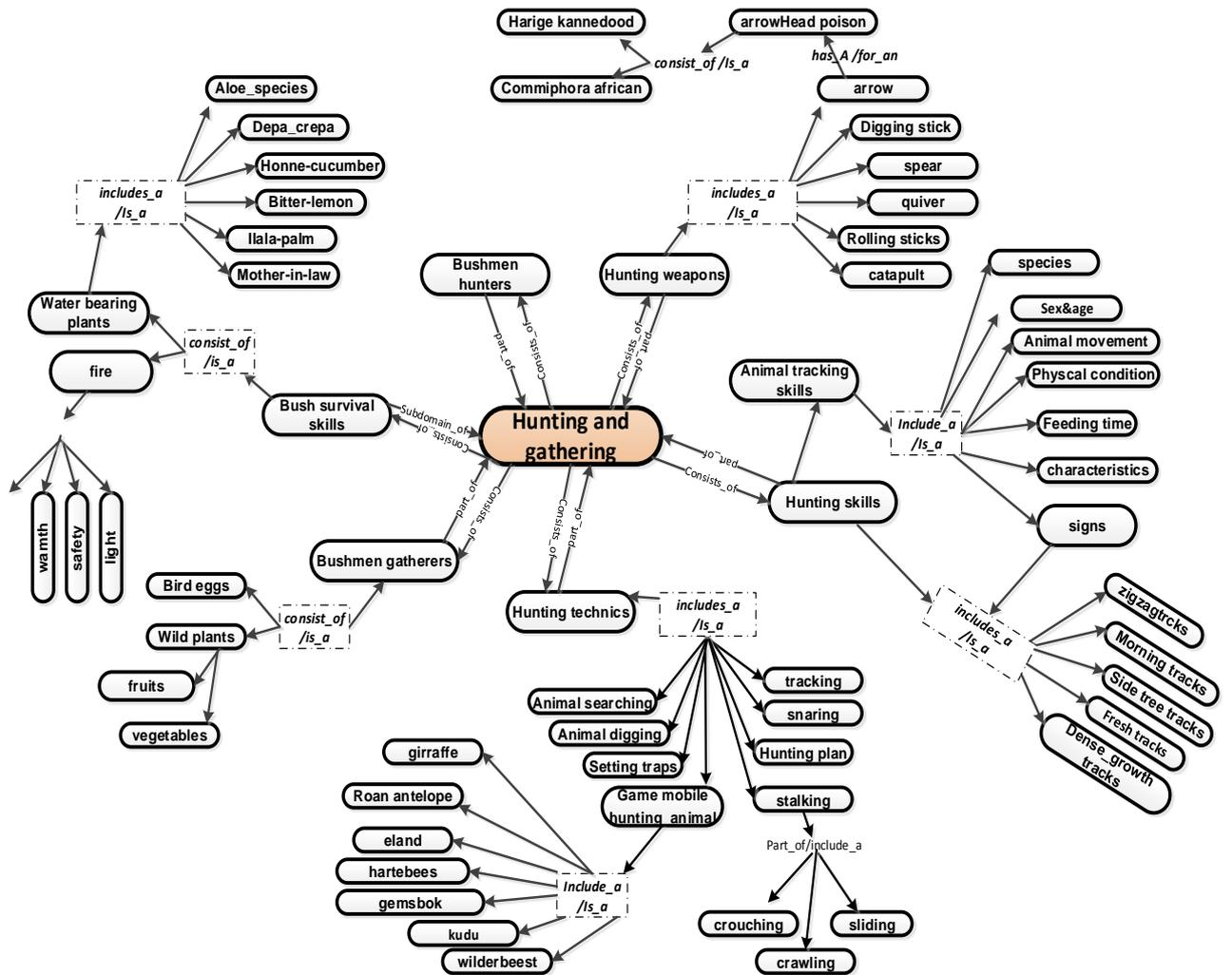


Figure 20: Conceptual map of Hunting and Gathering

Hunting and gathering domain deliberates six main concepts including **Hunting skills**, **Hunting technics**, **bushmen gatherers**, **bush survival skills**, **bushmen hunters** and **hunting weapons**. Relationships are consistently used as depicted in figure 21.

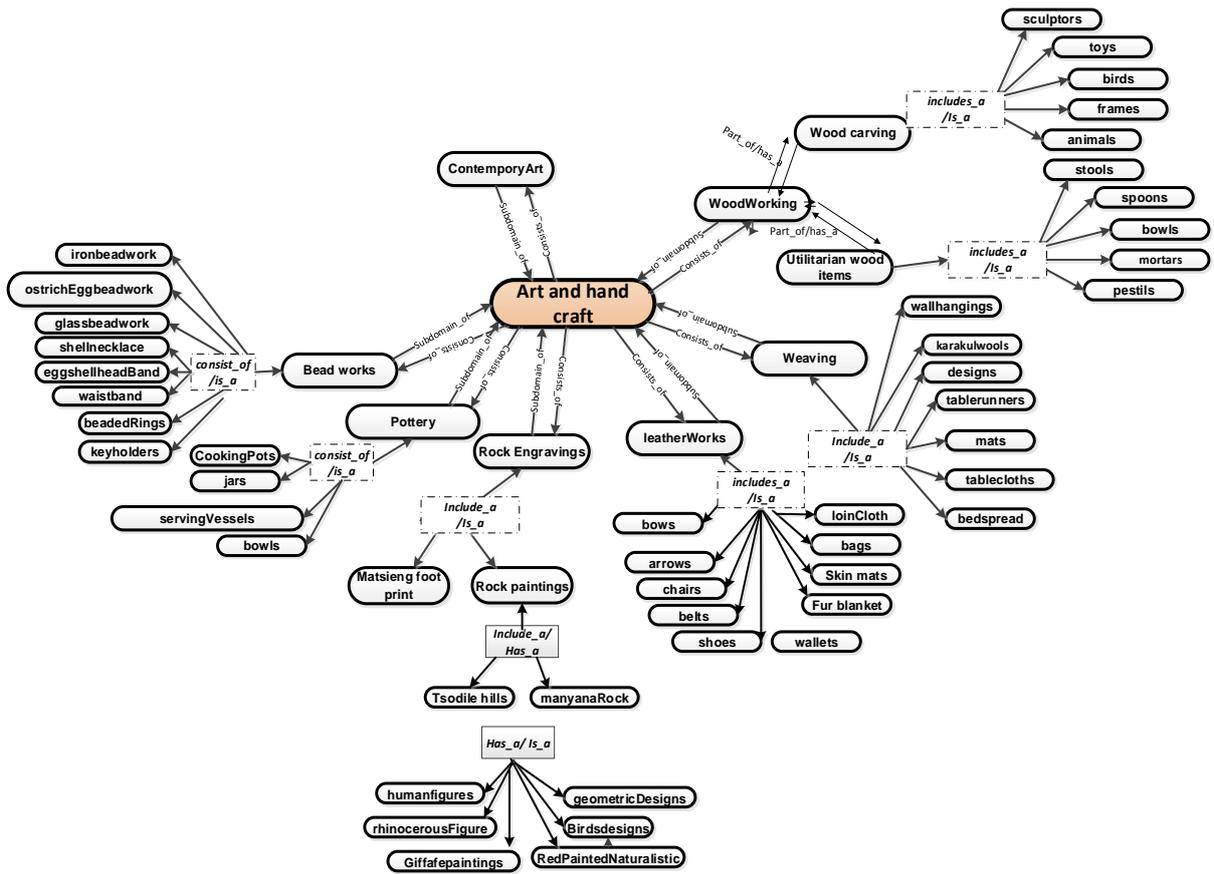


Figure 21: Conceptual map for Art and Hand craft

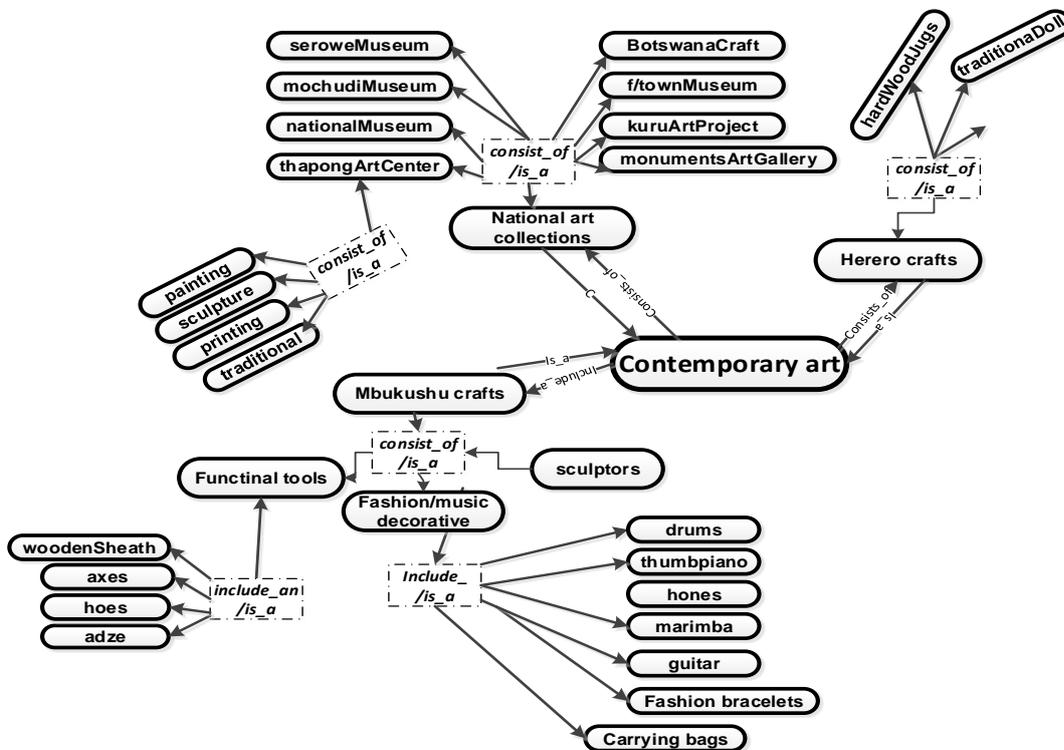


Figure 22: Conceptual map for Art and Hand craft- contemporary art

Art and hand Craft includes **Contemporary_Art, Bead_Works, Pottery, Rock Engravings, Leather_Works, Weaving, and Wood Working**. Relationships are used consistently to express the concepts as depicted.

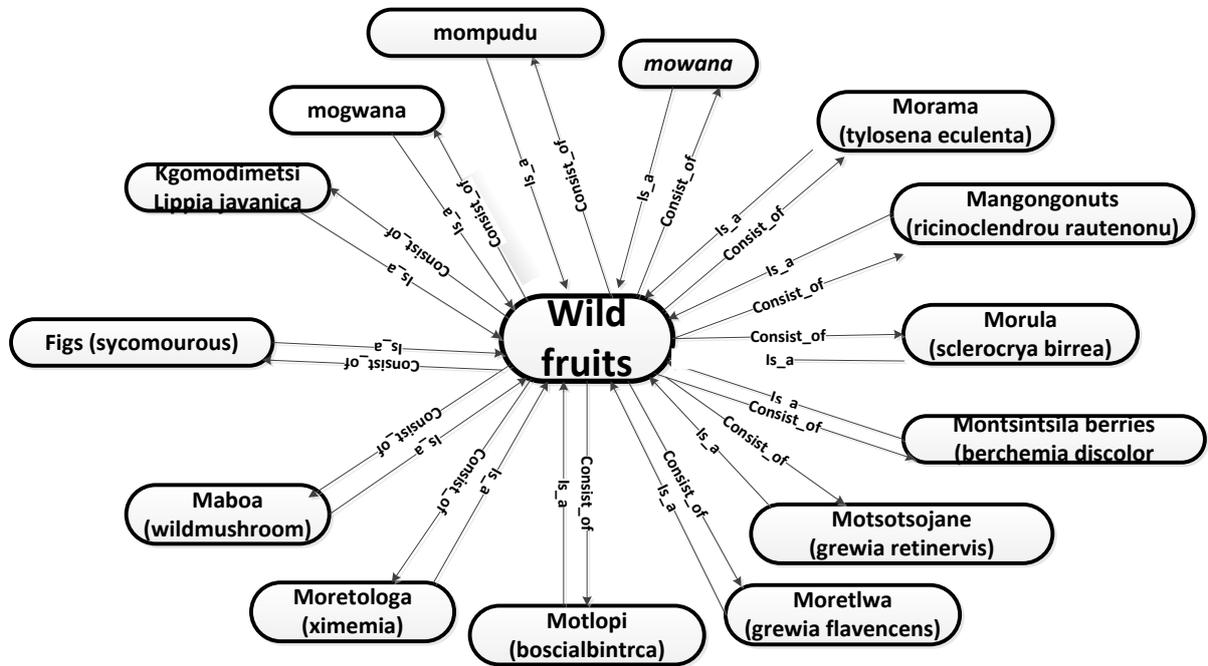


Figure 23: Conceptual map of Wild Fruits

Wild Fruits consists of **Mowana, Morama, Mangongonuts, Morula, Motsintsila, Motsotsojane, Moretliwa, Motlopi, Moretologa, Maboa, Figs, Kgomodimetsi, Mogwana And Mompudu**. Relationships used are *consist_of* and *Is_a*.

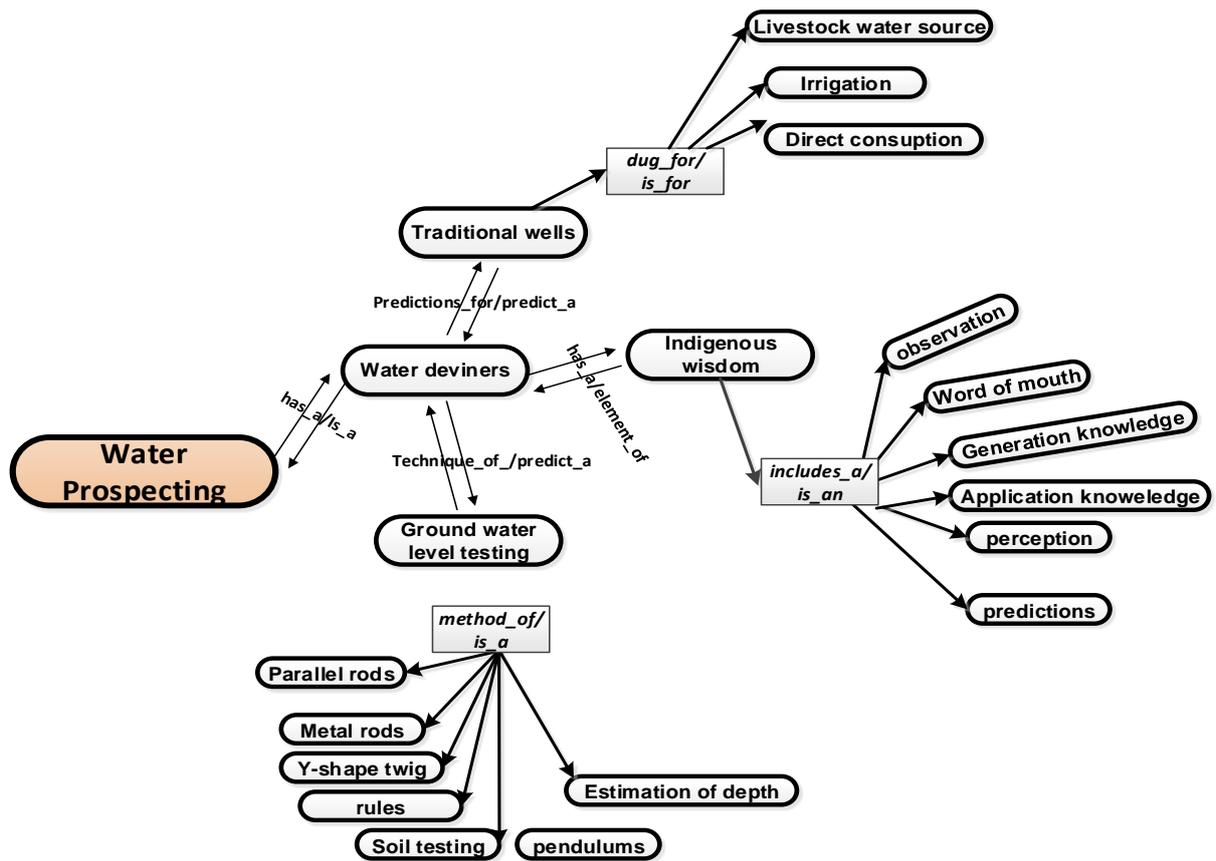


Figure 24: Conceptual map for Water prospecting

Water prospecting is identifying the presence of ground water, it consists of water diviners that predict **Ground Water Level** then dig **Traditional Wells**, by the help of the **Indigenous wisdom** they acquire. Relationships used are *has_a*, *element_of*, *predict_a* and *Includes_a*.

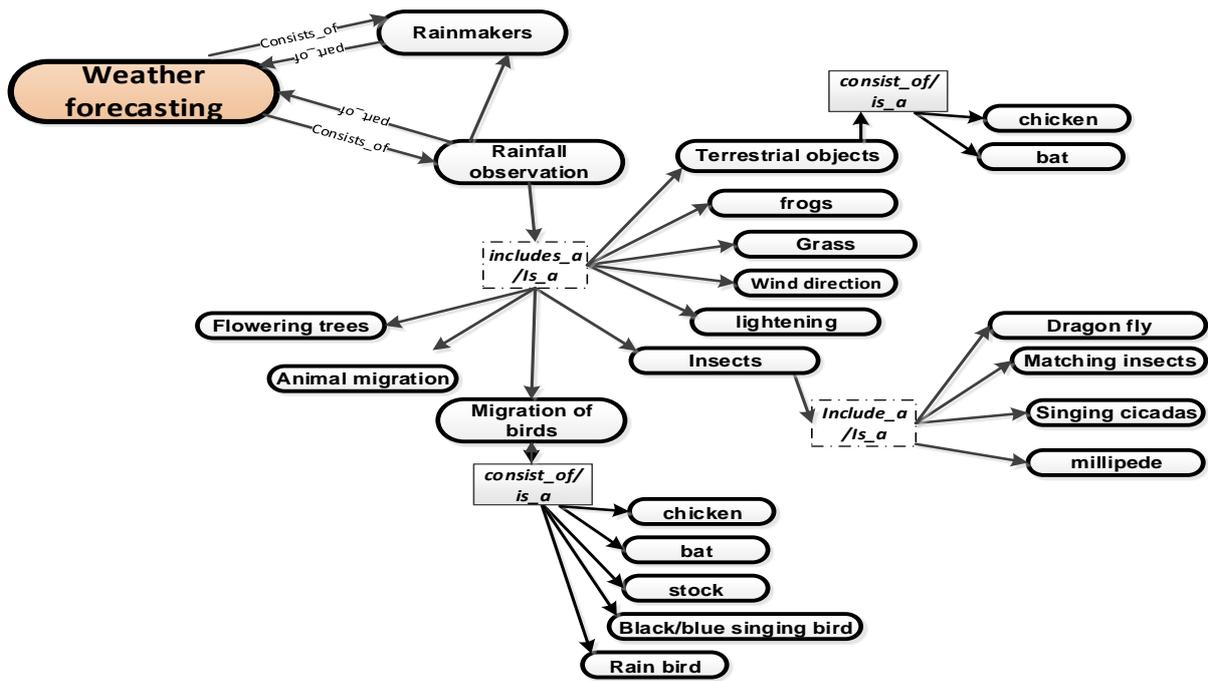


Figure 25: Conceptual map of Weather Forecasting

Weather forecasting consists of **Rainmakers** and **Rainfall observation** concepts, relationships used to express the semantics are *consist_of*, *includes_a*, and *Is_a*

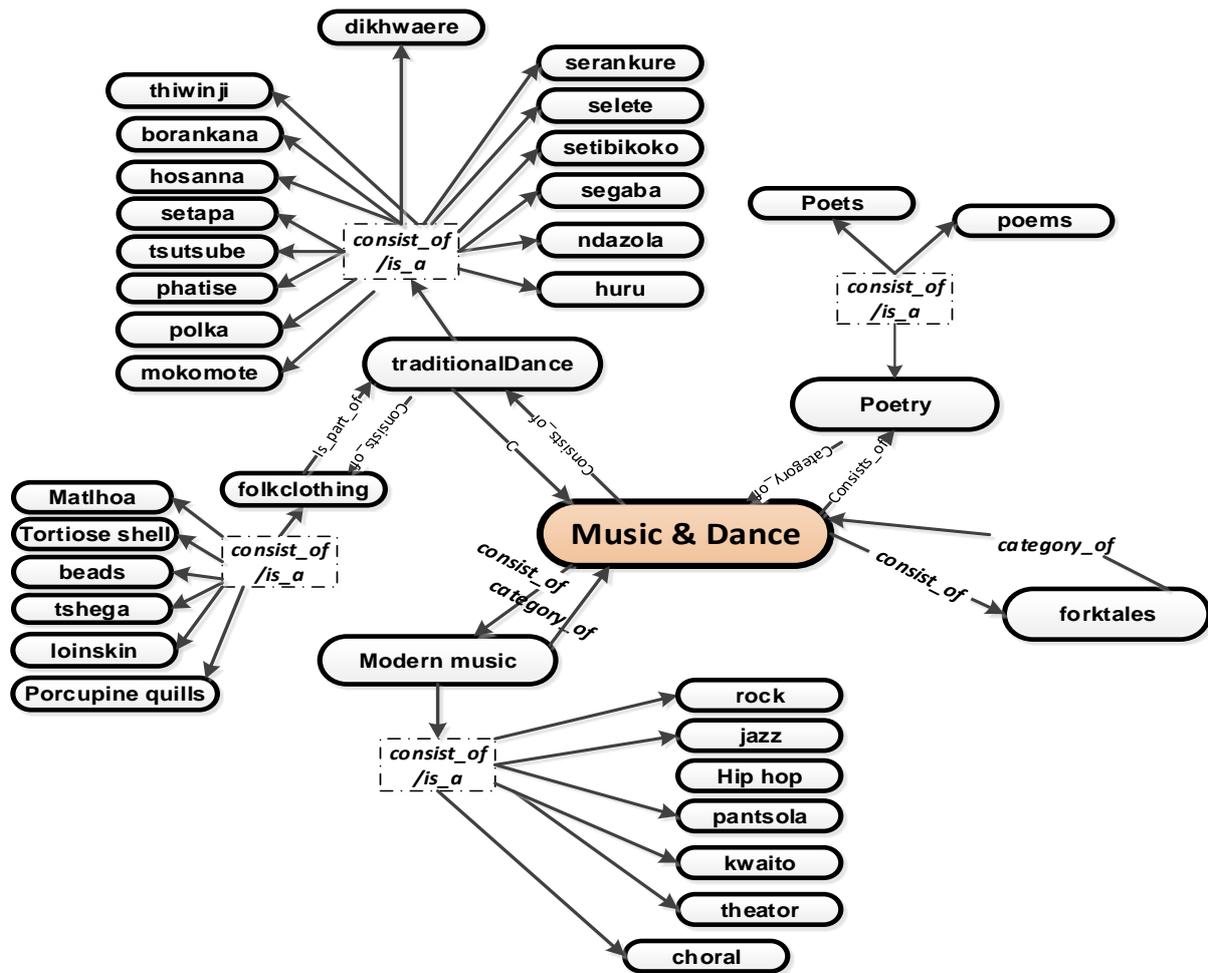


Figure 26: Conceptual map of Music and dance

Music and Dance consists Of **Poetry**, **Fork tales**, **Traditional Dance**, and **Modern Music**, relationships used to express the semantics are *consists_of*, *category_of*, *is_part_of* and *Is_a*.

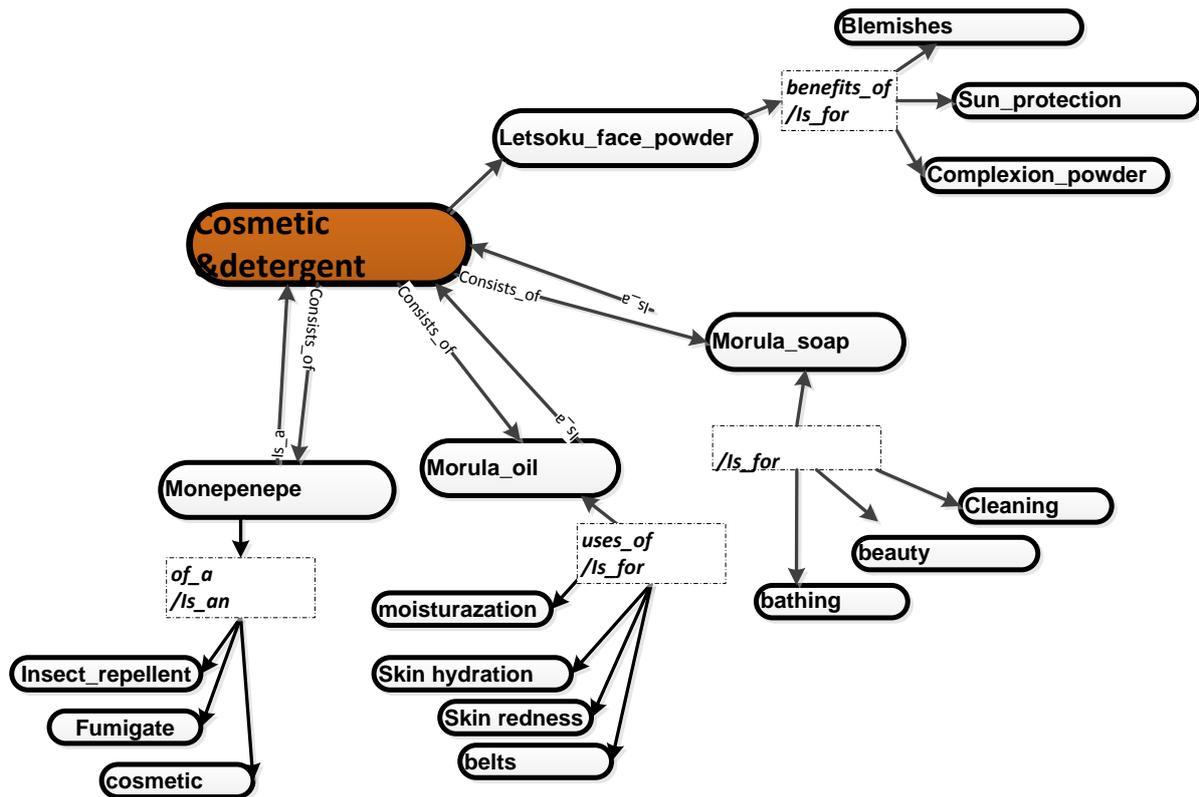


Figure 27: Conceptual map of Cosmetic and Detergents

Cosmetic and Detergent consists of Letsoku_Face_Powder, Morula_Soap, Morula_Oil, and Monepenepe. Relationships used are *consists_of*, *Is_for*, *Is_an*, *benefits_of*, and *uses_of*.

4.3 Ontology Evaluation Results

This research decided to use Protégé in the evaluation reported in Chapter 3. Protégé is a free an open source ontology editor for OWL ontologies, with an active community that enable to retrieval of preferred information by querying it via Descriptive Language (DL) Query engine or reasoners such as Hermit and Fact++). See figure 31 that depicts DL query for Traditional medicine in Protégé editor and Figure 29 illustrating the Ontology graphs for IKS, Figure 30 representing of the OWL Ontology, and the hierarchy structure for IKS Ontology shown in figure 31. It also used API to support the development of Protégé and OWL support within Protégé. OWL API, a high level Application Programming Interface (API) that supports the creation and manipulation of OWL Ontologies[57].

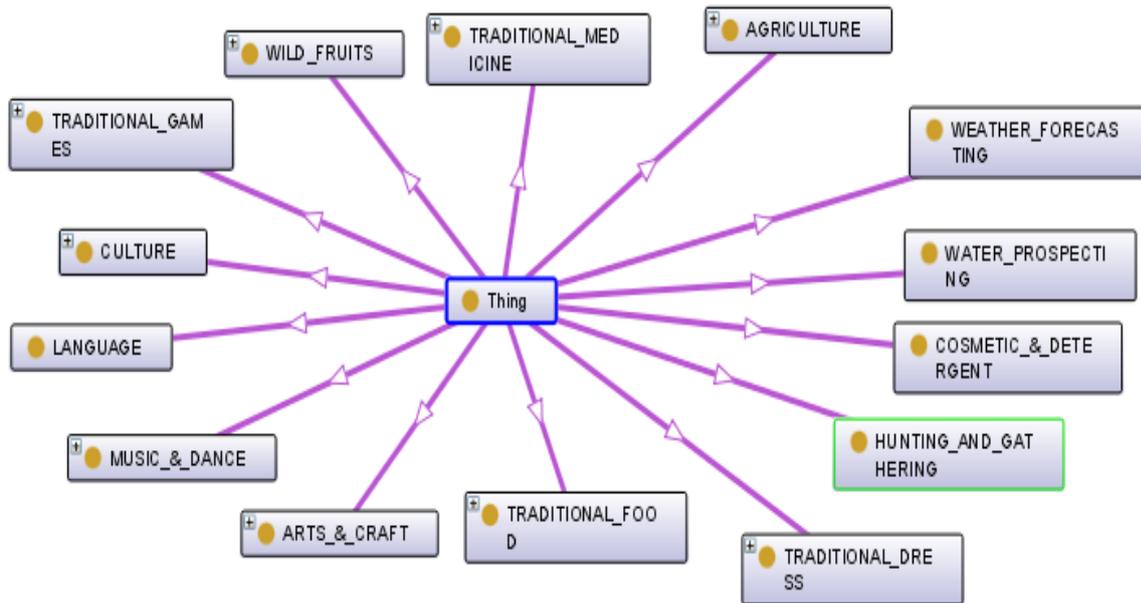


Figure 28 Ontology graphs for Indigenous knowledge systems

Figure 29: The Representation of the OWL Ontology

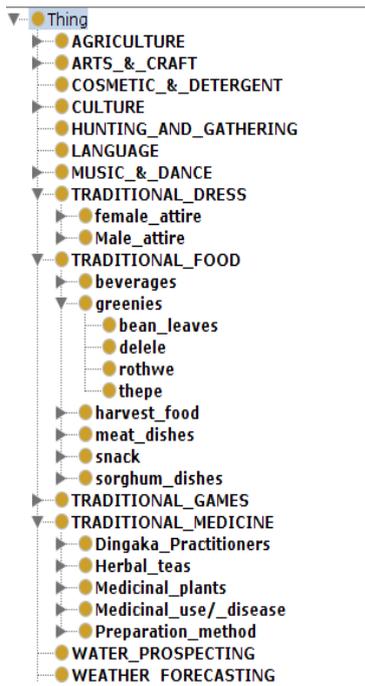


Figure 30: The hierarchy structure for IKS Ontology

Category	Class	Count
Ancestor classes (1)	Thing	1
Super classes (1)	Thing	1
Sub classes (5)	Dingaka_Practitioners	1
	Herbal_tea	1
	Medicinal_plants	1
	Medicinal_use/_disease	1
	Preparation_method	1

Figure 31: The DL query for Traditional medicine

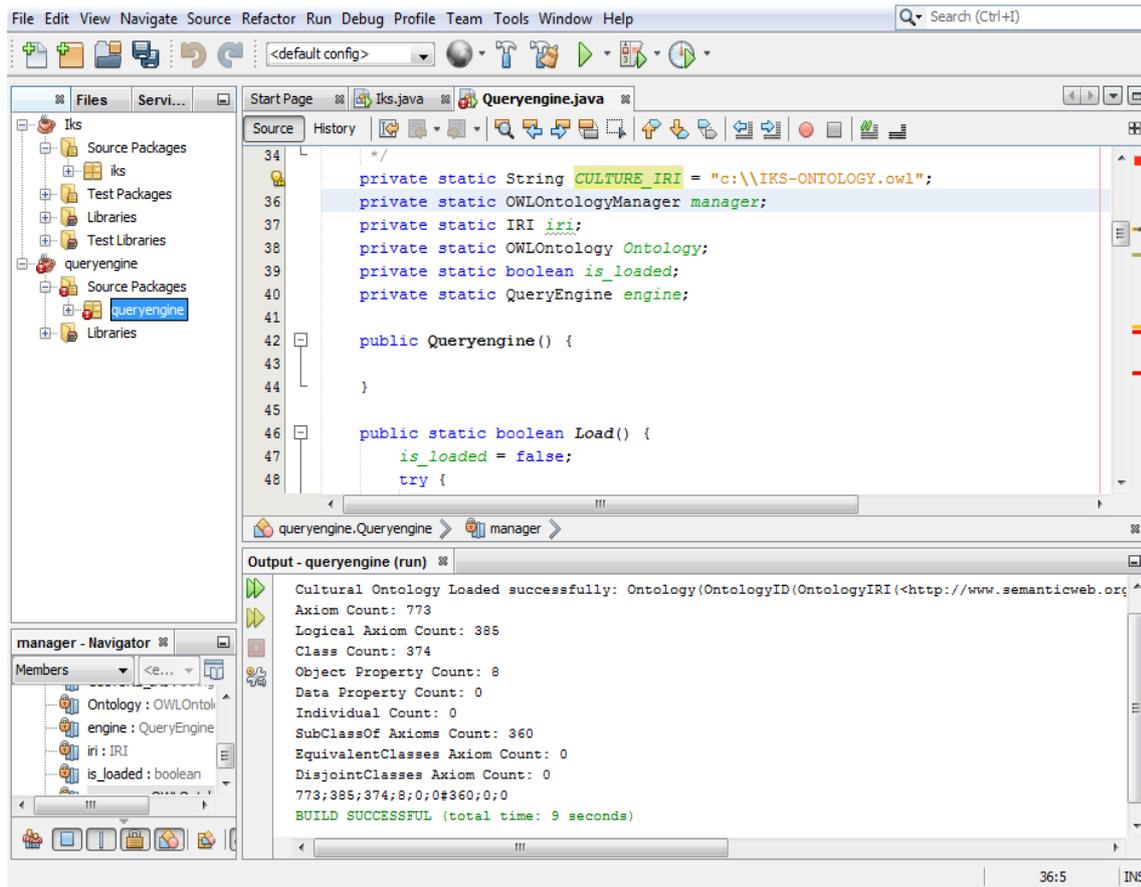


Figure 32: The Net beans IDE, a java class to count number of Concepts in a loaded IKS Ontology.

A java class was created in Net beans IDE, as depicted in figure 33 to load the ontology and count the number of Axiom, Logical Axiom, Classes, Object Properties, Data Property, Individuals, Subclass of Axioms, Equivalent Classes Axiom, Disjoint Classes Axiom and number of statements. Finally after the revelation of the above mention, the research used a simple additive weighting scheme (SAW) to derive weights empirically from semiotic metrics in order to come up with the Semiotic perspective (Syntactic, Semantic, Pragmatic and Social quality metrics) of the Ontology. Calculations of metrics were made against the quality attributes of the ‘Ontology, see table 7 and 8 to achieve the Overall results of the IKS ontology.

Syntactic Quality: Is measured and represented according to the syntax of a preferred machine readable language, richness attribute present a syntactical value for syntactic quality

Semantic Quality: Covers the most area of interest partially because not all attributes are included in the evaluation, hence there is a possibility to easily extend the domain and cover attributes such as Interpretability and adaptability.

Social	History	Percentage of the accesses to an ontology	0.1
	<i>Total</i>		0.1

Table 7: calculations of Metric Values for quality of the Ontology

Metric	Dimension	Description	Total
Syntactic	Richness	Percentage of available syntax used	2.007792
	<i>Total</i>	SR will be = x/y	2.007792
Semantics	Cohesion	Percentage for number of root classes	1.038889
	Consistency	Percentage of number of classes and properties in ontology	2.007792
	Clarity	Average correctness of words in ontology	1.015707
	<i>Total</i>	NoR and NoL+	4.062388
Pragmatics	Completeness	Average precision of words in ontology	0.511968085
	Relevance	Percentage that provide subclass information	0.49806
	<i>Total</i>	PR+F ₁	1.010027594
Social	History	Percentage of the accesses to an ontology	0.1
Quality Total			7.180207

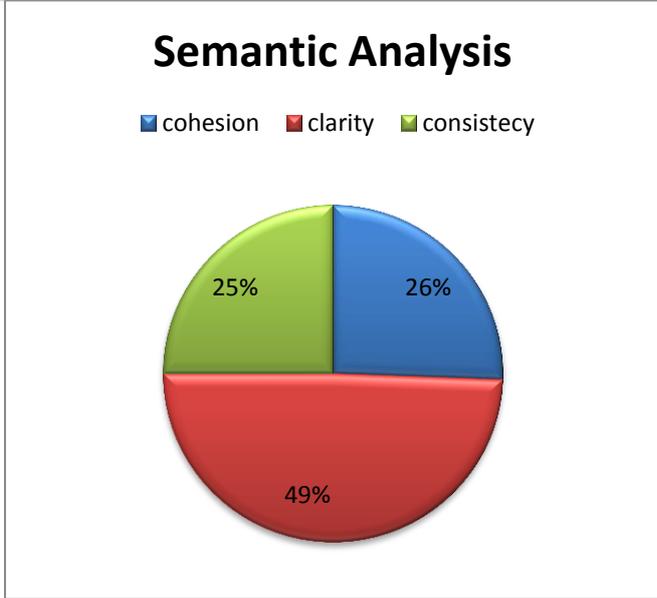
Table 8: Total quality of the Ontology

4.3.1 Overall results

Table 8 present the total results of the IKS Ontology, the observations were made with regard to IKS Ontology. The results of the research are imperative in such a way that a the semiotic metric suite adapted to evaluate the quality of the Ontology could help the Ontology developer to conceptualize their domain of interest, produce better designs and evaluate the aspects of the Ontology such as syntax, semantic, completeness, relevance as well as clarity. The total of syntactic recorded 2.0 values which is 28% of the overall total, The semantics recorded 4.1 value which is the 57% , the Pragmatic recorded 1.01 value with 14%, while social recorded 0%.The Social recorded 1% because IKS is an innovative Ontology that is not yet accessed by agents. The results reveal that upon empirical evaluation of the Ontology, Semantic quality is the most significant.

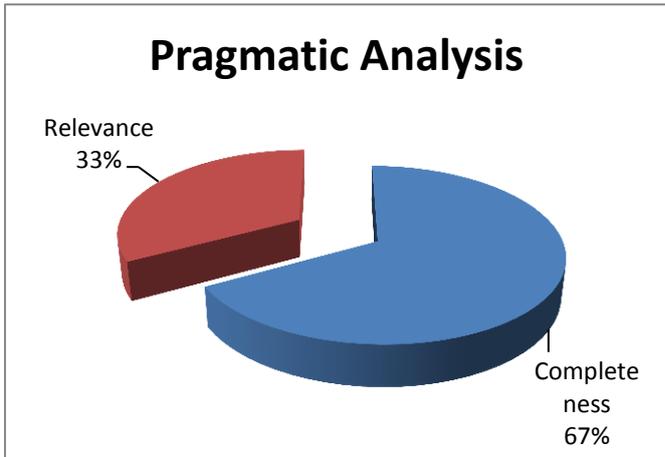
Table 9: results of IKs Ontology

Semantic



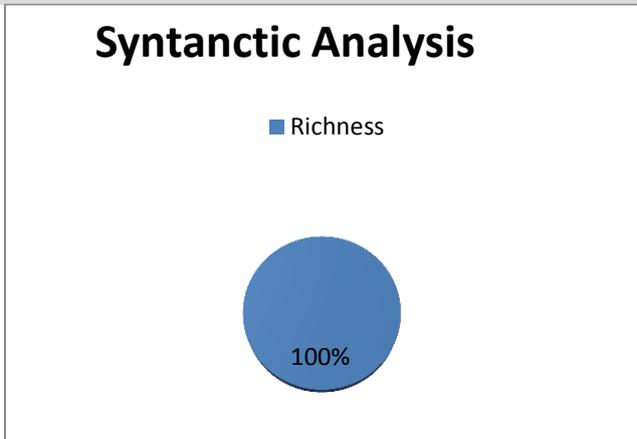
cohesion 1.038889
 clarity 2.007792
 consistency 1.015707

Pragmatic



Completeness 1.010027594
Relevance 0.498059508

Syntactic

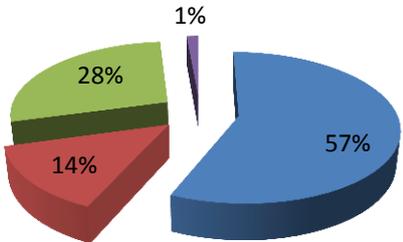


Richness 2.007792

Total Metric

Metric Total quality

■ Semantic ■ Pragmatic ■ Syntactic ■ Social



Semantic	4.06
Pragmatic	1.01
Syntactic	2.01
Social	0.10
	7.18

Chapter 5

5. Conclusion and future work

IKS plays a tremendous role among humanity around the world as it contributes to sustainable local, national to economic development in developing countries. Africa is now realizing IK to shape the future development challenges, it is now recognized as a problem solving tool for indigenous people to eradicate poverty. Though global support for IKS in Africa appears to be waning, countries like China are playing a part to assist Africa in its development as they both have a rich and long tradition of IKS. The World Bank, which got interested in advancing innate information in the mid-1990s and distributed a few great reports, has not had any distribution on IKS since 2004. Nuffic of The Netherlands made an Innate Information Unit in the early 1990s and it utilized to frequently distribute reports, particularly on Africa but it halted its exercises in the early 2000s. There is therefore a need for ICT to play a role in the preservation and dissemination of IKS. Studying indigenous knowledge is vital as we can learn from it, and use it on both a personal and societal level. A semiotic framework, consisting of the status of IKS in Botswana has been presented. Three main benefits of using the framework can be identified. First the framework provides the coherent way to identify IKS by highlighting if it still exists, relevant and known. Secondly it classifies the knowledge domains that could possibly exist, and thirdly addresses the phases of knowledge engineering in pursuit of representing Indigenous Knowledge. The IKS Ontology is developed to impart the proof of concept for this research. The ontology is built using Owl to represent the rich indigenous knowledge, with the purpose to preserve and disseminate the knowledge and enable reinvention.

The IKS Ontology is evaluated by proposing a metric suite to assess the quality of the Ontology that is based on the Semiotic Evaluation approach. Semiotic approach is mainly adopted to demonstrate the possibility and usefulness of the metrics suite and determine what elements suit to evaluate the quality of IKS Ontology. The contribution of this research is that the current work adapts the metric suite developed by Andrew Burton-Jones [52]. Though it is difficult to determine what elements should be considered to evaluate quality of the Ontology, the research chose the metrics that could suit the evaluation process. Finally the

study revealed the objectives and the research questions of the study to determine if they are all achieved as depicted in table 10 and 11.

Table 10 : Evaluation of the Objectives of the Study

Study	Research Objective	Technique Used	Contribution	Limitation
1	To identify the domains of Indigenous Knowledge Systems from literature as a springboard for developing the proposed semiotic framework	IKS domains were derived from literature, archives, and museums	A semiotic framework is developed.	It was hard to determine elements that should be used to evaluate quality of the Ontology
2	To formalise the knowledge by developing the IKS ontology	Protégé ontology has been used	IKs ontology that formalise the knowledge has been represented.	More concepts needs to be covered
3	To evaluate the ontology that formalise the Indigenous Knowledge System domains	A Semiotic approach metric suite has been used	Comprehensive semiotic metrics suite that justifies the improvement of evaluating the quality of the domain ontology contributed to the evaluation	More attributes/ element required to evaluate the ontology can be used
4	To evaluate the Proposed semiotic framework	Empirical experiments done by conducting three group of studies	The proposed criteria used evaluate the semiotic framework is helpful in decision making	More studies can done

Table 11: Evaluation of the research questions

No	Research questions	Technique Used	Contribution
1	How can semiotic framework be applied to classify and identify Indigenous Knowledge System domains?	Empirical study comprised of three groups was conducted to apply the semiotic framework	A semiotic framework is developed. Integrating both Semiotic framework and Ontology revealed the proof of concept for the research
2	What is the contribution of the ontology in the preservation and dissemination of indigenous Knowledge Systems?	Conceptualization process- Ontology represents knowledge in traditional software Conceptualization process, that is, the process by which concepts are generated. concept which tries to capture its meaning	IKS ontology is developed
3	How does Semiotic framework contribute to the formalisation of Indigenous knowledge Systems?	Empirical study conducted.	IKS is realised as one of the Information management system
4	How will establishing the analytical framework be useful in the preservation of IKS?	Empirical study conducted.	IKS is recognized, interpreted and is embraced as of significant value for sustainable development

5.1 Future Work

The contribution of this research is the comprehensive semiotic metrics suite that justifies the improvement of evaluating the quality of the domain ontology, and some ideas used in this paper could be reused to other applications by multidisciplinary experts to build in a collaborative environment and develop a knowledge based system. The Ontology is an artefact that comprises vocabulary, taxonomy and relationship between concepts therefore the users evaluation is realized from the structural level (*syntactic*), and demonstrated in regard to the intended task (*cognitive semantics*) and address the communication to its *pragmatics*.

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Appendices

Appendix A: Sample Questionnaire

Status of Indigenous Knowledge Survey

Age Gender Profession

The study embarks to determine the status of IKS in Botswana, please indicate whether you know the following concepts with a tick on provided check boxes .

tumelo	yes <input type="checkbox"/>	No <input type="checkbox"/>	dhobi	yes <input type="checkbox"/>	No <input type="checkbox"/>
botsetsi	yes <input type="checkbox"/>	No <input type="checkbox"/>	khadi	yes <input type="checkbox"/>	No <input type="checkbox"/>
bogosi	yes <input type="checkbox"/>	No <input type="checkbox"/>	rothwe	yes <input type="checkbox"/>	No <input type="checkbox"/>
bogwera	yes <input type="checkbox"/>	No <input type="checkbox"/>	thepe	yes <input type="checkbox"/>	No <input type="checkbox"/>
bojale	yes <input type="checkbox"/>	No <input type="checkbox"/>	delele	yes <input type="checkbox"/>	No <input type="checkbox"/>
ditloo	yes <input type="checkbox"/>	No <input type="checkbox"/>	setopoti	yes <input type="checkbox"/>	No <input type="checkbox"/>
ntshe	yes <input type="checkbox"/>	No <input type="checkbox"/>	mokuru	yes <input type="checkbox"/>	No <input type="checkbox"/>
dinawa	yes <input type="checkbox"/>	No <input type="checkbox"/>	mosukujane	yes <input type="checkbox"/>	No <input type="checkbox"/>
legapu	yes <input type="checkbox"/>	No <input type="checkbox"/>	madila	yes <input type="checkbox"/>	No <input type="checkbox"/>
lengangale	yes <input type="checkbox"/>	No <input type="checkbox"/>	kgosana	yes <input type="checkbox"/>	No <input type="checkbox"/>
morula	yes <input type="checkbox"/>	No <input type="checkbox"/>	bambukushu	yes <input type="checkbox"/>	No <input type="checkbox"/>
lethodi	yes <input type="checkbox"/>	No <input type="checkbox"/>	bayei	yes <input type="checkbox"/>	No <input type="checkbox"/>
leswabi	yes <input type="checkbox"/>	No <input type="checkbox"/>	bapedi	yes <input type="checkbox"/>	No <input type="checkbox"/>
lebelebele	yes <input type="checkbox"/>	No <input type="checkbox"/>	batlokwa	yes <input type="checkbox"/>	No <input type="checkbox"/>
mosokwane	yes <input type="checkbox"/>	No <input type="checkbox"/>	mothiba	yes <input type="checkbox"/>	No <input type="checkbox"/>
papa	yes <input type="checkbox"/>	No <input type="checkbox"/>	phayana	yes <input type="checkbox"/>	No <input type="checkbox"/>
sebube	yes <input type="checkbox"/>	No <input type="checkbox"/>	thoro	yes <input type="checkbox"/>	No <input type="checkbox"/>
maere	yes <input type="checkbox"/>	No <input type="checkbox"/>	phayana	yes <input type="checkbox"/>	No <input type="checkbox"/>
sebube	yes <input type="checkbox"/>	No <input type="checkbox"/>	german print	yes <input type="checkbox"/>	No <input type="checkbox"/>

	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>
logala	yes <input type="checkbox"/>	No <input type="checkbox"/>	leseka	yes <input type="checkbox"/>	No <input type="checkbox"/>
legodu	yes <input type="checkbox"/>	No <input type="checkbox"/>	motseto	yes <input type="checkbox"/>	No <input type="checkbox"/>
mokwetsepe	yes <input type="checkbox"/>	No <input type="checkbox"/>	mothibampa	yes <input type="checkbox"/>	No <input type="checkbox"/>

serobe	yes <input type="checkbox"/>	No <input type="checkbox"/>	tsutsube	yes <input type="checkbox"/>	No <input type="checkbox"/>
borankana	yes <input type="checkbox"/>	No <input type="checkbox"/>	hossana	yes <input type="checkbox"/>	No <input type="checkbox"/>
setapa	yes <input type="checkbox"/>	No <input type="checkbox"/>	phatise	yes <input type="checkbox"/>	No <input type="checkbox"/>
huru	yes <input type="checkbox"/>	No <input type="checkbox"/>	ndazola	yes <input type="checkbox"/>	No <input type="checkbox"/>
segaba	yes <input type="checkbox"/>	No <input type="checkbox"/>	serankure	yes <input type="checkbox"/>	No <input type="checkbox"/>
setibikoko	yes <input type="checkbox"/>	No <input type="checkbox"/>	dikhwaere	yes <input type="checkbox"/>	No <input type="checkbox"/>
polka	yes <input type="checkbox"/>	No <input type="checkbox"/>	selete	yes <input type="checkbox"/>	No <input type="checkbox"/>
thiwinji	yes <input type="checkbox"/>	No <input type="checkbox"/>	matlhoa	yes <input type="checkbox"/>	No <input type="checkbox"/>
dibaga	yes <input type="checkbox"/>	No <input type="checkbox"/>	kgole	yes <input type="checkbox"/>	No <input type="checkbox"/>
tshega	yes <input type="checkbox"/>	No <input type="checkbox"/>	pantsola	yes <input type="checkbox"/>	No <input type="checkbox"/>
kwaito	yes <input type="checkbox"/>	No <input type="checkbox"/>	choral	yes <input type="checkbox"/>	No <input type="checkbox"/>
mainane	yes <input type="checkbox"/>	No <input type="checkbox"/>	maboko	yes <input type="checkbox"/>	No <input type="checkbox"/>
phitlho	yes <input type="checkbox"/>	No <input type="checkbox"/>	badimo	yes <input type="checkbox"/>	No <input type="checkbox"/>
lenyalo	yes <input type="checkbox"/>	No <input type="checkbox"/>	monesapula	yes <input type="checkbox"/>	No <input type="checkbox"/>
lobola	yes <input type="checkbox"/>	No <input type="checkbox"/>	luthere	yes <input type="checkbox"/>	No <input type="checkbox"/>
roma	yes <input type="checkbox"/>	No <input type="checkbox"/>	serolong	yes <input type="checkbox"/>	No <input type="checkbox"/>
sesobeya	yes <input type="checkbox"/>	No <input type="checkbox"/>	batswapon	yes <input type="checkbox"/>	No <input type="checkbox"/>
sekgalagadi	yes <input type="checkbox"/>	No <input type="checkbox"/>	sekgatla	yes <input type="checkbox"/>	No <input type="checkbox"/>
mmopudu	yes <input type="checkbox"/>	No <input type="checkbox"/>	morama	yes <input type="checkbox"/>	No <input type="checkbox"/>
mowana	yes <input type="checkbox"/>	No <input type="checkbox"/>	go loga	yes <input type="checkbox"/>	No <input type="checkbox"/>
kgomodimetsi	yes <input type="checkbox"/>	No <input type="checkbox"/>	go seta	yes <input type="checkbox"/>	No <input type="checkbox"/>
maboa	yes <input type="checkbox"/>	No <input type="checkbox"/>	go roka	yes <input type="checkbox"/>	No <input type="checkbox"/>
moretologa	yes <input type="checkbox"/>	No <input type="checkbox"/>	go taka	yes <input type="checkbox"/>	No <input type="checkbox"/>
motlopi	yes <input type="checkbox"/>	No <input type="checkbox"/>	marimba	yes <input type="checkbox"/>	No <input type="checkbox"/>
moretlwa	yes <input type="checkbox"/>	No <input type="checkbox"/>	moropa	yes <input type="checkbox"/>	No <input type="checkbox"/>

motsotsojane	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	karata	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
sangoma	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	koi	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
moporofiti	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	morabaraba	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
ngaka	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	boleke mapatile	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
monokwane	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	molao-molao	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
sekaname	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	diketo	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
morolwane	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	sunababe	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
borumlane	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	mantlwane	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
mogatana	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	pitse-maretse	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
thothamadi	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	sekonti-bolo	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
sekaname	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	mhele	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
sengaparile	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	pitse-mareks	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
makgonatsotlhe	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	thupathupana	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
masigomabe	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	morabaraba	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
phekolola	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	koi	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
morollwane	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	majako	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
mogatana	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	masotla	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
motsididi	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	go photha	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
mabeleapodi	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	motshelo	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
mosetlha	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	letsema	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
monepenepe	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	maraka	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
xaoji	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	mabele	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
sengaparile	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	maraka	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
hodia	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	sesigo	yes	<input type="checkbox"/>	No	<input type="checkbox"/>
pelobothoko	yes	<input type="checkbox"/>	No	<input type="checkbox"/>	letole	yes	<input type="checkbox"/>	No	<input type="checkbox"/>

morara yes No leselo yes No

Thank you for being part of the research study.....

Principal Investigator: Naledi Kefitile.....

[Appendix A: Conference Paper](#)