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Knowledge Based System for Ground Water Potential Prediction

By: Adem Beyene

Principal Advisor: Chala Diriba (Assistant Professor)

Co-Advisor : Workineh Tesema (Assistant Professor)

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Approval sheet

A research entitled "Knowledge Based System for Ground Water Potential Prediction" for the course graduate research in Information and Knowledge Management (INKM 516) for the Degree of Master of Science (IKM) in the Department of Information Science, Jimma University.

Advisor's Name	Signature	Date
Principal Advisor: Chala Diriba (Assistant Professor)	___________	___________
Co-Advisor: Workineh Tesema (Assistant Professor)	____________	__________

Examiner Name	Signature	Date
Chair Person _________________________	__________	_________
Internal Examiner _______________________	_____________	__________
External Examiner ______________________	____________	__________

Dedication

I dedicate this thesis to my father who passed away not taking part of my success and happiness with me.

Acknowledgment

First of all, I would like to thank my advisors to my principal advisory Chala Diriba (Assistance professor) and Co-advisory Workineh Tesema (Assistance professor) for their remarkable advice and critical comments from the very beginning of the research work to the end. Their valuable advice, support and constructive comments helped me a great deal in shaping this paper in to its present form. My thanks are due also to Jimma University Institute of Technology, Faculty of Civil and Environmental Engineering, Jimma Zone and Jimma Town Water and Energy organizations during collection of data for their tolerance, advice; encouragement and guidance as well as willingness of share their knowledge during my study period. Helped me in providing the necessary information over the topic under study. In addition, I would like to express my sincere gratitude to my best friend Mr.Mosesa Egigue who every time beside me in any condition and that have supported for the success of my study throughout the whole process. Plus to that, I am great thanks to my brother Dr. Bonso Bude for financial support me and I am great thanks to my friends Birhanu Megersa, (PhD candidate), Mr Daniel Getachew and Mr Girma Mogessie for support in proof reading. Finally, I want to thank you Jimma university Institute of Technology Faculty of Computing and Information to give me this chance.

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Acronyms and Abbreviation

AHP........ Analytical Hierarchical Process

AI ....Artificial Intelligence

ANN:.......Artificial Neural Network

BPANN.....Backward Propagation Artificial Neural Network

CBR:......... Case Based Reasoning

ELM...........Extreme Learning Machine

GIS.............Geographically Information System

GWPI..........Ground Water Potential Index

GWPP.........Ground Water Potential Prediction

IE ....Inference Engine.

KA ....knowledge Acquisition

KB................Knowledge Base

KE................Knowledge Engineer

KBS.............Knowledge Based System

RSM.............Remote Sensing Method

SSA..............Sub Saharan Africa

Abstract

*G*roundwater potential prediction here refers to the total amount of permanent storage water that exists in the aquifers. Groundwater potential is the function of the porosities of the rocks and amount of open space in rocks that could store water. Most of Ethiopia population lives in rural area have not got sufficient water for drinking, irrigation and livestock raring. Lack of pure water in the rural area and town is the major problem for industrial development and economically. Using ground water is the solution for the problem of lack addressing sufficient water for people in Ethiopia. The aim of this study was developing knowledge base system for groundwater potential prediction. To do so, a design science research methodology was used. Development of KBS for GWPP to improve the quality of decision making for fresh hydrologist and geologist to predict groundwater potential effective and efficiently in the shortage of domain expert. To achieve this objective knowledge was acquired by using sample size from Jimma University Institute of Technology, Faculty of Civil and Environmental Engineering, Jimma Zone and Jimma Town water and Energy organizations. Purposive sampling techniques used to selected domain expert and secondary was collected from difference of journal article, groundwater directive, manuals, books and different website working on assessment of groundwater potential.KBS is developed by using conceptual model and representation which is supported by decision tree easily to understand and interpret the steps of groundwater potential prediction. Prototype is developed based on the conceptual model using WINprolog version 6.4.0. production rule if then rules,and forward chaining reasoning mechanism to inference engine rule and appropriate decision making. Performance of the prototype KBS have got excellent acceptance by system evaluator and 85.7% users satisfied by the performance of the prototype developed. Finding of this research was performance of system evaluated by using confusion matrix predict validation techniques by using twenty two parameters of predicting groundwater potential then result of validation parameters of prototype is 84.33% accurate to predict GWPP. Future work proposed by researcher predicting spring water potential continuity by using knowledge based system.

Keywords :groundwater, predict, potential, knowledge based system, domain expert, water

CHAPTER ONE

1. Introduction

1.1. Background of Study

Water quality is inherently linked with human health, poverty reduction, for drinking, food security and livelihoods. Therefore the preservation of ecosystems also economic growth and social development of the societies (Jha et al.,2020). Groundwater more reliable source of fresh water under various pressure to satisfy water demand for increasing global population in the world. Water is primary source of all life and it should be available sufficiently for all the specified demands.

Socio-economic development is closely linked with the supply and accessibility of groundwater resources (Robins & Fergusson, 2014). The increased population dependence has also impacted spring water levels (Uhleman et al., 2016). This is more evident in Sub-Saharan Africa (SSA) where the hydro climate variability and droughts pose a true challenge to scientists (Yang, 2015). Extreme drought were having an extended lasting economic impact on the livelihoods of individual in SSA (Hyland and Russ, 2019). In addition to this groundwater flows in aquifer layers towards the point of discharge which include wells, springs, rivers, lakes and the ocean.

Groundwater makes up about 60% of the world fresh water supply, which is about 0.6% of the entire world's water (Manap, 2011). Using ground water reduces certain problems that have been around the world. Some of the problem that groundwater minimize was river waters have been over used and polluted in many part of the world due to waste material released from different industrial area to the rivers polluted ,so that using groundwater was the best option to reduce side effect of water born disease around the world (Kumar &Singh, 2015).

Groundwater is important source of fresh water all over the world that was used for a various purpose service such as agricultural, domestic, transportation, industrial and recreational purpose. Ethiopia is also using groundwater potential for fulfillment of its urgent water needs for drinking and irrigation (Tamiru, 2006). Groundwater have important role by integrating various types of ecosystem that available around the world particularly those found in the aridity and semi-aridity climates zone (Perez et al., 2014). The distribution of groundwater in Ethiopia estimated about 185 billion cubic meters which cover area of 924,140km^2 depending on the nature which made of Sedimentary, Volcanic and Quaternary rocks and sediments including highland and rift valley area (Alemayehu, 2006).

The availability,accessibility, movement and occurrence of groundwater potential prediction depend on the geology, slope aspect, lineament, drainage density, land use or land cover, rainfall, surface runoff and Geo morphology of the world (Shaban et al., 2015). So as to effectively manage under groundwater potential resources, it's important to possess accurate policy making and forecasts of groundwater potential levels (Basant et al., 2017).

Groundwater is one among the foremost valuable natural resources supporting human health and economic development. Due to its continuous availability and excellent natural quality, groundwater becomes crucial source of water system in many urban and rural areas of the world (Todd &Mays, 2005). Consistent with International Atomic Energy Agency (IAEA) (2013) in Ethiopia, most towns and villages get theirs domestics water system from groundwater sources through developed springs, bore wells and shallow water. In Ethiopian condition, subsurface studies are often carried out when there arises a requirement for local specific developments of groundwater exists including borehole, spring, shallow or hand dug wells for domestic water supply.

The difficult of unsustainable groundwater utilization is becoming clear problem and therefore the key concern for several developing countries like Ethiopia (Hussein et.al.,2017. The subsurface mainly contain method of test drilling of boreholes and geophysical logging techniques. Although the subsurface method were accurate for groundwater assessment they incur large investment since drilling, completing and development of wells could also need for the effective application of those methods. Therefore, it's a usual practice to undertake through surface investigation methods for locating potential groundwater sources (Kibrit and Samuel,2020).

Knowledge Based System (KBS) can be defined as an automated system that uses knowledge about some domain in order to deliver a solution concerning a problem (Fasth, 2000). The first generation of KBS was expert systems using a set of facts and rules. KBS is advance in modern technology with the help of new knowledge, new tools and new resources and development of systems that make use of intelligence, knowledge and wisdom had bee n provide more insight and also the way for GWPP. The ability to makes intelligent system to capture and redistribute expertise has significantly implication on development of nation and community (Wemembu et al., 2015).

KBS is may a system allow documentation of one or more expert knowledge and utilize the knowledge for problem solving in cost effective way as well as allows for controlled manner, import of expert experience in various areas that the nation lacks of expert and also export of data concerning domestic areas of experience, and therefore the duplication and redistribution of scarce knowledge in a cost effective manner (Rajan, 2015).

More details are often specified to refine its performance more concepts and links among concepts are often specified to broaden its range of applicability. KBS it doesn't tell the program what to it do, it tells it what to understand or perform function. It keeps the knowledge in the knowledge base. Choose a representation that is as high level transparent as possible.

KBS are in the context of encompassing knowledge management issues since knowledge based systems represent but one component of the knowledge issue, and knowledge based systems would be integrated all over corporate knowledge management program in the knowledge base. KBS are just one stop solution for any case or issue to solve. Their development relies on the transformation of human informal knowledge into formal knowledge with some support from knowledge engineering techniques (Suheir, 2018).

Recent study on prediction and modeling groundwater resource using ANN by(Ali et al., 2016). Prediction using this parameters models reducing relate expense and presentation overall and comprehensive for water resource manage. ANN method is diverse input for groundwater resource prediction. Machine learning process is the model for input parameters by using root mean square error and correlation coefficient to actual and predicts best output result. The result was machine learning process models the high conformity to predict ground water than ANN. According to Nurhayati et al., (2013) conducted study to test the use of ELM (Extreme Learning Machine) for forecasting groundwater levels on tidal lowlands in Indonesia.

In this study, backward propagation ANN (BPANN) was used for validation, and the results showed that the training result and the groundwater prediction using ELM yielded better results than BPANN methods.

KBS which store knowledge in knowledge base for solving problem or class problem easy to solve depending on the reasoning, facts about how particular problem solved and explanation mechanism. However KBS provide high intelligence level to helps people those discovering and developing not professional field of study by storing knowledge in the KB very vast amount of knowledge in different area of study.

In addition KBS can be acquire new perception by simulating unknown situations and also offers significant software productivity improvement. KBS is solve the problem when an expert not available by store for future use and by grouping more than one expert knowledge on one platform. The benefit of KBS is to increase output and productivity, improve quality, reduce downtime, flexibility and reliability and knowledge documentation and easy to knowledge to transfer. Motivation of this study was researcher working in governmental financial institution which dealing in the governmental economic cooperation and economic development in south west of Oromia Region which was dealing with documents of bid deal agreement between contractors and project owners and follow financial payment to contractors for a numbers of years on the groundwater potential assessment in the south west of Oromia region. According the researcher investigation assessment of groundwater potential based on the manual searching groundwater potential without understanding the factors of effect groundwater potential contractors drilling wells but didn't get groundwater potential according to the agreement they drilling a numbers wells in the same area changing the place which have no enough groundwater potential this what the reason motivate researcher to conduct this study. The strength of this study was precise prediction of ground water potential levels can helps policy makers to resolve the best approach to ground water potential management problems and use of ground water properly. Researcher was identify the weakness of contractors and project owners they was manual predicting groundwater potential availability without understanding environment factors effect of groundwater potential in the area. However developing KBS for GWPP was the great opportunity for contractors, stakeholders, community and project owners as well as the best treat to the grievous happen before to search groundwater potential.

KBS use is increasing in many companies and systems are having wide range of applications in AI systems and decision making systems. The aim of this study was to develop a knowledge based system for predicting the groundwater potential during investigating, site selection process for the ecologist, water factories and other water related project.

1.2. Statement of the Problem

In Ethiopia there’s shortage of water for drinking and irrigation due to increasing a number of populations in urban and rural areas as well as high need water in the country. As the researcher identified there’s a number of groundwater potential drilling wells in the South West Ethiopia, Oromia Region Jimma Zone and Jimma Town by foreign company. Groundwater potential drilling wells is very cost without having any information about the status and distribution of groundwater potential level . Those foreign company working on the drilling wells they predict groundwater potential manual mostly probably they didn’t get sufficient groundwater potential according to bid deal agreement between contractors and project owners was the core problem. They take previous bid deal agreement expense decided for brand sparking new status high groundwater potential drilling wells was the problems in several areas to assess groundwater potential.

Drilling wells within the area with limited information, facilities, intelligent models with lack of spatial distribution of qualitative and quantitative parameters for groundwater potential prediction which was based on the traditional method of groundwater potential predicting to drill wells not assist fresh and senior hydrologist and geologist to predict groundwater potential level in the area. In addition to this they use mathematically modeling techniques to predict groundwater potential based on the topography, geologically features, drainage, elevation, geology, Geo morphology, land use or land cover, lineament and rainfall pattern less accurate to predict groundwater potential without interrelation of those parameters (Maroufpoor et al., 2020).

Ethiopia have different climate ranging from aridity and semi-arid desert type within the lowlands to humid and warm type of climatic condition which shortage of surface water resource (Beyene,2010). Theirs also variability of rainfall in Ethiopia which is mean annual rainfall of Ethiopia range 141mm in arid area which enforce to use groundwater potential (Berhanu et al.,2013). The complex topographical and geological feature of the country have strong impact on the spatial variation of climate and different rainfall region in Ethiopia to manual predict groundwater potential (Zeleke et al.,2013).

Ethiopia constitutes about 99.3% land area and the remaining 0.7% is covered with water bodies as well as the country has 12 major basins, 12 large lakes, and differently sized water bodies which have three of the major basins are dry basins, which do not have any stream flow in these basins (Mowe, 2013). Increase of a number population in Ethiopia increase the problems the need of water for drinking and irrigation special the population those who live in local area, which have no any infrastructure build for water transfers. Most of the rivers in Ethiopia are cross the boundary about 97% estimated annual stream flow out of Ethiopia into neighboring countries and only about 3% of this amount remains within the country (Berhanu, 2014).

In Ethiopia there is lack of in depth understanding of the groundwater potential of Ethiopia as well as there is high disparity of groundwater potential in Ethiopia (Kibrit and Samuel,2020). On the other hand, there are also very limited studies on the use of groundwater for irrigation utilization purpose in Ethiopia. This indicates that there is lack of understanding of the available groundwater potential resource and uses in the Ethiopia (Kibrit and Samuel,2020).

In addition, the challenge of predicting Ground Water Potential Prediction (GWPP) in Ethiopia is technical challenge because lack of data, information and knowledge is misleading during search for ground water potential in the country highly crisis economically and kill time (Berhanu, 2014). Natural challenge which is spatial and temporal variability of climate, topography, soil, and geology of the country induce high variability in the amount and distribution of groundwater potential resources in Ethiopia.

Always the occurrence of groundwater potential is especially influenced by the geophysical and climatic conditions of the area. The difficulty in obtaining productive aquifers is a particular feature of Ethiopia, which is characterized by the wide heterogeneity of geology, topography, and environmental conditions (Alemayehu, 2006). However, the occurrence of groundwater potential is not uniform because it depends on various environmental and geological factors. Selection out of site and improper evaluation of ground water potential prediction and site selection is usually expected to be problem (Tesfaye, 2012).

Therefor the proposed study was developing a KBS to predict groundwater potential resources which save budget, time consuming and high resources consumption process as well as support fresh and senior hydrologist and geologist those haven't any more experience of drilling wells. In order to conducting this study is very important gap identified by researcher the matter mention above. This study was attempted to obtain answers for the following research questions:

- ✓ What type of knowledge required for developing knowledge based system for GWPP?
- ✓ To what extent the proposed knowledge based system support for GWPP?

1.3. Objective of the Study

1.3.1. General Objective

The general objective of this study was developing a knowledge based system for groundwater potential prediction.

1.3.2. Specific Objective

- ✓ To acquire knowledge from professional expert and different documents analysis to predict ground water potential.
- ✓ To model and represent domain knowledge acquired from domain experts
- ✓ To develop prototype system for ground water potential prediction
- ✓ To evaluate the performance of the prototype knowledge based system GWPP.

1.4. Significance of the study

The proposed KBS for GWPP would be support fresh and senior geologist and hydrologist professional to make decision easily. The precise prediction of ground water potential levels can helps policy makers to resolve the best approach to ground water potential management problems and use of ground water properly. The developed knowledge based system for ground water potential reduce unwanted cost paying for extra jobs in the absence of expert, easy to carryout technically risk assessment during searching ground water potential prediction, helping any users for further consulting without limitation of education background, race, sex and religious difference to get information for assessment of ground water potential. Moreover, easy to review all parameters of predicting ground water potential in a few time. Immediate beneficiaries of this study professionals those works in Ethiopia Ground Water Resources Assessment Program, Ministers of Water and Energy, Minister of Agriculture and all community as well as sector working on the ground water potential to improve ground water potential prediction problem. Furthermore, this study is significant in saving human power, time and cost in field work during site selection, ground water potentially prediction for organization who are working on it. Moreover, this study also used to transform tacit knowledge of experienced domain experts on GWPP into new or inexperience experts.

1.5. Scope and limitation of the Study

The study focus would be only on development of knowledge based system for GWPP. Design science research methodology would be used for this study. Study areas were Jimma University Institute of Technology, Faculty of Civil and Environment Engineering, Jimma Zone and Jimma Town Water and Energy Organization. Tool would be used for this study SWI prolog (Programming in Logic) programming language would be used as a tool to develop prototype KBS. In addition, a number of different approaches for KBS development method would be used as well as for this study production rule based approach was used. Purposive sampling technique was used to select domain expert. Limitation of this study was KBS for GWPP not predict the depth of groundwater potential, lack of local related work done related to title and Jimma Zone and Jimma Town Water and Energy Organization area.

1.6. Operational definition

Knowledge Base knowledge base contains the domain-specific knowledge required to solve the problem.

Knowledge engineering is refers to developer of knowledge based system that follows the approach respect to the qualification, personality and process.

Knowledge Based System is the collection of relevant knowledge that is stored in the computer and is organized in such a manner that it can be used for inferences, which is the reasoning process of Artificial Intelligence that takes place in the brain of an Artificial Intelligence process.

Domain Expert domain expert is a person who expertise in his/her domain area.

Inference Engine it carries out the reasoning where by KBS reaches a solution. It links the rules given in the knowledge base with the facts provided in the database.

Explanation Facilities able the user to ask the KBS how a particular conclusion is reached and why a specific fact is needed.

User Interface is the means of communication between users' seeking a solution to the problem and KBS.

1.7. Organizational study

This study contains seven chapters.

Chapter one discusses background of the study, statement of the problem and research questions, the general and the specific objectives of the study, significance of study , and scope and limitation of the study.

Chapter two discusses about theoretical and empirical works review that are relevant for this study. In this chapter, the researcher discussions about artificial intelligence, knowledge bases systems, types of knowledge representation techniques, System Performance Evaluation Methods and related works which are relevant for this study.

Chapter three deal with methodology of study, area of the study data gathering using different method such as questionnaire, semi structured interview and documents analysis.

Chapter four of this thesis presents the about the knowledge acquisition processes, knowledge representation techniques and knowledge modeling process.

Chapter five discusses about Design and Implementation. In this chapter the structural design of the system, knowledge base and inference engine as well as the user interface are presented.

Chapter six discusses about implementation and evaluation of the prototype systems. In this chapter the performance of the prototype is evaluated both the performance of the system and the acceptance of the system by the users. Finally, the researcher dedicated

chapter seven for conclusion and recommendation. In this chapter, the researcher discussed the evaluation results and based on the result the researcher presents findings and concludes the study by recommending future works.

CHAPTER TWO

2. Literature Review

2.1.Artificial Intelligence

Artificial Intelligence (AI) is a science and engineering of creating intelligent machines, especially intelligent computer programs. It's associated with the similar task of using computers to know human intelligence, but AI doesn't need to confine itself to methods that are biologically observable (Priyanka, 2010). Intelligent machine have ability interact with world are often to perform task like speech recognition, understanding and synthesis. Intelligent system is going to be capability to perform task like continuous learning, reasoning and adaptation.

An intelligent system might be a system exhibits and possesses some basic attributes like performing some actions, reasoning for a few particular domains, making decision and goal oriented problem solving capability. A system or an agent is often said to be intelligent when the agent's performance cannot be distinguished from that of a person performing the same task (Honavar, 2006).

One among the application of AI is predicting the problem based on the past predict future what happen counting on the previous problems. Intelligent system have play vital role that in our daily activities that everybody has perform activities like Banking (automatic check reader or signature verification system), Telephone (automatic voice recognition), Computer Company(automatic diagnosis for help of desktop application), MasterCard Companies (automated fraud detection) and Netflix (movies recommendation) (Raza, 2009).

2.2.Knowledge Based System

Knowledge based system (KBS) mainly focuses on systems that use knowledge based techniques to support human deciding, learning and action. Such systems are capable of cooperating with human users to give standard support and therefore manner of its presentation is important issues (Gabriela, 2005). KBS would be a software system capable of supporting explicit representation of knowledge and its appropriate reasoning mechanism in ordered to supply high level problem solving performance (Kariuki, 2015).

KBS is depending on the AI method and a technique which is hardware and software systems to perform task precisely according to specific sort of knowledge representation. Knowledge formalized from organization point view of learning and support different specific task which held all knowledge in one database to solve specific domain expert in several representation forms like experiences, software,procedures, databases, process descriptions and formalization degrees, and including groupware and knowledge sharing mechanisms (Stelzer, 2003).

Deployment Knowledge Based Systems have a number of application areas which the foremost profit. This typically sort of systems, stand-alone or embedded in other tools, proved to be very useful in domains such as: natural resource management, environmental monitoring and cleanup, construction, manufacturing, transportation, aerospace or defense force, communications, electric-power generation, wholesale or retail distribution, financial services, logistics, law enforcement, medicine and pharmaceutics (Rajan et al., 2015).

KBS can be act behave of expert on demand without considering time and place to make decision. KBS can save money by leveraging expert, allowing users to function at higher level and promoting consistency (Sajja & Akerkar., 2010). KBS is computer based system which automate and generates knowledge from data ,information and knowledge. These automated system capability to understand information under process and can be make decision based on the residing information.

KBS contains KB and Inference Engine(IE)of search query. The IE software code of program which infer knowledge in the knowledge base. As an expert's power lies in his explanation and reasoning capabilities, the expert system's credibility also depends on reason of system and decision by system (Kesarwani and Misra, 2013).

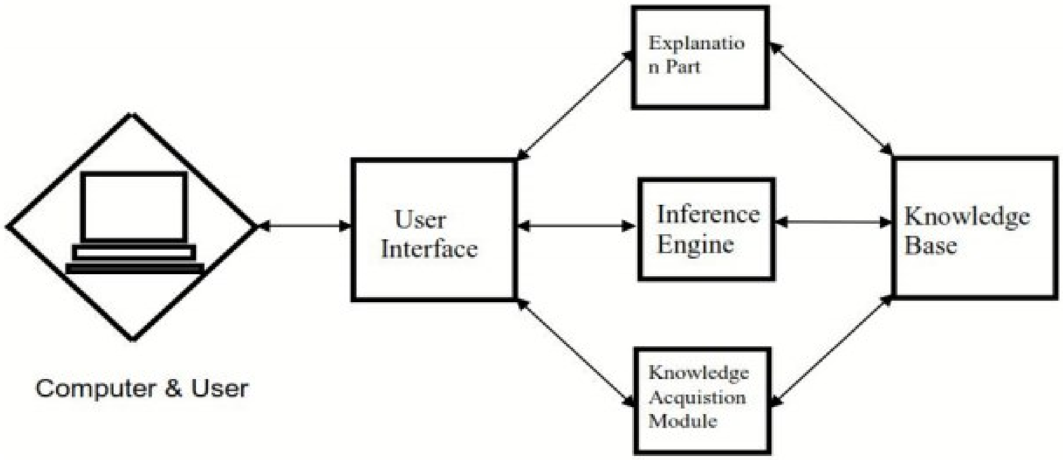

Figure 2:1.Architecture of knowledge based system (Saxena, 2011).

2.3. Knowledge Based System Structure

Knowledge Based System (KBS) is one among the family members of the AI group. With availability of advanced computing facilities and other resources, attention is now turning to more and more demanding tasks, which might require intelligence (Sajja & Akerkar, 2010). KBS has the following component; knowledge base, inference engine, user interface, explanation facility and learning facility (kariuki, 2015).

Knowledge Base: knowledge base contain specific domain knowledge to solve specific problem. KB is created by knowledge engineer who conduct serious of interview and questionnaire with domain expert and organize knowledge in the form of that directly used by the system or write code of programming to computer understand and interprets by the system. Knowledge engineer have knowledge of KBES technology and should know how to develop expert system using development environment or expert system development shell (Kariuki, 2015). KB consists domain specific knowledge in ordered to solve problem. Expert system based on the rule based which knowledge represented in the form of set rule. Rule based have specific relation, recommendation, directive, strategy or heuristics and has IF-THEN condition structure. When condition satisfied the rule said to be fire and executed..

Inference Engine: it carries out the reasoning where by KBS reaches a solution. It links the rules given in the knowledge base with the facts provided in the database.

Explanation Facilities KBS have explanation facility for user task how particular conclusion reached and why specific action needed by KBS must be to explained its reasoning and justify its advice,analysis or conclusion.

User Interface is the means of communication between user seeking a solution to the problem and KBS.

Learning Facilities working memory or database contain a set of facts used to match against the IF condition part of rules stored in the KB.

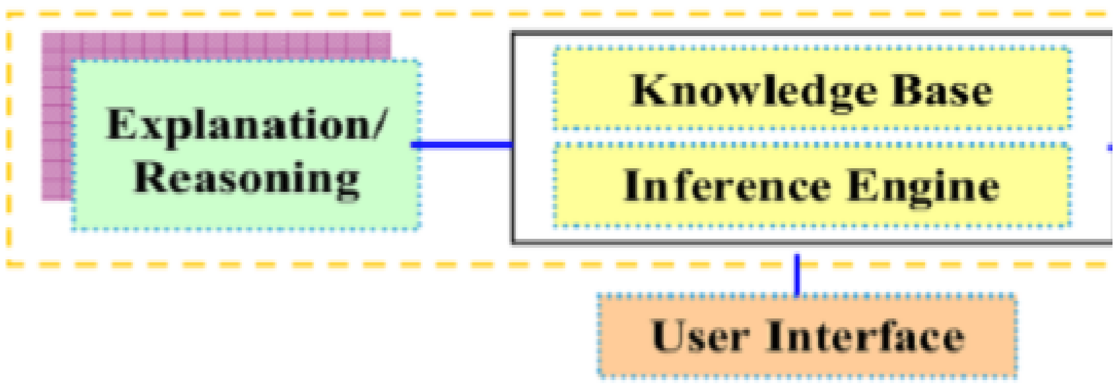

Figure 2:2. Structure Knowledge Based System (Sajja and Akerkar, 2010)

2.4.Knowledge Based System Development

Knowledge based system development pass through some phase. Those phase are knowledge acquisition, knowledge representation, knowledge modeling and evaluation. KBS is application software with an explicit, declarative, and description of knowledge for cetain application (Speel et al.,2014). Expert knowledge is stored in his or her mind in a very abstract way. However every expert might not familiar with KBS terminology and how to develop an intelligent system but knowledge engineer is responsible person to acquire, transfer and represent the expert knowledge in form of computer system (Sajja and Akerkar, 2010).

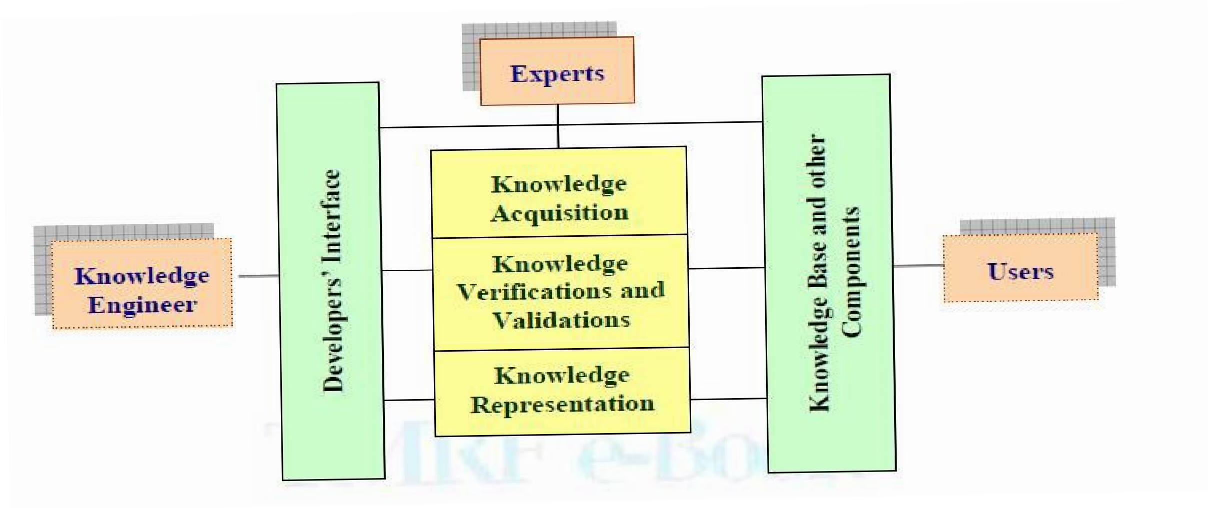

Figure 2.3 : Development of Knowledge Based System (Sajja & Akerkar, 2010)

2.4.1. Knowledge Engineering

Knowledge engineering is refers to the process of developing knowledge based systems. KE thus the developer of knowledge based system shall follow the approach respect to the qualification, personality, process and attribute. KE is depending on some criteria during knowledge based system development those are: Knowledge acquisition, knowledge modeling, knowledge representation, differentiating and explanation. Some task premed by knowledge engineering is extracting from people in some form, including knowledge in a computer program which makes use of knowledge and validating the software system produced (Kariuki, 2015).

2.4.2. Knowledge Acquisition

The knowledge acquisition (KA) process incorporates typical fact finding methods like interviews, questionnaires, record reviews and observation to acquire factual and explicit knowledge. However, these methods are not much effective to extract tacit knowledge which is stored in subconscious mind of experts and reflected in the mental models, insights, values, and actions of the experts. For this, techniques like concept sorting, concept mapping, and protocol analysis are being used (Sajja & Akerkar, 2010).

Acquired knowledge should be immediately documented in a knowledge representation scheme. At this initial stage, the selected knowledge representation strategy might not be permanent. However documented knowledge will lead the knowledge engineer or developer to better understanding of the system and provides guidelines to proceed further. Rules, frames, scripts and semantic network are the typical examples of knowledge representation scheme. It is responsibility of the knowledge engineer to select appropriate knowledge presentation scheme that is natural, efficient, transparent, and developer friendly (Rajeswari, 2012).

Knowledge acquisition provide effective elicitation techniques facilitate to acquire relevant knowledge form domain experts. According to Wang (2011) the most commonly used to knowledge acquisition the techniques as follows.

Interview

Knowledge acquisition use interview technique to interacting with domain expert on how they perform the task based on theirs professional or experts. Knowledge acquired through direct elicitation methods are procedural knowledge this based on the structure interview have categorized into those are structured ,semi structure and unstructured interview (Henok, 2011).

Structured interview: Structured interview is the way of asking question domain expertly directly to face to face. Its goal oriented process to force organized communication between the knowledge engineer and the domain expert. Structured interview educes the interpretation problems inherent in unstructured interviews and allows the knowledge engineer to prevent the bias caused by the subjectivity of the domain expert (Ranjan, 2006).

Semi structured interview: An interview that usually use both closed-ended and open -ended question to make decision with domain experts. This type of interview is more flexible when compared other interviews and interviewer have chance of change order of question and expand dimension of question depend on the participant response (Rajan.2006).

Unstructured interview: This interview technique provides complete or well-organized descriptions of cognitive processes. There are many reasons that enforced to applying unstructured interview. Domain the experts usually find it very difficult to express some of the most important elements of their knowledge. Through structured interview it is difficult to acquire the required knowledge. With good training and personal experience knowledge engineers can use unstructured interview to acquire relevant knowledge from domain expert.

In generally effective interview based on the knowledge engineer ability to articulate implement implicitly knowledge into explicit knowledge. On the other hand eliciting knowledge using indirect methods requires human intervention such as observation, document analysis, etc. (Wang, 2011).

Observation

Observation is obvious and straightforward approach of knowledge acquisition techniques. This techniques knowledge engineer directly observe how the problem addressed by domain expert. Observation is what particular domain expert physically when solving problems of predicting groundwater potential. It was useful in determining what types of knowledge the human expert used to solve problems and the forms in which the knowledge were stored. Observations are used primarily as a way of supporting verbal protocols. In generally, acquiring knowledge through observation is expensive and time taking procedure (Wang, 2011).

Documents analysis

This is the final point of knowledge acquisition from document analysis which concerning detail analysis of existing documents to extract knowledge in the form of documentation. This techniques is used to collect existing documents from professional literature, brochures, manuals, guidelines, employees, hand books, reports, course texts, and others relevant all materials. Knowledge elicitation methods can be classified into different types. Direct and indirect is the commonly known methods of knowledge elicitation. The way of classification depends upon how knowledge engineer directly obtains information from the domain expert (Osuagwu, 2006).

2.4.3. Knowledge Modeling

Knowledge modeling are used to capture the essential features of real systems by breaking them down into more manageable parts that are easy to understand and to manipulate (Abduliah,2002). Knowledge modeling helps people to appreciate and understand such complexity by enabling them to look at each particular area of the system in turn. Models are used in systems development activities to draw the blue prints of the system and to facilitate communication between different people in the team at different levels of abstraction. People have different views of the system and models can help them understand these views in a unified manner.

The modeling process constructs conceptual models of knowledge-intensive activities (Schreiber et al, 2001). During the knowledge acquisition stage, most of the knowledge is unstructured and often in tacit form. The knowledge engineer will try to understand both the tacit and the explicit part of the knowledge and then use simple visual diagrams to stimulate discussion among users and knowledge experts .This discussion process generates ideas and insights as to how the knowledge is used, how decisions are made, the factors that motivate and so on. The knowledge engineer then has to construct the conceptual model from what has been discussed during the knowledge acquisition stage. This communicates the knowledge to the information specialist who will transform the model into workable computer programs or codes (Abduliah, 2002).

A Knowledge model is important for understanding the working mechanisms within a knowledge based system, such as: the tasks, methods, how knowledge is inferred, the domain knowledge and its schema. Conceptual modeling is central to knowledge engineering (Schreiber et al, 2001). Knowledge modeling contributes to the understanding of the source of knowledge, the inputs and outputs, the flow of knowledge and the identification of other variables such as the impact on the organize knowledge (Davenport & Prusak , 2000).

2.4.4. Knowledge Representation

The tool should have enough expressive power for representing engineering concepts. The combination of scientific knowledge, that is often exact and complete, and heuristic information, which is based on empirical observations, is a critical issue in the development of a KBS. Ideally a combination of rules following the IF-THEN construct to represent the procedural knowledge and objects or frames to represent declarative knowledge can provide a powerful environment for development of a KBS in engineering disciplines. The combination should be such that the rules and frames should be able to interact with each other during the problem solving.

Frame based Representation

A frame is defined as a unit of a knowledge source described by a set of slots. The slots can be of two types, viz., abstract or concrete. This classification is made based on the type of information associated with them. Frame can also be made relational in nature, where in the slot contains information on the relationship of the frame with other frames (Grundspenkis, 2014).

Decision trees

Decision trees are related to decision tables and are popular in many places. They are composed of nodes representing goals and links representing decisions. The major advantage of decision trees is that they can simplify the knowledge acquisition process. Knowledge diagramming is often more natural to experts than formal representation methods (Vadera, 2005). Decision trees can easily be converted to rules. The conversion can be performed automatically by a computer program. In fact, machine learning methods are capable of extracting decision trees automatically from textual sources and converting them to rule bases. It is responsibility of the knowledge engineer to select appropriate knowledge presentation scheme that is natural, efficient, transparent, and developer friendly and the degree of familiarity of the knowledge engineer with a technique. One may think for hybrid knowledge representation strategies (Sajja & Akerkar, 2010).

Semantic Networks

Semantic networks very powerful forms of representing facts in expert systems. They are ideally suited for representation of declarative knowledge, which describes physical entities and semantic relationships between them. Any knowledge engineer activity is centered around any facility, and detailed information about the attribute is required to make decisions concerning it. Different attributes of the artifact may be used at different stages of a problem such as planning, analysis, detailing, manufacturing or construction (Arenas, 2010).

Case Based Representation

Case based representation the first uncertainty management scheme which was tailored to be used with knowledge intensive rule-based systems (Kimble, 2006). The scheme got refined during the development of system in order to overcome the weakness of the probability theory based approaches. The case based approach proposed and successfully implemented. In expert systems using certainty factors, the knowledge consists of rules in the form “IF <evidence> THEN <hypothesis> CF”, in which CF denotes hypotheses belief given observed evidence. Before any combination of evidence can be performed, two intermediate functions must be calculated.

Rule Based Representation

Typically a knowledge base will consist of a large number of rules. Logically the rules can be grouped into different rule bases. Knowledge net representing the set of rules in a rule base should be complete with proper connectivity of nodes in the net. Hence, drawing the knowledge net gives the knowledge engineer an opportunity to verify the knowledge base for possible inconsistencies and redundancies. It is a common practice in the development of expert systems to logically divide the rules into smaller rule bases and to control from a higher-level rule base which has knowledge about the different rule bases in the knowledge base. If there are more than one rule bases, each of them should have separate contexts.

Rules based representation is a simulation of the cognitive behavior of human experts. It represents knowledge, but also represents a model of actual human behavior. Rules are easy for a human expert to read, understand and maintain. If the knowledge is expressed as data and not encoded in the program’s control mechanism, it can be returned to the user in the form of explanations. Production rules involve simple syntax that is flexible and easy to understand. They are quite efficient in diagnosing problems of the form: if (condition) then (conclusion) (De Ko ck , 2003).

Rule Based Reasoning Techniques

One of the most important capabilities of human experts and one of the most difficult to faithfully replicate in an expert system is the ability to deal with imprecise, incomplete and sometimes uncertain information. However, efforts have been made and techniques have been proposed by researchers working in the field, to incorporate inexact reasoning based on uncertain information in expert systems. Uncertainty is obviously present in most expert system algorithms because experts can rarely be sure of the statements they make. Major sources of uncertain information in knowledge bases of expert systems can be the following: unreliable information, imprecise descriptive languages, inference with incomplete information and poor combination of knowledge from different experts (Abdullah et al., 2015).

Forward chaining

Forward chaining is a data-driven inference process. The user of the system has to give all the available data before the start of the inference. The inference mechanism tries to establish the facts as they appear in the knowledge base until the goal is established. Consider the same rule base**.** The user gives the available data and the state of the context before start of the inference. The inference process selects the first rule in the rule base and discards it since the first condition itself evaluates to false. Then it goes to the second rule, which is also discarded. The condition in the third rule evaluates to true and it is fired resulting in a new fact being added to the context (Dwi, 2018).

Backward Chaining

As stated earlier, backward chaining is a goal-driven process. It tries to establish goals in the order in which they appear in the knowledge base. The goal variable defined in the rule base for selection of a structural system. The inference process will stop once this variable gets a value. The three dynamic data structures used during the inference process are working memory /context, a rule stack and a goal stack. Whenever any one of the actions of the inference process, viz., select, match and execute occur, one or more of these data structures get modified. Hence, working of the inference process is described through the changes that occur to the context, a rule stack and a goal stack. Rule stack and goal stack are temporary data structures created for bookkeeping. When the process starts, the context is empty and the goal variable is pushed to the goal stack (Alhazov, 2011).

Backward Versus Forward Reasoning

Backwards and forward reasoning both reasoning have mostly similar function (Hargis, 2012). The difference occurs between two reasoning depend on the data structure of knowledge based system. Backward and forward reasoning have area when and how to apply to reasoning have their own ways to solve problem. Some of the point discussed as follow on those reasoning.

- ✓ Backward and forward reasoning used to solve problems depend on the properties of the rule set and initial starting of the facts.
- ✓ Backward chaining is more efficient when you avoid drawing conclusion from irrelevant facts , if you have particular goal.
- ✓ Backward chaining sometimes it very wasteful , because it need many possible ways to checking the goal and also checking all rules before finding one that works.
- ✓ Forward chaining is better to use during small set of initial facts and when theirs a numbers of rule which allow draw the same conclusion
- ✓ Backward chaining might better, if you have single facts and set of initial facts as well as forward chaining use a lot of rules to eligible to fire goal driven.

2.5. Knowledge Based System developments Tools

KBS development tools is a set of instruction and software package utility to assist the development of KBS. KBS developed on the personal computers by using programming language such as Java and framework.NET can also be used in KBS development. These programming languages are used for specific purpose and also being used to develop other application than AI applications (Sajja & Akerkar, 2010).

KBS shell with the ready made utilities of self- learning; explanation and inference and user interface . Programming language like Java Expert System Shell (JESS), GURU, Vidwan are more specific and can also be useful to develop KBS. KBS can be developed by using programming languages like LISP and Prolog. Prolog is a logic programming language for general purpose of programming by using fifth generation (AI) language. It has a purely logical subset know as pure Prolog as well as a number of extra logical features. Prolog has its own roots in formal logic, and unlike many other programming languages as well as Prolog is declarative. Prolog program is a logic that expressed in terms of relations, and execution is triggered by running queries within relations (Sajja & Akerkar, 2010).

KBS implementation was depend on the high level of programming language. However modern KBS development tools is depend on the purpose, functionality and feature of the system used by user and support user using the system for appropriate decision making. KBS development tools classified into general purpose and specific purpose programming language. Specific purpose programming language such as Java and framework.NET and general purpose programming are like JRULES,CLIPS, JESS (Lamma, 2001). Most of the popular expert system development tools was CLIPS to represent program of list structure. Lisp is the foundation of many expert system and shell such as CLIPS for development tools of KBS.

According to (King, 2000) development of many KBS tools depend on theirs functionality. The easy use of KBS nature and parameters used for development tools of KBS. Prolog is one of the most programming language in was used in AI research conducted previous to develop intelligent system used for different purpose. However C, C++, and Java programming language used for development of imperative as well as prolog programming language used to development of declarative during implementing solution for problem by specify the issues such as rule, fact and goal (reply query) by using prolog interpreter derive the solution for problem. Prolog programming language is very important to solve complex problem in the area(Endriss, 2007).

Prolog derive by using procedural interpretation of logic to solve any problem. It is also solve problem by representing knowledge in terms of procedure and reasoning in simple ways process and right procedure. Prolog programming language is a attractive logic for professional in the area of Knowledge Engineering and Artificial Intelligence. This software is used various application in the most common domain area such as Environmental, Modeling, Sales Modeling, Medical domain, Fungus Identification, Image processing or recognition, Management Consultancy etc (Pfennig, 2007). For this research study prolog programming language was used.

2.6. Methods of Evaluation

KBS evaluation method can be split into verification, validation, assessment of human factors and assessment of correctness. Verification is an evaluation process that should be implemented during system design and development to answer the question did we build the system correctly. Validation the concept of validation refers to determining the correctness of the system with respect to user's needs. Evaluation of human factors is the process of determining the acceptability and usability of the knowledge based system. Evaluation of explanations is used to evaluate the explanation ability of knowledge based system detail discussed as follow (Kimble, 2006).

Verification : verification is the process of evaluation system during implementation system design and prototype development answer question correctly for the user. Verification process checking compliance with the system specification assessment based on the user interface, explanation facility, performance and security of the system design. Program correctness proofed depending on the confirmation in the program logic with mathematical method and test proof strategy confirms partial correctness of the given test parameters.

Validation: validation is a concept of determining correctness of the system respected to users need from system specifically build. Validation of the system based on the criteria of system compares previous result with present or known result, against expert performance and against theoretical possibility. In addition to this validation test user acceptance survey, direct comparing random test parameters between human expert and system as well as system test performance in the working environment.

Evaluation of human factors: This is process of determining user acceptance towards system build and use of knowledge based system for specific program. This factors measure usefulness and user satisfaction against the system from different point of view such as content and interface satisfaction as well as the fulfill of the system satisfaction institutional objective.

Evaluation of Explanation : This is used to evaluate explanation ability of knowledge based system and how the system facilitate explanation felicity for the user get acceptance and provide meaningfully feedback. In addition to this evaluation of explanation includes brief explanation more than ways to describe one attribute as well as this methods might able to answer question that users want to ask and there's no limitation of question prediction of the system by developers.

2.7. Ground Water

Ground water is the most important natural resources found beneath the earth surface stored in void space of geological stratum used in economic development, domestic life, and any ecological diversity (Rashman, 2016). Ground water the occurrence and flows system of ground water is depends on geological characteristics of its porosity and permeability and the formation of land forms such us high mountains, rift valley's and flat areas and the role of land form on surface run off and infiltration to the ground (Rajaveni et al., 2015). Ground water potential it is the percolation or infiltration of water from unsaturated zone to saturated zone through porosity and permeability of water table and finalizes precipitation, infiltration and percolation of the surface water to the subsurface influenced by geology and geo morphology.

2.8. Ground Water Potentiality Prediction Method

There are several methods that can be used to explore ground water potential prediction but can be grouped into two major categories. Those are conventional and advanced methods (Lakshmi,2018).

Conventional method

Conventional methods of exploration may not be highly reliable to assessment of different factors effect presence of groundwater potential (Biswajeet and Saro et al., 2012). Similarly Geographically information system (GIS) is an efficient tool for calculating and storing large volumes of data, integrating spatial and non-spatial information in a single system, offering a consistent framework for analyzing the spatial variation depend on the geographically information and allowing connection between entity of proximity to predict groundwater potential (Pradhan, 2011).

Advanced method

Advanced method of exploration groundwater potential highly reliable. This is depending on the Remote Sensing Method (RSM). RSM can be use Analytically hierarchical process (AHP) methods to explore ground water potential.

Analytical Hierarchical Process

Analytical Hierarchical Process (AHP) is a multi-criteria decision making method. This method use strategy to get proportion scales from paired difference. The information has been taken from actual measurements such as weights, price and from subjective conclusions. AHP use nine parameters would be used to explore ground water potential zones such as drainage, elevation, density, geology, Geo-morphology, land use and land cover, lineament and dykes, rainfall pattern, slope and soil texture. Digitizing is done in query GIS into vector format and convert into the raster format. The analytical hierarchical process is used to create thematic layers and weights are calculated and assigned. The ground water potential zones are classified into five categories are very poor, poor; moderate, good, excellent (Waikar and Nilawar, 2014). Ground water potential index (GWPI) is helps to predict ground water potential (Shekhar and Pandey,2014).

2.9. Case Based Reasoning for Ground Water Potential Prediction

Case Based Reasoning (CBR) system maintains a structured memory of parameters which represents the experience and a means for specifying the similarity between parameters (Panchal et al., 2019). Thus the main advantages of CBR are basically knowledge acquisition, high solution efficiency and easy knowledge accumulation (Yang, Zhu & Gui, 2008). CBR is to acquire new skills based on our past experience. CBR have importance for retrieval of similar parameters from the stored database. CBR systems depend on the, geographical parameters and their corresponding solutions for the possibility of GWPP (Average, Poor, High, Moderate and Low) are stored as parameters in the case base.

CBR is used for GWPP depend on a knowledge based problem solving technique that relies on the reuse of past experience, similar to a cognitive human approach. Unlike traditional knowledge based techniques that apply rules and reasoning to solve each individual problem from scratch, CBR uses problem solving experience captured in similar parameters contained in a case library. It is based on the primary assumption that similar problems have similar solutions and hence new problems can be solved by reusing and adapting solutions used in previous parameters. It also assumes that it is feasible, and more efficient, to reuse past experience rather than solving problems from scratch (Fenner, 2007).

2.10. Hybrid Knowledge Based System for Ground Water Potential Prediction

Hybrid knowledge based system a coupling between knowledge based and numerical methods for groundwater potential prediction. Hybrid knowledge based system is the integration of two or more knowledge representation format or knowledge representation method for artificial intelligent study area. The integration consists of rule based and case based format of knowledge representation to predict ground water potential.

Hybrid knowledge based for ground water potential prediction use rule based system to problem from scratch and cased based system use previous stored situation to deal with similar instance as well as new instance to predict new situation. Therefor the integration of both approach to be turn out natural and useful (Chan et al., 2000). Hybrid knowledge based system use both procedural and declarative knowledge representation through application of relation database by rule based system and case based system converting into table (Owaied, 2011).

2.11. Related Works

There are various studies that are conducted around the world on the prediction of ground water potential level. However there is no such works are conducted in our country context and most other studies where focused on applying of machine learning algorithm in order to identify the ground water level on the given ground water sites. Some of recent related works are reviewed and discuss below.

Author	Technique used	Result	Significant	Gap identified
Kouziokas et al., (2017)	ANN	Changing the different parameters on ANN experimentation get a better model of ground water prediction as compared as previous predictive models.	Build a ground water prediction model.	prediction model was less predict when compared to neural network that based on experimental
Lohani & Krishan (2015)	Expert system	developed prediction model where highly match with the observation of the ground water on the given station.	Predict the ground water by using standard feed forward neural network.	Artificial neural network is a very complex system in order to use by other domain experts.
Aguilera et al.,(2019)	Bayesian framework	Developing accurate prediction model is highly affected by pumping of propels on the nearest area.	Flexibly predicts a groundwater level in order to support seasonal water management process	Prediction of ground water not throughout the year.
Saeed et al., (2018)	Gaussian processes classification and back propagation neural network	Affected areas for future severe drought	Find their association of climate drought and decline in ground water quantity.	Gaussian processes classification is less predict of groundwater potential

Bale et al., (2014)	Experimental	Comparing three models. Second and third models schemes the best to improve monthly and seasonal groundwater prediction.	Improving groundwater prediction utilizing season precipitation forecasts from general circulation models forced with sea surface temperature forecasts	Precipitation forecasts helps for inter-annual variability but not very useful for reducing error forecasts or conditional bias in prediction ground water potential
Fagbohun et al.,(2016)	GIS and Remote sensing methodology.	Integrates AHP weight map and index analysis GIS environment to map ground water potential zone.	Testing the ability an empirical hydrology model to verify a knowledge based system for groundwater zone mapping methodology	GIS less predict of groundwater potential compared to Remote sensing and KBS
Huang et al.,(2019)	ANN	Ground water prediction is complex process due to this it require capture dynamic and provide scientific ways for decision making	Developed estimated and compared the performance of linear regression, multi-layer perception and long short term memory models to predicting groundwater potential recharge	linear regression was the poorest prediction when compared with two models used for prediction ground water potential

Huang and Tian (2015)	ANN,SVM, and M5 model trees	application and comparison of three data driven model for prediction of short term groundwater level	Prediction of Groundwater Level for Sustainable Water Management in an Arid Basin Using Data driven Models.	physically based model simulation of ground water and prediction not applicable in arid and semi-arid area due to lack of data.
Nikunja et al.,(2010)	ANN and Bayesian regularization	hybrid neural model which combination of ANN and Genetic Algorithm for accurate prediction of ground water level	Hybrid neural modeling for groundwater level prediction	convectional ANN and Bayesian regularization model less prediction compared to others models.

Table : 2.1. Related work

Generally most of the reviewed studies focused on the prediction of already identified and existed ground water level for future. Additionally, most of the studies where focused on enhancing the accuracy on prediction of ground water level models. Therefor the knowledge based system is useful than other research conducted before because KBS is store important knowledge related with ground water potential prediction. Knowledge based system use knowledge base to store experts knowledge, use rule based system, internet applications for extracting knowledge and intranet facility for Organizations Knowledge.

KBS is store knowledge in knowledge base that can be used during domain expert not availability or absence domain expert was gaps identified by researcher . This study was supporting of different hydrologist and geologist to easily predict groundwater potential based on some useful variables and conditions as well as study also contribute by developing knowledge based system by acquiring knowledge from domain experts and international methods in order to avoid the problem of consume time, cost and resources consuming processes in the country.

CHAPTER THREE

3. Methodology

3.1. Research Design

In order to develop a KBS for GWPP the Design Science approach was used for this study. Design Science is the systematic types of designing and knowledge acquisition related to design and its activity (Alturki et al., 2011). Design Science is the root in engineering and science of artifact which was considering fundamentally problem through creative innovation based on define ideas, practices, technical capabilities, and products in which analysis, design, implementation, and information system use which can be effectively and efficiently reached (Ayanso et al., 2011).

Design Science Research has been third form science of artificial in addition to natural sciences and human sciences (Alturki et al.,2013). This method was considered as research activity that was build new invent , innovative, artifact of problem solving or improvement of new innovative artifact create new reality, rather than existing reality been explained to create and evaluate information technology artifact which intended to solve identified organizational problem. According to Peffers et al.(2006) design science research have six sequential order form research process.

Problem identification and motivation: This is defines specific research problem and justify the values of the solution to problem. Problem definition is would be used to develop effective artifact solution. It may also use to automate the problem conceptual and give solution to complex problem captured. Justifying values of the solution depend on two things. Those is what the motivate researcher and the audience of the research accept the result and the researcher understanding the problem of the research including what the resource required to activity during working research as well as knowledge to understanding state of the relevant problem and importance. This discussed under chapter one.

Objective of a solution: Objective of the solution start from a problem definition. Objective is where new artifact expected to support the solution of the problem not addressed before. Objection is also rationally from problem specification and implicit in relevance.therefor objective of study explained in introduction section

Design and Development: To create art factual solution which is potential defined depend on broadly, construct, models and method (Hevner et al., 2004). Design and development more focus on priority of literature basis for development of six steps process models. Resource also required during move from objective to design and development which can be including knowledge theory that can be best output solution for the problem. In of this research the designed and development were performed in chapter four.

Demonstration: Demonstration is the ability artifact to solve problem effectively and efficiently. Under these steps its was use experimentation, simulation, case study, proof appropriate ways to use the system. Demonstration includes effectively knowledge use to solve the problem and the result of process model would be supported by case study discussed under chapter four and chapter six.

Evaluation: Evaluation is observed and measures the effectiveness of artifact solution to the problem.This including comparing objective of a solution with actual observed of artifact result demonstration. Evaluation was require knowledge of relevant metrics and analysis techniques. This would be comparing research design process model with objective. System performance evaluated by user’s 85.7% and system accuracy of prediction 84.33% evaluated. This was discussed under chapter six.

Communication: communicate the problem and importance of utilization, artifact and the effectiveness of the researchers and related audience. Communication include effectiveness and efficiency of the discussed using related different publication under chapter six related work done by KBS user acceptance and performance of the system as well as accuracy of system system prediction.

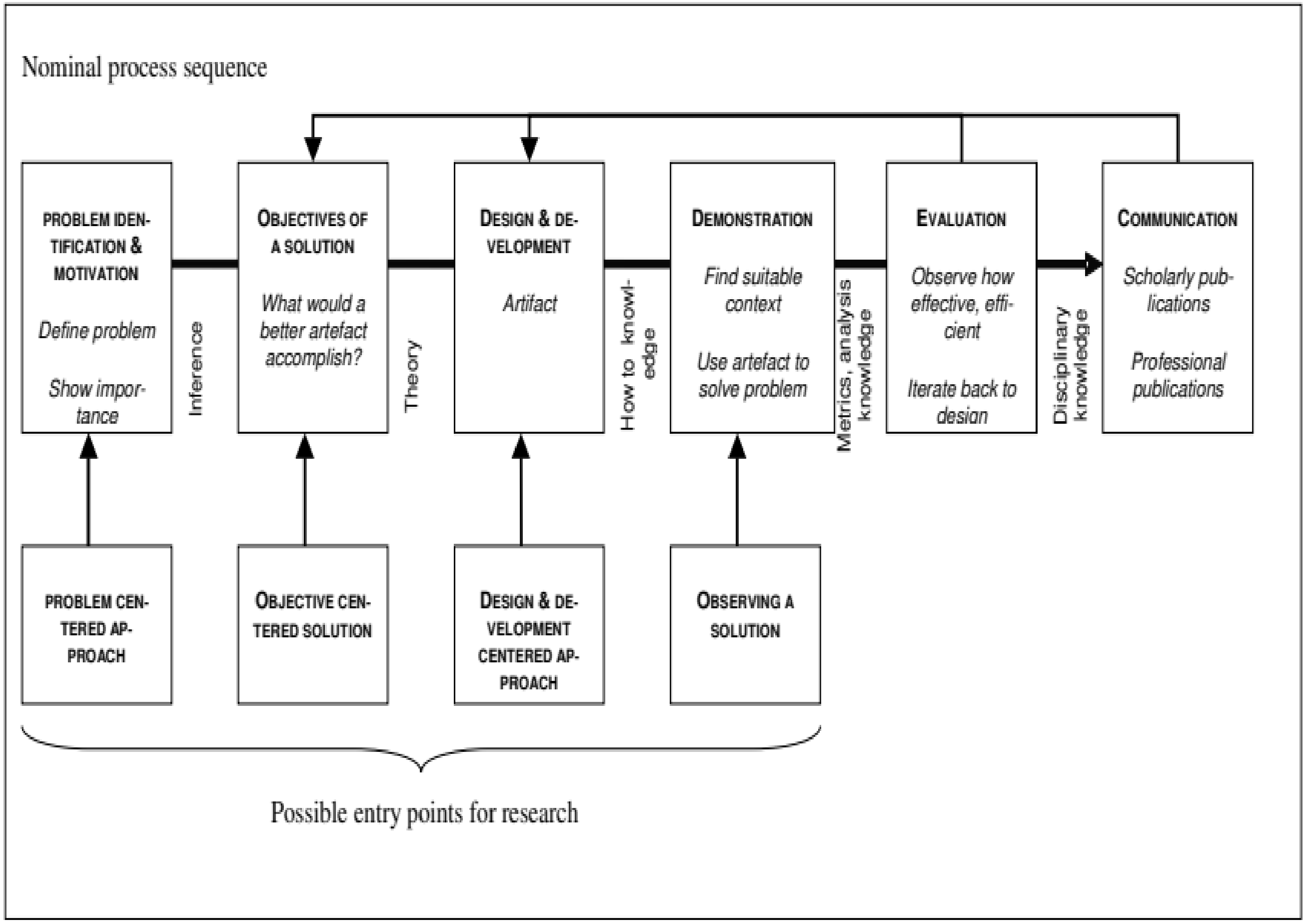

Figure 3.1 Design Science Research Process Model Peffers et al.(2006)

3.2. Study Area

Jimma University Institute of Technology, Faculty of Civil and Environment Engineering, Jimma Zone and Jimma Town water and energy organization. The reason why these areas were selected is Jimma University Institute of Technology, Faculty of Civil and Environment Engineering is the area of teaching and learning as well as research center ,hence domain experts were selected depend on the profession and experience on ground water potential.

Jimma Zone located in Oromia region state the south west of Ethiopia. Geographically location of Jimma zone latitude of 7°40N36°50E elevation above sea level 1780m , Jimma town located in Oromia region south west of Ethiopia 350km from Addis Ababa. Normally most Districts of Jimma Zone receive spring rain from February, with intermittent rains continuing up to October (Lemessa , 2000). Jimma zone mainly covered by tertiary volcanic flows, pyroclastic flows, pyroclatic fall-outs, ash flows and to a lesser extent by quaternary ash-falls, and quaternary alluvial deposits rock and soil type. Jimma Zone and Jimma Town Water and Energy Organization knowledge acquired from domain expert depending on profession and working experience. Jimma Zone and Jimma Town water and Energy Organization different from Jimma University they have ground water potential project from different district in the zone and ground water potential project working wells in the near the town for the purpose of drinking water and irrigation for the community live in the zone and town.

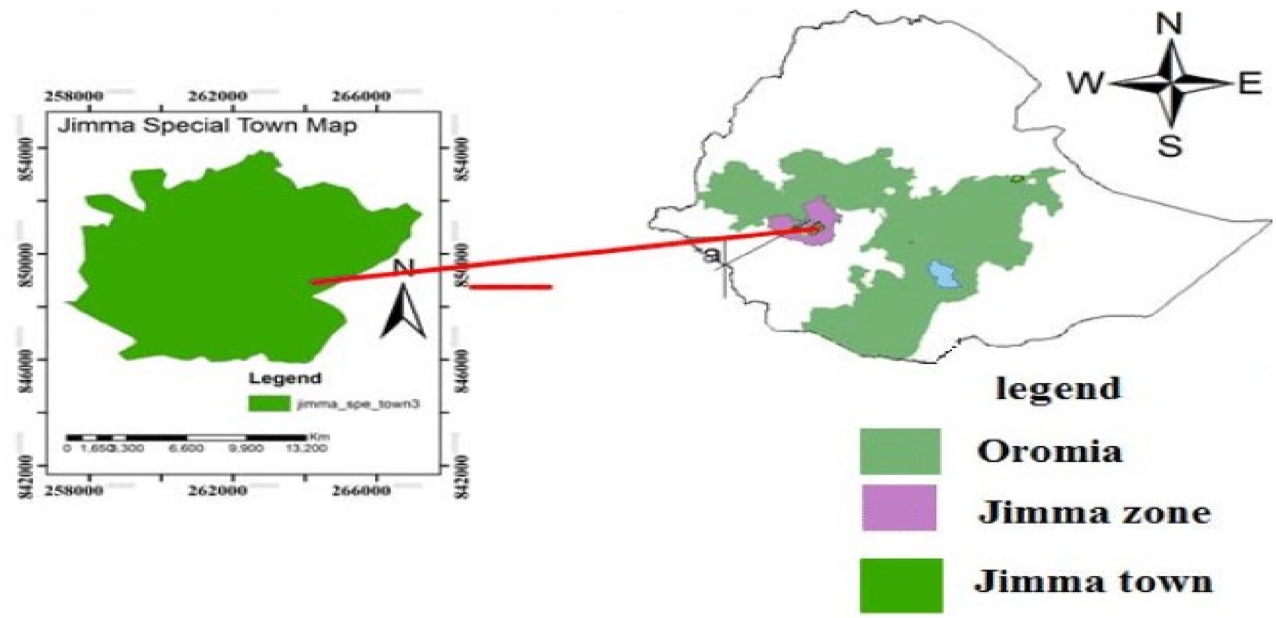

Figure 3.2. Map of study area

3.3. Sampling Techniques and Sample Size

Purposive sampling technique is used for this study because it is one of the most common sampling techniques in qualitative research in which participants group are decided to pre-selected criteria relevant to a particular research question. Therefore, purposive of sampling assist to select sample which can help to acquire the required knowledge from the domain experts. The domain experts would be selected based on their educational qualifications related to the domain area, year of experience and willingness.

3.4. Data Sources, Types and Data Collection Methods

The study was conducted based on data obtained from primary and secondary sources for both qualitative and quantitative data type from study area. The primary data were collected from Jimma University Institute of Technology, Faculty of Civil and Environment Engineering teachers, Jimma Zone and Jimma Town water and energy organization employees. Survey is a type of research design. The survey data was collected by using structured questionnaire (i.e. the questions as well as their order is already scheduled before asking question with open and close ended question), face-to-face interview with semi-structured question (i.e. a number of planned questions, but the interviewer has more freedom to modify the words and order of questions) and a structured discussion tools. In addition to, secondary data was collected by reviewing published and unpublished materials.

3.5. Study Population

The study respondents were selected on the basis of their knowledge of the phenomenon being studied. The study population was Jimma University Institute of Technology, Faculty of Civil and Environment Engineering teachers, Jimma Zone and Jimma Town water and energy organization employees. Purposive sampling technique would be used selected a total ten (10) from the Jimma University Institute of Technology, Faculty of Civil and Environment Engineering, three (3) from Jimma Zone and two (2) from Jimma Town water and energy organization totally fifteen (15) respondents. The sampling technique would be used employed to choose participants for focus group discussion and interview would be used judgmental or purposive, because GWPP require knowledge and practices are well known by professionals and very few people. Focus group discussion, semi-structured interviews and observations would be used data collections techniques to collect information. Jimma zone and Jimma town selected for collection data for this study because Jimma Zone is manage all district project of ground water drilling wells and Jimma town also manage their own project of groundwater potential drilling wells so that sample of data collected as follow on the figure 3.3

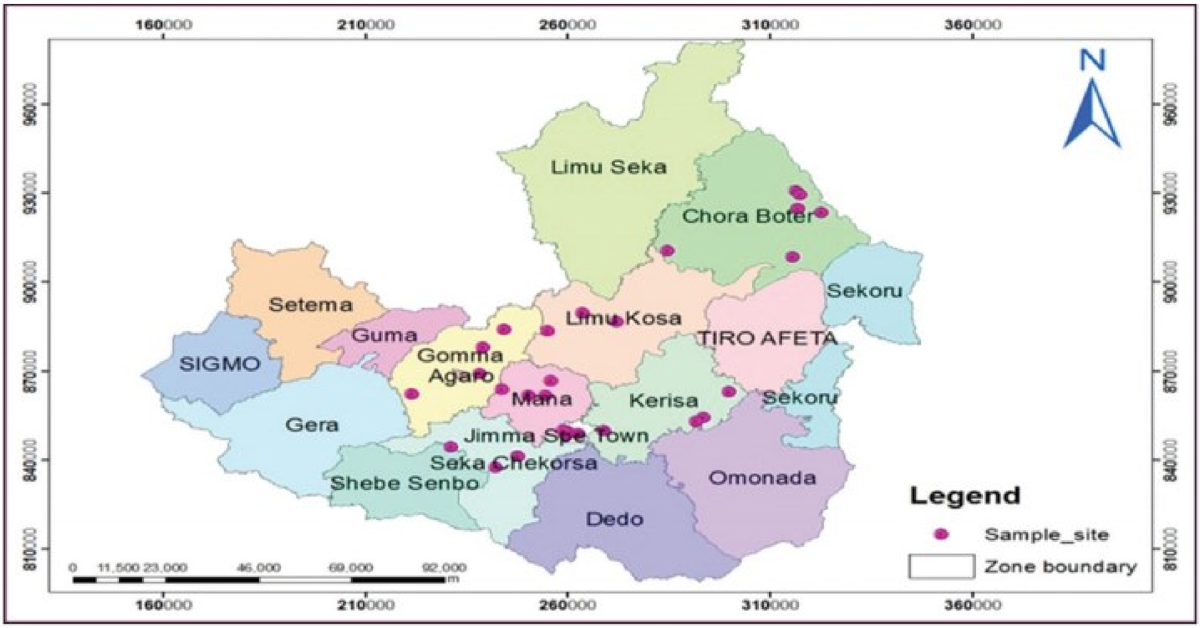

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Figure: 3.3. Sample point map of ground water potential in Jimma Zone

3.6. Knowledge Acquisition

Knowledge Acquisition (KA) is the process of acquiring relevant knowledge from domain experts and other sources of information such as books, databases, guidelines, manuals, journal articles, computer files, etc. Knowledge engineering is the process of eliciting, structuring and representing domain knowledge from different sources. The acquired knowledge can be specific to the problem domain, it can be general or it is meta-knowledge (knowledge about knowledge). Knowledge acquisition is the first step and critical task in the development of knowledge based system. The knowledge would be used acquired from domain experts works in the above mentioned offices.

3.7. Knowledge Representation

After the knowledge is acquired, it would be used represented using production rule knowledge representation method. For this research, the knowledge representation method production rule is chosen because; it clearly demonstrates the domain knowledge. Rule based system much of knowledge represented in the form of rule, so that conditional statement relating statement of fact with one another. Most of the times ruled based representation method was more appropriate to represent and demonstrate the real domain expert knowledge. Ruled based reasoning is the best chosen method is the common one and powerfully satisfying the given condition to building useful application. Knowledge acquired from domain experts and from experience was represented in the form of IF-THEN rules (Siew et al., 2005).

3.8. Knowledge Modeling

Knowledge modeling is a cross disciplinary approach to capture and model knowledge into a reusable format for the purpose of preserving, improving, sharing, aggregating and processing knowledge to simulate intelligence (Aronson and Turban, 2007).Conceptual modeling is the basic activity of deciding what to model and what was not model. In addition to this conceptual model is non-software specific description of computer simulation model which was describing the objectives, inputs, outputs, contents, assumptions and simplification of model (Robinson, 2008). A decision tree was used for conceptual modeling of the acquired knowledge in this research.

3.9. Implementation Tools

SWI prolog (PROgramming in LOGic) programming language used as a tool to develop prototype KBS. It is the most popular logic programming language within the realm of Artificial Intelligence (AI). SWI prolog is fifth generation of AI language used for general purpose of logic programming. It has a purely logical subset, called pure Prolog, as well as a numbers of extra logical features. Prolog is a programming language developed especially to enable the implementation of logic-based systems.

Prolog is used to write the code in design phase, prolog is a high level, programming language that is specifically designed for applications in AI. It is based on predicate calculus. It is used to develop automated system and automated problem solver. SWI prolog in nature being logical and logical problem solver which is very powerful due to flexibility, especially when compared with shells, and control strategy there is no need to write an inference mechanism more to compile program.

3.10. Testing and Evaluation of the System

After a prototype KBS is developed, evaluation procedures were conducted to check the performance of the prototype system and acceptability by the users. So that the evaluation processes focus on systems user acceptance of the prototype and the performance of the system (kimble, 2006). To meet the established objectives of this study, the prototype system is extensively tested and evaluated including both performance of the prototype system and issues of user's acceptance. In the process of testing the performance of the prototype system, to classify correctly and incorrectly the parameters of by comparing the judgments reached by the prototype system.

Then it was calculated by precision, recall and F-measure. Issues of user's acceptance testing are also done to see the quality of advice and to access to what extent the KBS satisfies the domain experts. During testing the users acceptance, the applicability of the prototype would be used evaluated by potential users of the system. Accordingly the system user acceptance testing was conducted by questionnaire for respondents after fully visualized the respondent the developed prototype.

CHAPTER FOUR

4. Knowledge Acquisition, Representation and Modeling

4.1. Knowledge Acquisition

Knowledge acquisition is the process acquiring relevant knowledge from domain experts and others related information source. Such as books, database, guideline, manuals, journals, articles, computers files etc. Knowledge acquisition is the process of eliciting, structuring and representing domain knowledge acquired from different source of knowledge. Knowledge acquired specific to the problem domain. Knowledge acquisition is the first step for knowledge based system development (Sagheb, 2009).

According to Miller (2009) stated there are certain important steps for knowledge engineer to carry out during knowledge acquisition process. Those are: Eliciting data and information from domain experts, interpreting the acquired information to understand human experts reasoning process, construct model to represent the expert knowledge and repeating step one and three for knowledge base system involve into functional system.

In this study required knowledge gathered from tacit knowledge and explicit knowledge from domain expert. Critically knowledge gathered from professional or domain expert. Primary assessment have been done by investigate where fresh and senior geologist and hydrologist difficult in prediction of ground water potential. Fresh and senior geologist and hydrologist fail difficult doe to complex topography, geographical features, drainage, elevation, density, geology, soil type , rocks ,Geo-morphology, land use and land cover, lineament and dykes and rainfall pattern highest conceptual problem for predicting ground water potential during drilling wells. Primary knowledge gathered from Jimma University instructor by interview as well as secondary source of knowledge gathered from different journal, article, books, directives, manual and computer database etc.

According to some domain expert predicting ground water potential is not easy for fresh and senior geologist and hydrologist due to lack of experiences on reading different machine which indicate ground water potential. However fresh and senior geologist and hydrologist they must gain knowledge acquire of elevation, density, geology, soil type, rocks, geo-morphology and reading machine about drills wells and how to use during prediction of ground water potential availability.

4.2. The Process of Knowledge Acquisition

Knowledge acquisition is the process acquire knowledge by interview, questionnaire, record reviews, manual, directives and observation acquire fact and explicit knowledge. The main objective of knowledge acquisition is gather required knowledge, interpreting acquired knowledge, analyzing and validating knowledge content obtained. Knowledge acquired designed by using decision tree model for the proposed knowledge based system developments. Therefore knowledge acquisition process depending on the domain expert interview and reviewing related source of documents. The acquired knowledge discussed as follow.

4.3. Interviewing Domain Experts

Primary source of information collected from Jimma University Institute of Technology, Faculty of Civil and Environment Engineering, Jimma Zone and Jimma Town Water and Energy Organization. To acquire required knowledge semi structured and structured interview techniques is used. The main focus of interviewing domain expert's transfers elicits knowledge to explicit knowledge from domain experts. Fifteen (15) domain experts were selected by using purposive sampling techniques. Covid-19 pandemic disease is the main challenge during interview domain experts as well as theirs lack of willingness of domain expert to share knowledge, experience, information and data about ground water potential prediction to drilling wells which is very essential knowledge. Domain expert interviewed covers some issues ground water potential of the expert is how going to select the area of drilling the wells, what are main factors of during drilling wells, what are the possible recommendation for ground water potential prediction and how to overcome such problems. In table 4.1below the profile of domain experts presented.

Table: 4.1. Domain expert profiles

No	Educational level	Area of interviewed	Role
1	BSc	Soil	Worker and Teacher
2	MSc	Geology	Teacher
3	MSc	Hydrology	Teacher
4	Assistance professor	Soil, rock and environmental factors	teacher
5	BSc	Geology	worker

The participant in conducting research is government employees departments of civil, geology and hydrology engineering background of study those working in the Jimma Zone and Jimma Town water and Energy office as well as teachers those teaching in Jimma University. Most of domain experts for this study knowledge acquired from Jimma University Institute of Technology teachers those teaching in Jimma University, Faculty of Civil and Environment Engineering to investigate problem related to ground water potential prediction by collecting some relevant data and information such as location parameters, soil types and rocks type previous history of about drilling wells in the area. In addition to this what is general factors for ground water prediction? According to teachers the factors identified for ground water potential are rain fall, elevation, slope, drainage density, Geo morphology, geology, rocks types, lineament density, land use or cover and soil types.

In order to identify and determine groundwater potential zones, rainfall, land cover, lithology, slope and drainage density where prepared from geologically map, Landsat images, rainfall and river data. The identification of the local the groundwater potential zones, a surface watershed was delineated by obtaining from manual to digitization which is an overlay of digital elevation model and drainage network data. The delineated surface watershed was used to clip the slope, land use/cover, rainfall, and drainage and lithology data layers. Identification of groundwater potential classified based on the spatial analyst tools and data layers were assigned rank values with ratting scale of 1 up to 5 depending upon theirs suitability and capability to hold, store and transit of groundwater potential (Nag, 2005). In the rank scale values of 1 means that specific class factors which is highest weight groundwater potential and rank values of 5 means that specifics class of particular factors to lowest groundwater potential.

Table 4.2: Thematic layers, rank, influence and weight Groundwater potential

Thematic layers	Class	Rank	Groundwater Potential
Rainfall (mm)	1400-2400	1	Very high
	1200-1400	2	High
	800-1200	3	Moderate
	700-800	4	Low
	500-700	5	Very low
Land cover	Forest	1	Very high
	Bush land	2	High
	Agriculture	3	Moderate
	Scrub land	4	Low
	Urban area	5	Very low
Lithology	Sedimentary rocks	1	High
	Igneous rocks	2	Moderate
	Metamorphic rocks	3	Lo w
Slope	0-3	1	Very high
	3-8	2	High
	8-16	3	Moderate
	16-27	4	Low
	27-50	5	Very low
Drainage density (per KM)	0-0.3	1	Very high
	0.3-0.9	2	High
	0.9-1.5	3	Moderate
	1.5-2.3	4	Low
	2.3-3.9	5	Very low

Source :(Mwega, 2016).

Availability of groundwater potential is controlled by various factors those are groundwater recharge, discharge and rainfall. Rainfall is influenced by subsurface water resource in the part of rain water which on the ground in the form of infiltration to the soil recharge ground water penitential (Todd and May, 2005). Area with the highest rainfall (1400-2400) were categorized under area of high potential of groundwater accumulation as well as the area receiving low rainfall (500-700) is considered as low groundwater potential show in the table above 4.2.

Land covers/use is one of the parameter that influences the occurrence of groundwater potential in the Jimma Zone and Jimma Town. The effect of land covers/use is manifested either by reducing ground water runoff and facilitating or trapping water on theirs leaf. Water droplets trapped in this recharge to groundwater. Land cover/use may also negatively side effect on the groundwater potential by evapotranspiration, assuming interception to be constant (Sener et a., 2005). Very high ranking was assigned to the forest class and very low ranking was assigned to the urban areas table 4.2.

Permeability and porosity is controls groundwater potential occurrence and recharging of an area and porosity and permeability directly depend on the lithology of the area (Mwega ,2016). Highest ranking of ground water potential was assigned to unconsolidated rock types of in the study area, which were sedimentary rocks type high rank and low ranking consolidated under metamorphic rocks types in table 4.2.

The drainage density one of the important parameter of control and occurrences groundwater potential and recharging (Sener et al., 2005). Highest ranking was assigned to areas with low drainage density and low ranking was assigned to the areas with high drainage density in the Table 4.2.

Slope is crucial parameters for occurrence and recharging condition of groundwater in the particular area. Run off would be more and inflation is less in steep slope area (Mwega, 2016). Therefore highest ranking was given to area with lowest slope (0-3%) and highest ranking is very low groundwater potential when compared within (26-50%) respectively in the table 4.2.

Rainfall: Rainfall have role in hydrology cycle and groundwater potential control. Rainfall environments have high humidity incidentally consider high groundwater potential. Understanding nature and rain fall characteristic of enable one conceptualization and predict effect it runoff, infiltration and groundwater recharge. Rainfall ground water potential affected by number factors such as slope, geology, land use, drainage density, lineaments density and others related factors.

High rainfall: High rainfall area have high infiltration, low surface runoff, percolation and low evaporation have very high groundwater storage.

Low rainfall: Area which has low rainfall is contains high surface runoff, high evaporation from vegetation, lake, rivers and lakes as well as low water infiltration into the ground so that low rainfall low level of groundwater potential may be found.

Elevation: elevation or attitude effects on groundwater potential in the study area. Its related rainfall occurrence and recharge. High altitudes have more recharge of groundwater potential and availability of ground water in lowlands are watersheds. Ground water potential store high in lowlands area than high topography then higher elevation topography lesser groundwater potential so that this contain medium level of groundwater.

Slope: Slopes mainly affects the surface runoff process and partially determine groundwater potential recharge of watersheds. Topography highly influenced on the ground water flux than ground water depth and hydraulic gradients. This effect on the groundwater hydraulic gradient. Lower slope values indicate flatten terrain and higher slope values indicate steep and undulating terrain. Most of the lower slope area flat terrain allows rainfall infiltration and percolation. However higher slope area generate quick runoff from the terrain and little volume of ground water potential. .

Drainage density: drainage density is one of the factors of ground water potential indicating. Large drainage density areas have less ground water recharge due to this factors area near drainage channel had good ground water potential storage.

High drainage density: Area has high drainage density high runoff through the given channel and provides less opportunity infiltration water into the ground and percolation which have very low groundwater potential.

Low drainage density: Area has less surface runoff and high infiltration water into the ground and percolation is holding very good level of groundwater potential.

Geo-morphology: Geo-morphology is the study of earth structure and land forms that is related to ground water occurrence and structural features. Geo-morphology indicates the movement of ground water weathers it high potential or less ground water potential and control ground water movements. The main factors of Geo-morphology land forms which is flat plain, smooth plain, plain with high hills, low hills, high hills, low mountain and high mountain effect on the occurrence of ground water. Land forms have its own factors occurrence of ground water potential which means at high mountain occurrence ground water potential poor and flat plain area which means low mountains or low land area high ground water potential. In addition to this high hills land forms considered very low groundwater potential while smooth plain and flat plain have good ground water potential as well as valley plain and flat land have very good water potential.

Geology: Geology influence on porosity and permeability of aquifer materials which hold high groundwater. Geology is one of ground water controlling parameters and considered ground water studies while its play important role for distribution of groundwater and occurrence of ground water potential in the zone. Geologically characteristics of ground water potential depend on the resistivities which indicate the water bearing layers is a high yield of aquifers to predict true groundwater potential which shows that very high and high ground water potential occurrences in the zone.

Table:4.3 Resistivity of Geologically material

Resistivity(ohm)	Materials	Water bearing
1-40	Clay and sandy clay, soil intercalated with silt, sand and gravel	Occasionally water bearing(moderate)
40-200	Highly weathered ryholite, moderately weathered basalt and volcanic pyroclastic ash	Water bearing (high yielding aquifer) / high groundwater potential
200-500	Highly weathered fractured basalt	Less saturated and water bearing (low yielding aquifer) / low groundwater potential
500-1000	Weathered basalt	Dry to slightly water bearing/ dry groundwater potential
1000-5000	Slightly fractured dry and fresh basalt	dry
5000	Basalt basement rock	Very dry

Source :(WWDSE,2007)

Resistivity method is the most popular of all geophysical methods in groundwater exploration and investigations because it provides a good contrast water bearing zones and water-devoid zones, structural and lithological information of the sub-surface. This information include; thickness of aquifer overlying resistive bedrock, the quality of groundwater which could be saline, fresh, contaminated with toxic waste or brackish, strata thickness, depth to bedrock, hydro-geologically units, aquifer hydraulic properties, fault zones and types of subsurface materials(Mwega, 2016).

There is four major geology or lithology type identified in the study area. Those are tertiary plateau basalt and pyroclastic, tertiary upper basalt and trachyte, quaternary lacustrine sediments and tertiary upper lava flows.

.**Tertiary plateau basalt and pyroclasts :** The tertiary formation by dark grey, most course are grained and medium grain rocks. Tertiary plateau basalt is occurring massive, hard, dense and weathered rocks. This contains low ground water potential compare to others types of rock this found between 1-40 Ohm. Resistivity measure the ability store groundwater potential soil and rocks types that shown on the table .4.3

Tertiary upper basalt and trachyte: Geologically formation which behave like aphanitic, dark Grey, fine grained formation material, fracturing and spheroidal weathering dry ground water aquifers that found between 1000-5000 Ohm in the table 4.3.

Quaternary lacustrine sediments: This is young lithological formation. It contains thick brownish clayey soil and light Grey soil material assumed developed from sediments rocks. Quaternary lacustrine sediments occasionally water bearing capacity or moderate groundwater potential which is located 1-40 Ohm in the table above 4.3.

Tertiary upper lava flows: geological formation from structurally characterized by massive, less columnar horizontal and deeply weathered faults. This contains mainly basalt and lesser scoriaceous basalt and scoria falls. This compare to basaltic formation consists of pyroclastic and trachyte's contain high ground water potential. Tertiary upper lava flows include scoriaceous basalt in which layers of ground water occur most of the time this is located 40-200 Ohm in table 4.3.

Lineament density: lineament density is represent fault, fracture and master joint, long and linear geological formation, topographic linearity, valleys or straight course of stream and boundary between different geological units. Such as vegetation covers and artificial cover which is road and bridge area. Therefor lineament density ultimately indicates availability of ground water potential may it moderate level of water.

Higher lineament density: if lineament density is high groundwater potential also high which is contain linear geological formation, topographic linearity, valleys or straight course of stream

Lower lineament density: when lineament density is have fault, fracture and master joint, long and low lineament density have low groundwater potential.

Land use or cover: the surface covered by vegetation like forest and agriculture traps holding water in the roots of plants where as built up and rock land use effects of recharge ground water potential by decreasing surface runoff during rainfall. Built up and rocky surfaces less ground water potential as well as surface covered by vegetation like agriculture and forest area have higher ground water potential. However water body, forest, shrub land, cultivated land, grass land, bare land respectively suitable occurrence of moderate level of ground water potential.

Difficult drilling (boulders): The hardest ground formation base of Substantial Mountain with a formation consisting of a matrix of large rounded boulders inter filled with loose fine material. Drilling such area have no ground water potential drilling offer have no solution which means cutting hard rocking not penetrate the larger boulders.

Well sorted sedimentary deposits: sedimentary deposits from sand or gravel that are quite course and contain very high volume of ground water in very porous formation. Easy to drill and maintain well stability.

Poorly sorted sedimentary deposit : This have finer grains intermingled with course material which low water storage and porosity of formation. Easy to drill with drill and well to prove water availability but low level of groundwater volume containing most of the time.

Fractured rock: This type of formation occurs near water flow through the weathered mantle lying and fresh rock and stored water in the parts of weathered mantle and fractured rocks structure. This occurs in the area of intersect fractured zone which required high skilled geologist water diving and drilling of experimental no ground water or dry hole.

Porous rock: This contains high ground water storage that is found under very thick layers of the ground. Easy to drill with air compressor, and general water reliable area.

Confined and unconfined aquifers: Confined aquifers would be impermeable layer composed of clay and silt or consolidated rock which at lower elevation than water table. Confined layer is natural basin which is having very good ground water.

Hard rock: Confined aquifers conditions common in particularly hard rock area where water is located in the fissures within body of the rock at a hit and miss range depth of ground water.

Most of the hole drilling in this area contain moderate level of groundwater potential at high depth of wells.

Types of gravel: This contained grain size of that consistently larger and invariable gravel pack resemble coarse. Gravel pack is hard, washed, well rounded material contain alluvial soil source which contained medium level of water potential nearly in the area of dry rivers or lakes shore.

Soil: Soil water holding capabilities depend on the soil type and permeability. Study area have soil on the high altitude area such as eutric cambisols, chromic vertisol and eutric regosols poor ground water storage. Alluvial soils cover plateau and low area of in zone and jimma town area have very high potential for groundwater availability in the study area. Compacted soil environments and fine textured soils surface runoff than sub-surface flow low level of groundwater contain.

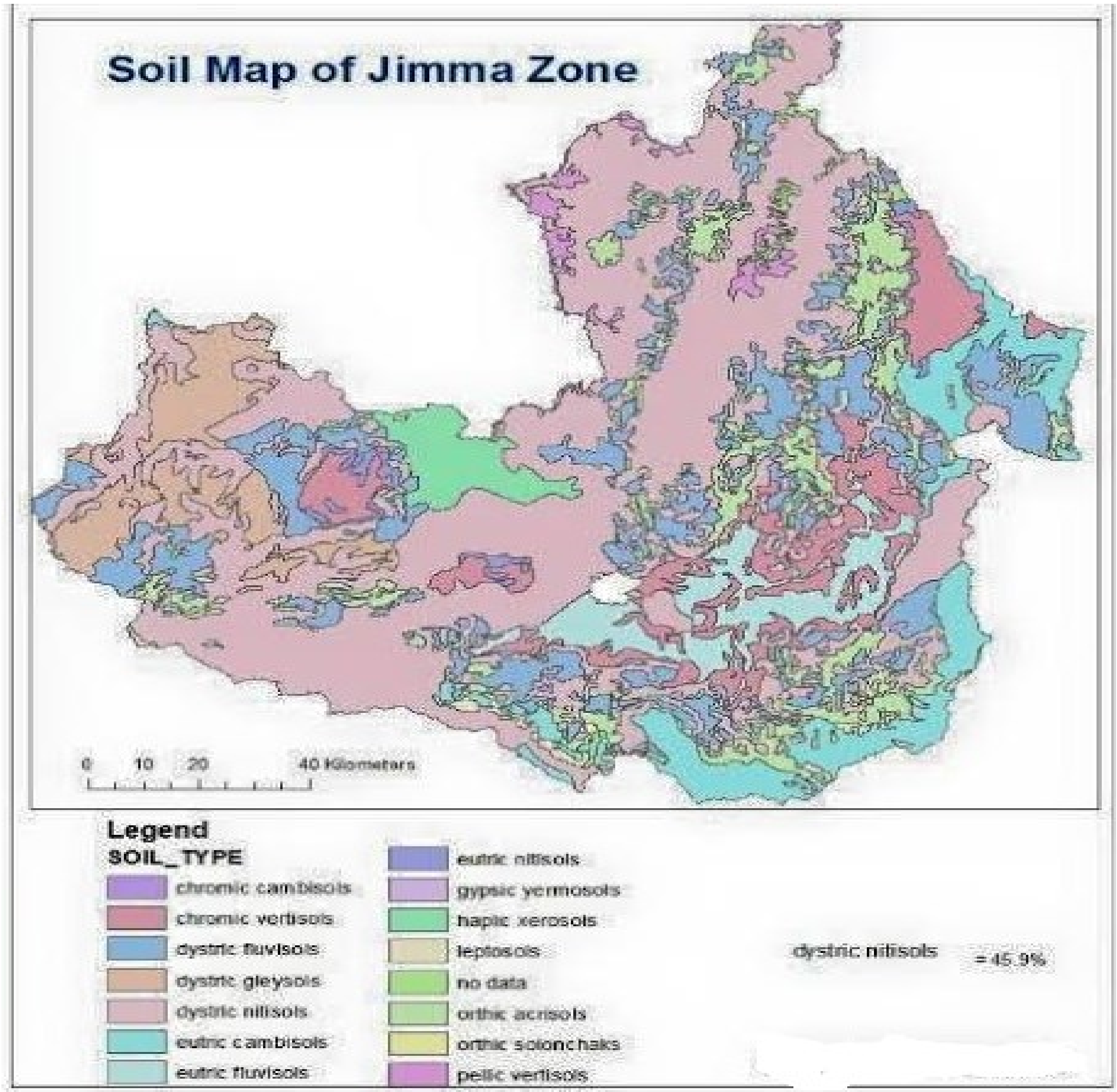


Figure 4.1: Soil map of Jimma Zone

Sand and clay soil texture and structure have found in the rainfall area have high infiltration and composite of groundwater rise add water plant root zone for plant growth green which area used for agriculture and irrigation store high groundwater potential in such area.

Sand soil found at 25-100mm/m per meter depth during drilling wells in the low land area which contain very high groundwater accumulation in arid and semi-arid of jimma zone

Loam soil found at 100-175mm/m per meter depth during drilling wells in the low land area which contain high groundwater potential in arid and semi-arid of Jimma zone

Clay soil found at 175-250mm/m per meter depth during drilling wells in the low land area which contain high groundwater potential in arid and semi-arid of Jimma zone.

Prediction of groundwater potential is used to draw dawn to assess potential impact on existing groundwater users this happen when loss of groundwater availability to water supply well or bore, groundwater dependent ecosystem examples when availability of groundwater to wetlands or springs, and surface water (base flow to the rivers and lakes) as well as regional impact models may be used to assess reduction in groundwater flows to surface water, such as lakes or streams (Schlumberger, 2012). Groundwater conceptual models may also be used to assess the potential impact of hydraulic fracturing on aquifer properties (including inter connectivity of aquifers and enhanced permeability) and estimating groundwater depressurisation to support predictions of potential groundwater subsidence(Coffey , 2014).

Groundwater conceptual model is used to estimating the volume of produced water and its quality. This information is required to plan and design treatment , use and disposal of produced water , simulating the impact of re-injection of (potentially treated) produced water on groundwater levels and quality (Brunner et al. ,2011). According to Commonwealth of Australia (2014) conceptual modeling have many advantage to predict groundwater Those advantage are identification of the water inputs and outputs (e.g. pumping activities, rainfall recharge, surface water interaction) for the broader hydrogeological and hydrology system under study and make simple the representation of the natural system are made, subject to data availability and the scale of the representation of groundwater potential.

4.4. Knowledge Representation

Knowledge representation is one of the basic steps in the process of knowledge based system development. Knowledge representation is the process of interpreting domain knowledge into computer understandable form using knowledge representation methods. The acquired domain knowledge is represented as a set of “IF – THEN” rules in the prototype. In order to fire the rule and the “then” side of the equation specifies the appropriate action to be taken. The inference engine evaluates the “if” portion of a statement and concludes whether a goal is satisfied or not. If the goal is not satisfied then the inference engines proceed to the next rule until the conditions are satisfied.

A rule is a conditional statement that links the given conditions to actions. Rules in the knowledge based are constructed based on the decision tree structure on conceptual model discussed above. To make easy and understandable prolog rules, the acquired knowledge from the domain expert is represented using the “IF-THEN” form. The rules are the base for the construction of knowledge base system.

Rule based reasoning mechanism were employed for the inference engine. In knowledge based system there are many reasoning mechanisms; among that the most commonly used are rule based approach, case based approach or the combination of the two. Case based approaches are designed to work in the way that the basic idea of similar problems having similar solutions (Aamodt & Plaza, 2013).

It is a rule based System that solves problems by remembering past situations and reusing its solution and lesson learned from it. Case based approach represents situations or domain knowledge in the form of parameters and it uses case based reasoning techniques to solve new problems or to handle new situations (Abdulahet al., 2014). Rule based reasoning, on the other hand reason from domain knowledge represented in a set of rules. The rules of the system were designed to illustrate how to represent various types of knowledge, rather than to provide accurate identification.

Rule formats

The rules for expert systems are usually written in the form:

IF
first premise, and
second premise, and

THEN

Conclusion.

Rule based reasoning is a system whose knowledge representation in a set of rules and facts. Symbolic rules are one of the most popular knowledge representation and reasoning methods. This popularity is mainly due their naturalness, which facilitates comprehension of the represented knowledge. The basic forms of a rule, if<condition> then <conclusion> where <condition> represents premises, and <conclusion> represents associated action for the premises. The condition of the rules is connected between each other with logical connectives such as, AND, OR, NOT, etc. thus forming a logical function. When sufficient conditions of a rule are satisfied, then the conclusion is derived and the rule is said to be fired.

Rules based reasoning was dominantly applied to represent general knowledge. Rule based expert systems have a significant role in many different domain areas such as medical diagnosis, electronic troubleshooting and data interpretations even in teaching concepts. A typical rule based system consists of a list of rules, a cluster of facts and an interpreter (Rajeswari, 2012).

It is mentioned as there are two main inference methods in rule based reasoning mechanism. These are backward chaining and forward chaining. The former is guided by the goals (conclusions), whereas the backward chaining guided by the given facts (Hargis, 2014). During forward chaining, the inference engines first predetermine the criterion and the next steps are to add the criterion one at a time, until the entire chain has been trained. With data driven control, facts in the system are represented in a working memory which is continually updated. Rules in the system represent possible actions to take when specified conditions hold items in the working memory. The conditions are usually patterns that must match with the items in the working memory. In forward chaining, actions are usually involves adding or deleting items from the working memory. Interpreter of the inference engine controls the application of the rules, given the working memory. The system will first checks to find all the rules whose condition holds true (Nalepa, 2015). Production rules as follow. From the above acquired knowledge from domain expert and document analysis the following knowledge representation were generated.

Production rule

Rule1: Groundwater, If

The areas have high infiltration,

There is high perception,

There is less surface runoff,

There is high annual rainfall, and lower slope,

There is high drainage,

There is alluvial soil,

Then area has high groundwater potential.

Rule 2: Rainfall, if

The areas have high infiltration,

There have less surface runoff,

There is high humidity,

There is little runoff and infiltration,

There is agriculture, vegetation, forest and water body,

Then areas have high groundwater.

Rule 3: Slope, if

There is high infiltration,

There is high humidity,

There is flat terrain,

There is no higher quick runoff, depth, hydraulic gradient,

There is lower slope,

Then areas have very high groundwater.

Rule 4: Geology, if

There is porosity and permeability,

There is sedimentary rock,

There is Basalt and trachyte rock,

There is no Dark-Grey, grain, medium, massive, hard, dense and weathered rocks,

There is Aphanitic, fine grained rock and fracturing rock,

There is Basalt and pyroclasts,

Then there is very high groundwater potential.

Rule 5: Land use, if

There is vegetation,

There is Forest, agriculture, shrub land and grass land,

There is not rocky surface,

Then area has high groundwater.

Rule 6: Soil, if

There is alluvial soil,

There is Fine textured soil,

There is no eutric, cambisols, chromic vertisol and eutric regosols soil,

There is Clay, silt and sand,

Then areas have very high groundwater.

Rule 7: Geo-morphology, if

There is not land form,

There is Mountain or valley area,

There is not High Mountain,

There is flat plain, smooth plain area,

There is not high hill, plain with high hill,

Then there is **very low groundwater.**

Rule 8: Lineament density, if

The area has fault, fracture and master joint,

There is vegetation cover, artificial cover road and bridge,

There is not bare land,

There is no elevation,

Then the areas have moderate level of groundwater.

Rule 9: Elevation, if

The areas have high rainfall and spring,

There is lowland elevation,

There is no high elevation in the area,

Then areas have medium groundwater.

Rule 10: Fractured rock, if

There is weathered,

There is fractured,

Then area is very low groundwater.

Rule 11: Porous rock, if

There is a very thick layer of the ground,

There is easy to drill with air compressor, Then there is high groundwater.

Rule 12: Confined, if

There is layer composed of clay and silt soil,

There is lower elevation,

Then area has high groundwater.

Rule 13: Hard rock, if

There is hard rock,

There is hit and miss range depth of water,

There high depth of groundwater,

Then there is moderate level of groundwater.

Rule 14: Poorly sorted sedimentary, if

There is finer grains intermingled with course material,

There is also low water storage and porosity of formation.

Then there is low groundwater.

Rule 15: Well sorted sedimentary, if

There is a sedimentary deposit from sand or gravel,

There is easy to drill and maintain well.

Then area has high ground water.

Rule 16: Boulders, if

There is hardest ground formation base around mountain,

There is fine material,

Then areas have low groundwater.

Rule 17: Types of gravel, if

There is consistently larger and invariable gravel pack resemble coarse,

There is alluvial soil source,

Then area has medium groundwater.

Rule 18: Tertiary upper lava flows, if

There is massive, less columnar horizontal and deeply weathered faults,

There is basalt and lesser scoriaceous basalt and scoria falls,

Then area has high ground water potential.

Rule 19: Quaternary lacustrine sediments, if

There is young lithologically,

There is brownish clayey soil and light Grey soil,

Then it store very high groundwater.

Rule 20: Tertiary upper basalt and trachyte's, if

There is aphanitic, dark Grey, fine grained formation material, fracturing and spheroidal weathering,

Then area is has high ground water.

Rule 21: Higher lineament density, if

Linear geological, valleys,

Then area has high groundwater.

Rule 22: lower lineament density, if

There is fault, fracture and master joint, long and low lineament density, Then areas have low groundwater.

Rule 23: High rainfall, if

There is high infiltration,

There is low surface runoff,

High percolation and low evaporation,

Then area has high groundwater.

Rule 24: low rainfall, if

There is low infiltration,

There is high evaporation,

There is high surface runoff,

Then area has very low groundwater.

Rule 25 : Infiltration, if

There is perception,

There is not high evaporation, lakes, rivers,

There is less surface runoff,

There is high annual rainfall,

There is high drainage,

Alluvial soil,

Then area have high groundwater.

Rule 26: perception ,if

There is less surface runoff,

There is high annual rainfall, percolation, lower slope,

There is high drainage,

Alluvial soil,

Then area have high groundwater.

Rule 27 : High humidity, little runoff and infiltration, if

There is agriculture,

There is vegetation,

There is forest,

There is water body,

Then area have high groundwater.

Rule 28: Alluvial soils, if

There is fine textured soil,

There is clay, silt and sand ,

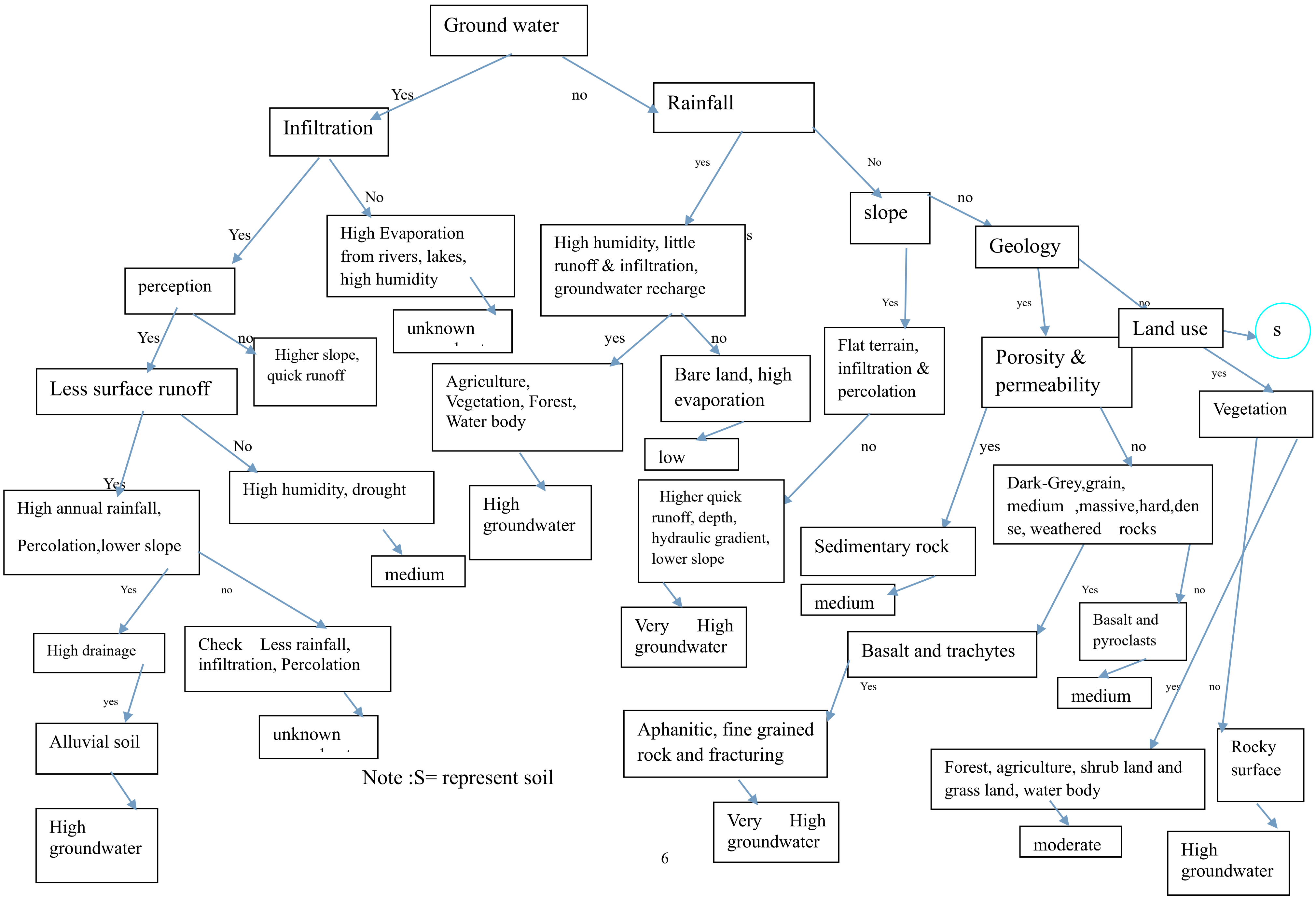
Then area have very high groundwater.

4.5. Conceptual Modeling

Conceptual Modeling of domain knowledge implies capturing the static structure of information and knowledge types. Decision trees (DTs) are modeling tools that use in a variety of different settings to organize and break down clusters of data (Lidtke, 2003). Similarly, decision tree have been widely used in practical applications area, due to its interpret ability and ease of use (Scott, 2004).

Currently, decision trees are used in many disciplines such as medical diagnosis, cognitive science and artificial intelligence (Quintana, 2009). The decision tree was used in the three main types of errors (syntax, logical and run time) domain to understand the dimension of the problem. Each tree starts with a set of errors and ends with solutions.

Decision tree structures are the bases for the development of prototype knowledge based system. The prototype follows the same procedures as presented in the decision tree when finding and correcting errors in any program. The system is implemented as defined in the succeeding diagrams. Generally, the tool's input and output requirements are defined in the diagram below. Decision tree structures are the bases for the development of prototype knowledge based system. The conceptual framework developed from the acquired and represented knowledge above.



Note :S= represent soil

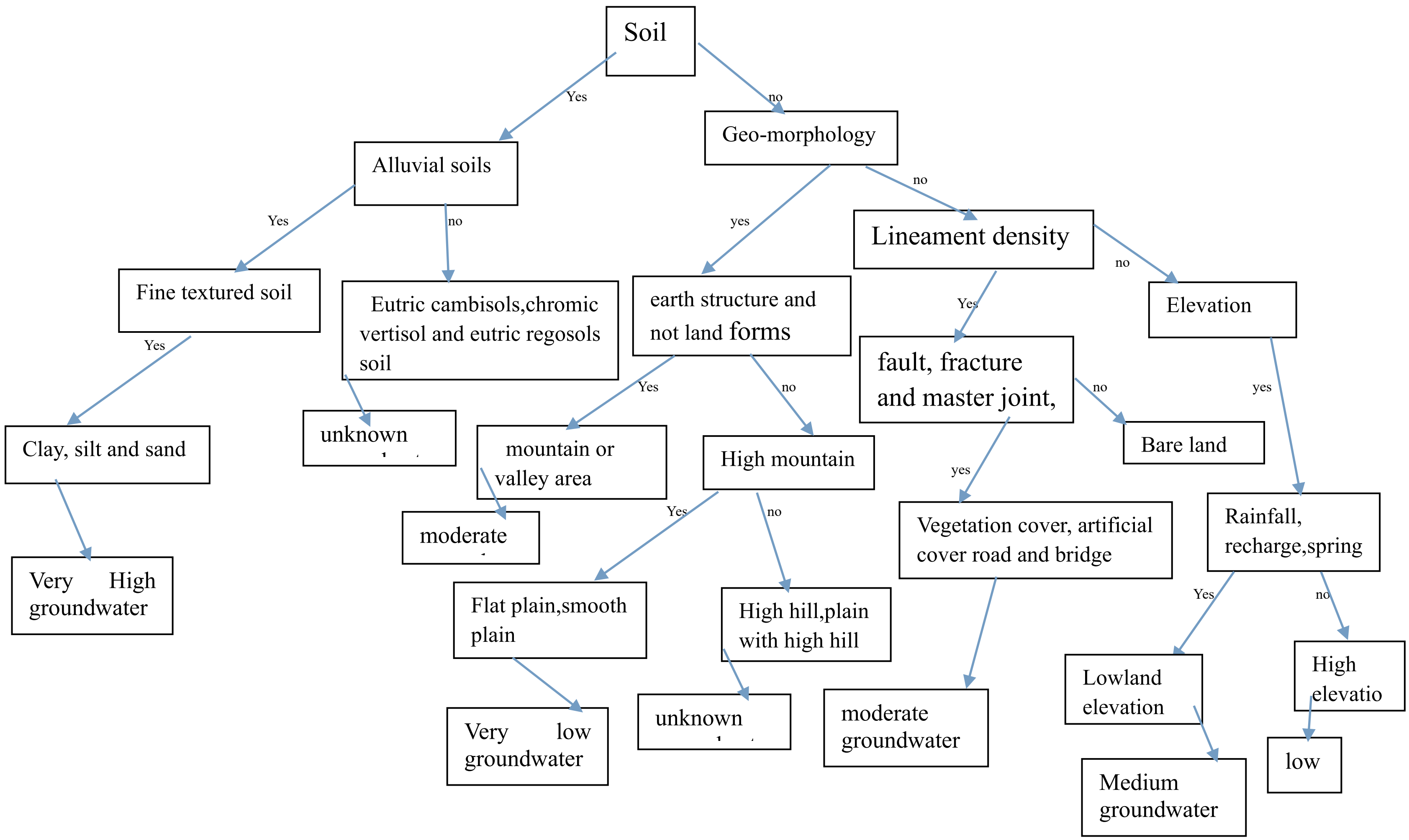


Figure 4.2 .Decision tree for groundwater, rainfall, slope, geology, land use, soil, Geo-morphology, lineament density, elevation

CHAPTER FIVE

5. Design and Implementation

The most important criterion for any Knowledge Based System (KBS) is the accuracy of their inferences engines. Also important are, robustness of the system when some information is missing, redundant and inconsistent. Human understanding support domain experts to understand knowledge contents and even modify its contents . The system's dynamic nature to adapt a new knowledge from the user response is critically important to measure system performance.

The proposed KBS implementation depends on the decision tree structure. Because of their simplicity, decision trees or generic rule-based models are commonly used to describe the knowledge acquired from domain expert. The if-then rules of KBS are generated based on the decision tree structure. A KBS tool is a set of computer software that manipulates programs and other information in order to design and assist the development of KBS (Kesarwani & Misra, 2013).

In addition, the main challenge of implementing KBS was choosing the appropriate representation method. Too large rules may reduce the performance of the system because, as the numbers of rules increases the inference engine fails to infer from the complex rules. The KBS incorporates knowledge base, inference engine, user interface, and explanation facility components.

5.1. Knowledge Base

The knowledge base stores all relevant knowledge, fact, rules, and relationships used by the KBS. The knowledge base incorporates the relevant knowledge usually acquired from the domain experts. The knowledge base of the prototype contains the domain knowledge which is used to identify the types of factors ground water potential prediction. The fact base component of KBS includes basic facts of different parameters that are handled during problem solving. The number of facts depends on the number of rules incorporated into the knowledge base. Functionally, the facts in the fact base are used to compare against the condition part of rules. Functionally, the facts in the facts base are used to compare against the "if" (condition) part of rules stored in the knowledge base.

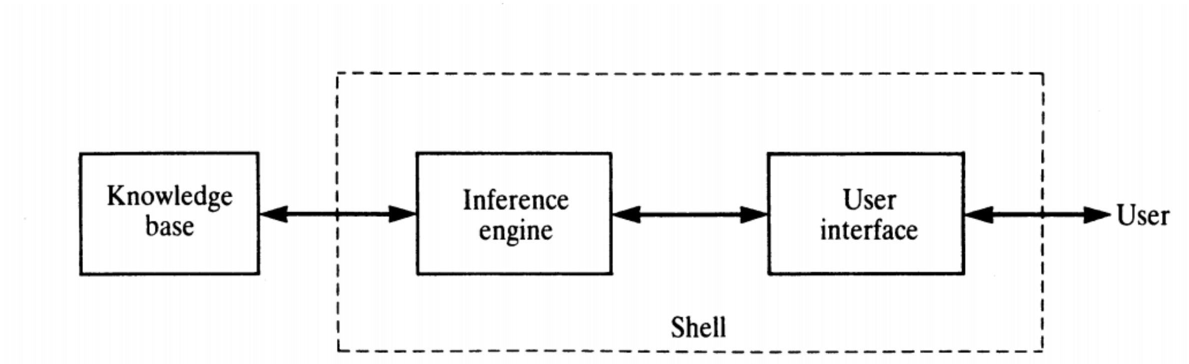


Figure:5.1. KB for GWPP system (Nalepa, 2015).

5.2. The Inference Engine

Inference engine simulation considered as domain expert reasoning process.It works from the facts in the working memory or fact base and stored knowledge in the knowledge base to fire the rule. It achieves the goal by searching through knowledge base to find rules whose premises match with the given facts in working memory. Inference engine searching process is continues until premises satisfy the given condition based on the fact of working memory.

The most general types of inference engine are forward chaining and backward chaining. Forward chaining reasoning mechanism was applied in this study. The most typical strategy is to use forward chaining as a general control strategy, while at some stages, if detailed goals are to be inferred. Forward chaining is guided by the goals or conclusions, whereas the backward chaining is guided by the given facts.

As decision tree model indicated the factor effecting to predict ground water potential rainfall, drainage density, geology, morphology, soil, elevation and land use or cover check all this factor before drilling the wells availability of weather the area selected contain very high, high, moderate, medium , average, low and very low water potential. To presence of ground water potential first check availability for a long period of time rainfall, infiltration of high water from rainfall, rivers, percolation, lower slope, lower elevation and spring in the area of drilling the wells theirs very high groundwater potential in the selected area.

Next domain expert or experienced geologist and hydrologist check to prove whether the indicator factors the fact to drill wells or not to drilling the wells due to different factors available in the area. Inference engine of rule based system follow similar procedure to experience geologist and hydrologist follow to indicate to check factor to predict ground water potential. Inference engine sequentially search each rule if match is found factors then inference engine draw the conclusion from condition found theirs very high ground water potential otherwise if the condition not satisfy or not match inference engine continue next rule until achieve the goal which is satisfy condition of ground water potential otherwise continues check others option of ground water potential.

Rule1: Groundwater, If

The areas have high infiltration,

There is high perception,

There is less surface runoff,

There is high annual rainfall, percolation and lower slope,

There is high drainage,

There is alluvial soil,

Then area has **Very High Groundwater Potential.**

Rule 2: Rainfall, if

The area has high infiltration,

There have less surface runoff,

There is high humidity,

There is little runoff and high infiltration,

There is agriculture, vegetation, forest and water body,

Then area has **High Groundwater**.

Inference engine can be reply users when condition satisfy by replying “yes” and replying users when condition not satisfy by replying “no” answer as shown figure 5.2.

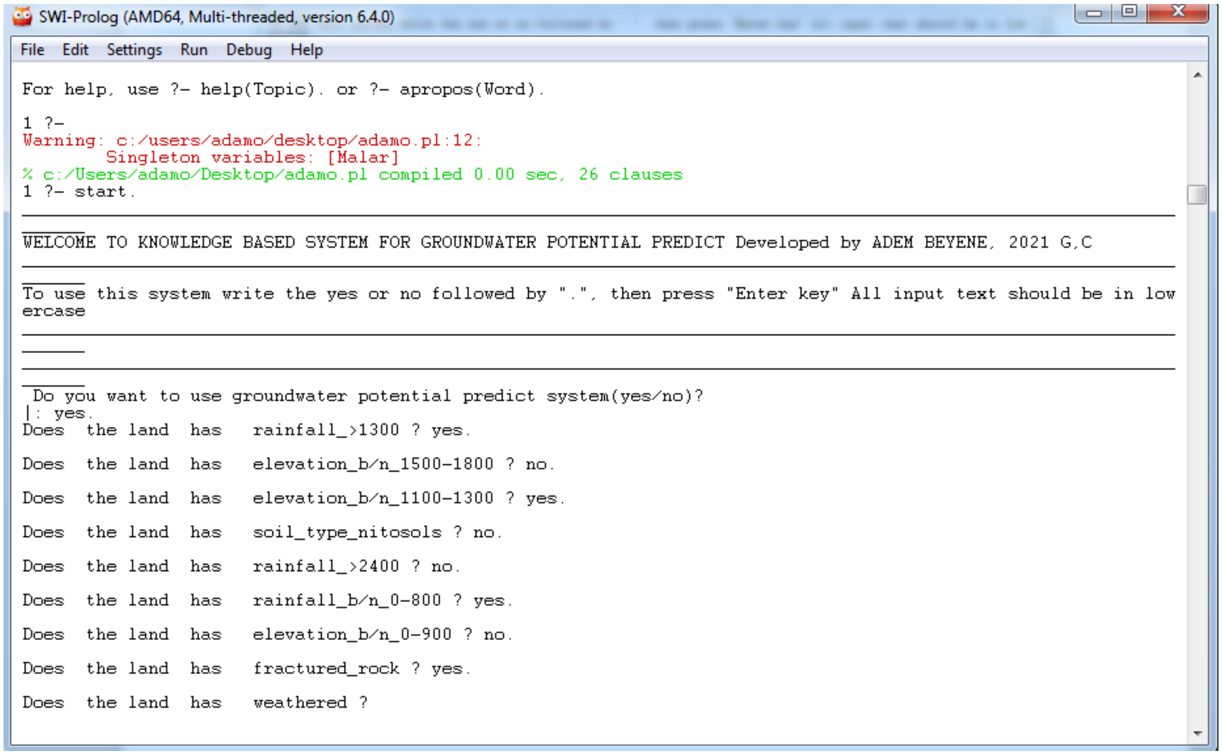


Figure 5.2: Inference engine

5.3. Implementation

KBS acceptability depend on the quality of user interface. The user interface is used as the means of interaction between a user and the KBS. For the proposed KBS, users interact with the system through “yes” and “no” response only. Based on the user’s response the system draws a conclusion for each rule in the knowledge base. System starting displayed on the user interface window as follow.

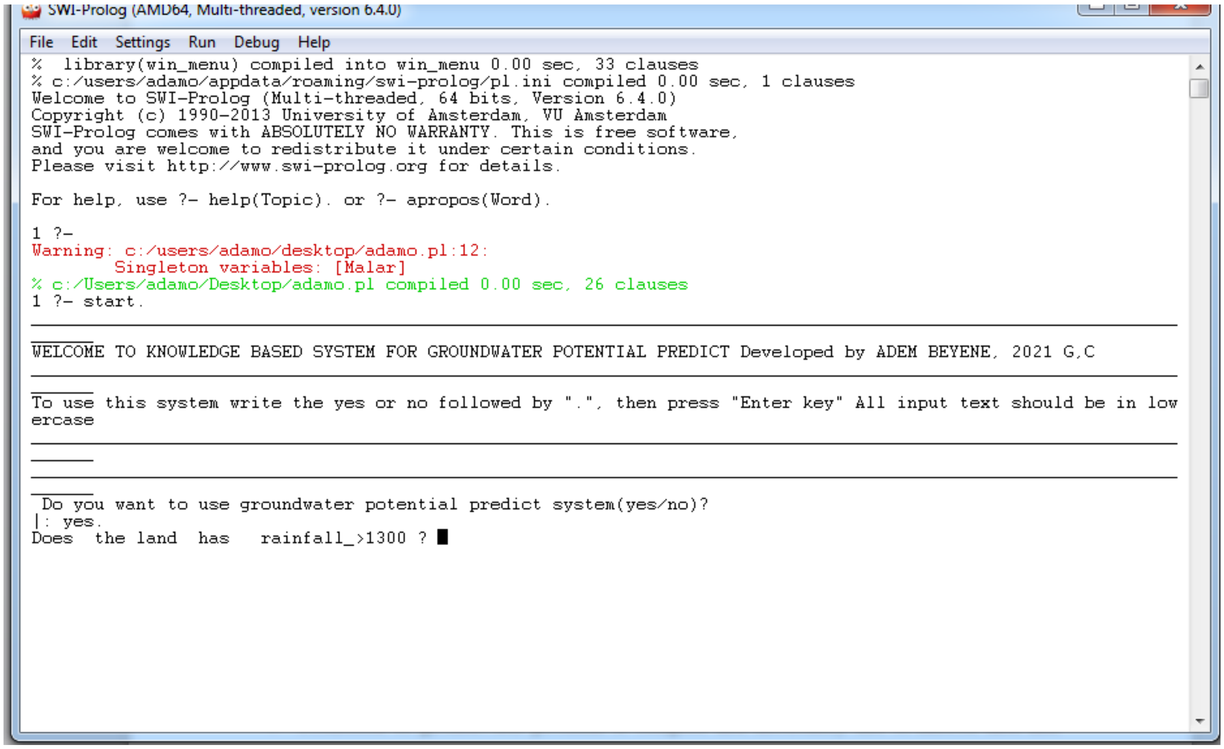


Figure: 5.3. Welcoming window of GWPP User interface

Welcome window of GWPP user interface displayed the user can interact with system the by typing “start” letter then followed by full stop or dot next to welcome screen of WINprolog window. After this user start interacting with the system by typing “start” followed by full stop or dot then user start perform task. Then user start by using basic parameters input to GWPP to get good judgment from parameters input for groundwater potential prediction check. The develop proposed system also providing guideline for users which help them easily interact with a system. The system asks users please respond the following question by saying “yes or no”.

KB was used for track the question can be asked user by system and user reacted with system to answer question. System gets information from users and remembering user response from the system. In using prototype System is ask user question which already the of answers the question were known and stored in the knowledge base .Then user asserts the answer for question. Ask question by system response only ‘yes or no ‘ answers. Furthermore inference engine used to expand users interaction with a system. System ask question user to response by ‘yes or no ‘. System provides different option is to the user list rather than single question about each parameters of check availability of groundwater potential. If the systems fulfill certain condition of groundwater potential availability then inference engine draws the conclusion from the given parameters.

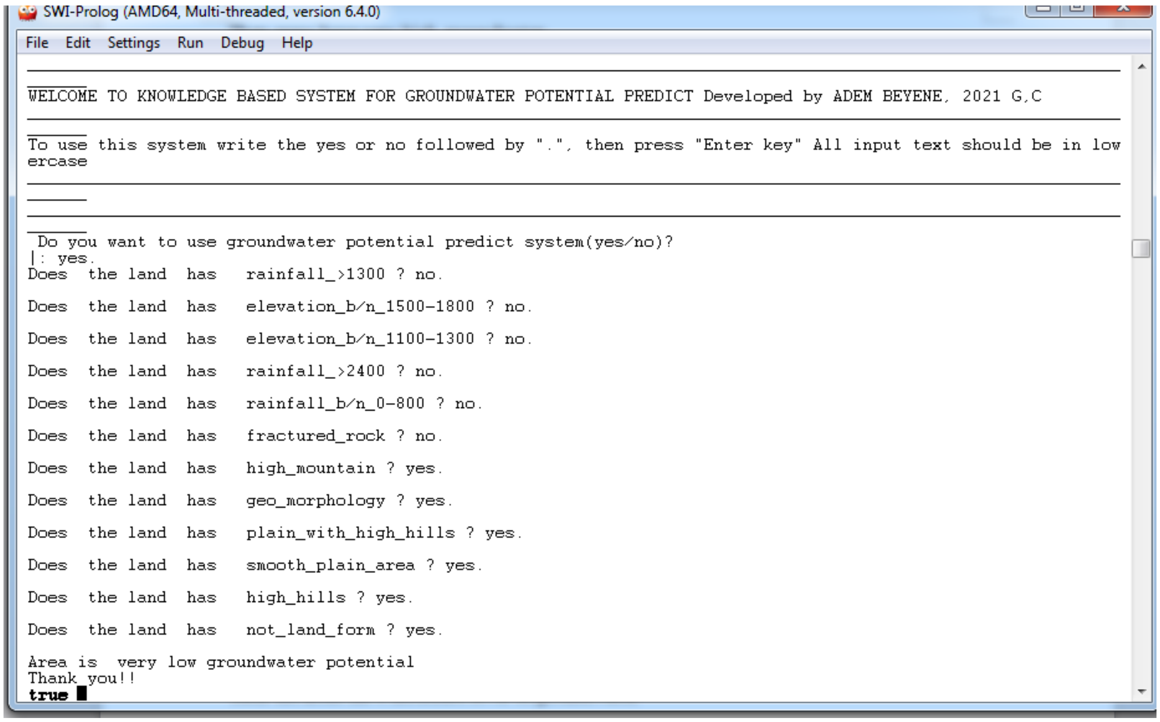


Figure: 5.4 .Very low GWPP

From the figure:5.4 shown above ,since the area satisfies the given condition of groundwater potential availability that means the areas have high mountain, Geo morphology , plain with high hills , smooth plain area ,high hills and not land form. Then areas have very low groundwater potential. This indicate that system conclude area have very low groundwater potential.

System concludes by identifying level of groundwater potential availability, category and parameters of searching of groundwater potential. If the area response doesn't match with criteria of groundwater potential then inference engine start check the next rule until the condition match with the given criteria. The following figure: 5.5 shows groundwater potential with all satisfied condition of low GWPP.

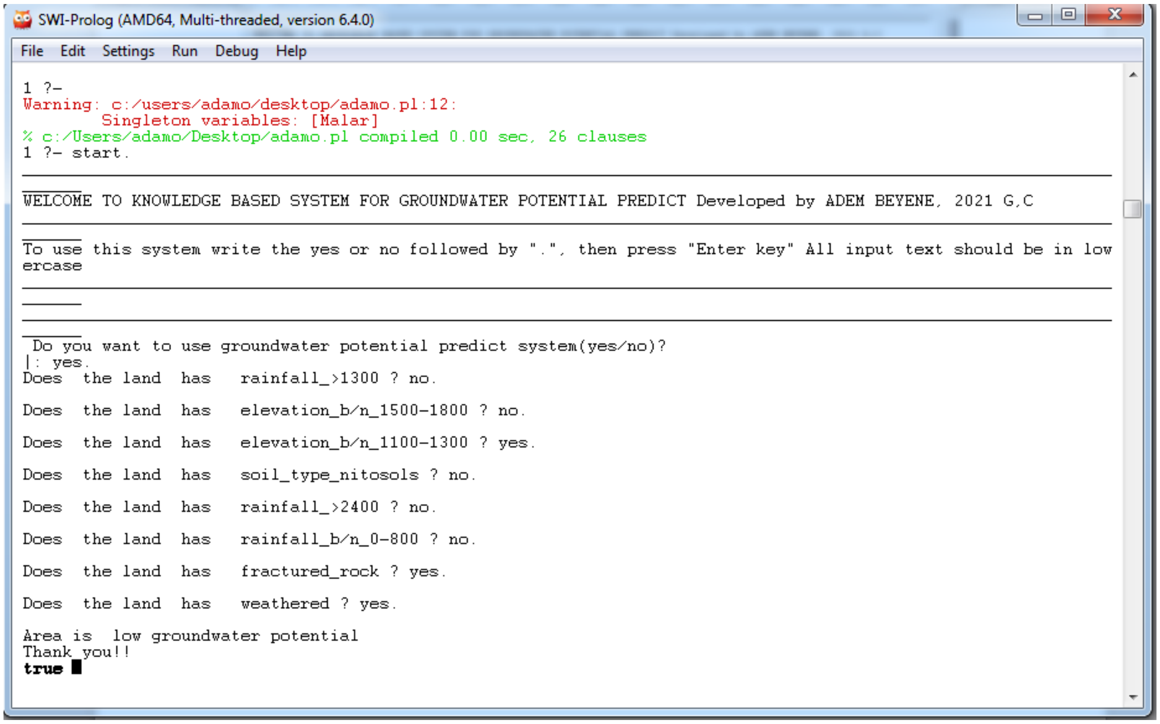


Figure: 5.5 Low GWPP

The figure 5.5 above show the system conclude that the area satisfy the condition to search groundwater potential when some possibly condition satisfied. However if the area response fails to satisfy some of the condition that means the area doesn't have high rainfall above 1300mm, elevation between 1500-180m above sea level and the area contain fractured rock and weathered types of rocks or geologically formation. So that conclusion made from the system area has low groundwater potential. The result of the satisfied the condition area have groundwater potential its can be drilling well possible condition satisfied.

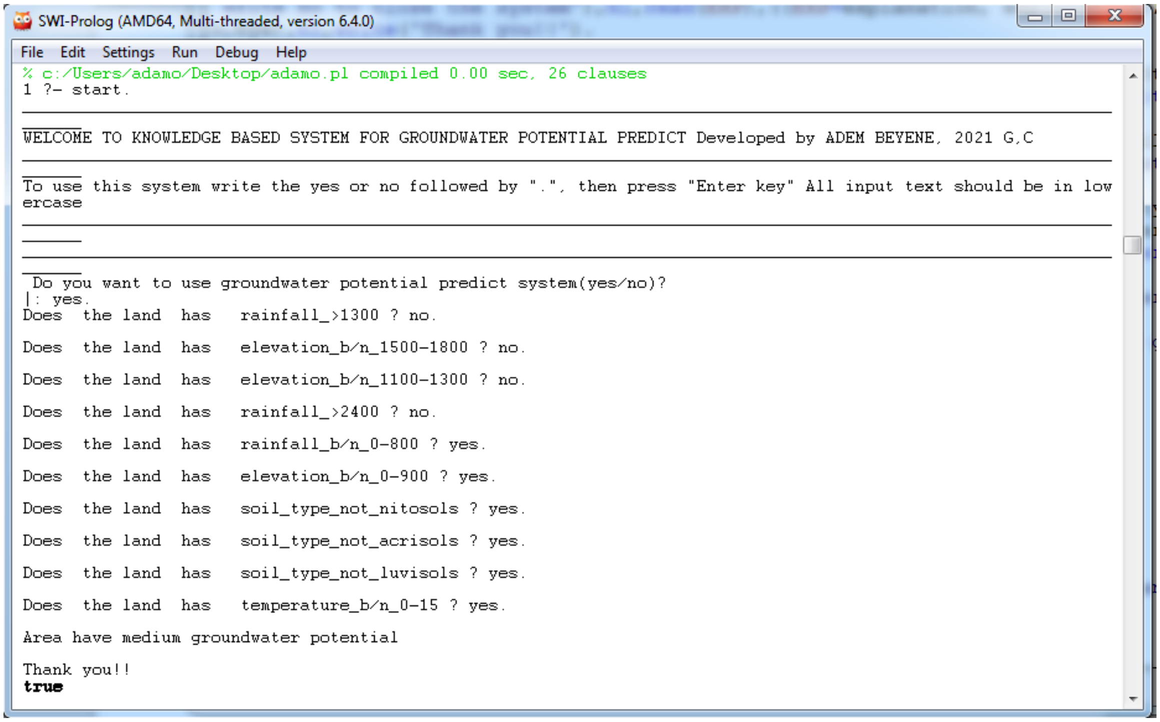


Figure: 5.6 Medium GWPP

From above figure: 5.6 shows that area have medium GWPP fulfills possibly condition of the given rule then the system draw possibly conclusion depend on the fact from knowledge base. This area was contains rainfall between 0-800mm , elevation 0-900m above sea level , not nitosols soil, not acrisoil, not luvisoil category and temperature of the area was between 0-15$C^{0.}$·. So that area contains medium level of ground water potential predicting according the parameters decision made by system to predict ground water potential.

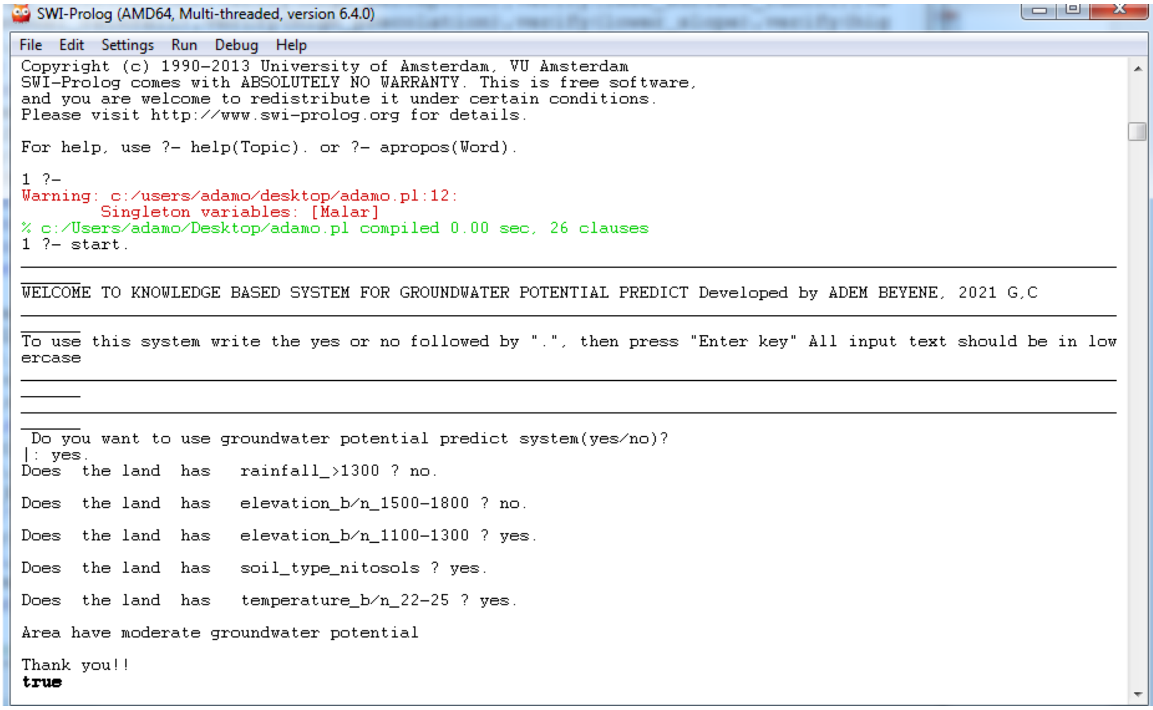


Figure :5.7 Moderate GWPP

According to figure 5.7 shown above ,since the area have moderate groundwater potential satisfies the given condition of groundwater potential availability that means the areas have no some of parameters of predicting groundwater potential for moderate groundwater those are rainfall was not greater than 1300mm, elevation of the area was not between 1500-1800m above sea level, and elevation of the area was between 1100-1300m above seal level and soil type in the area was nitosols, and temperature in the area was between 22-25C$^{0.}$ degree Centigrade, so that area have moderate groundwater potential. System concludes by identifying level of groundwater potential availability, category and parameters of searching of groundwater potential.

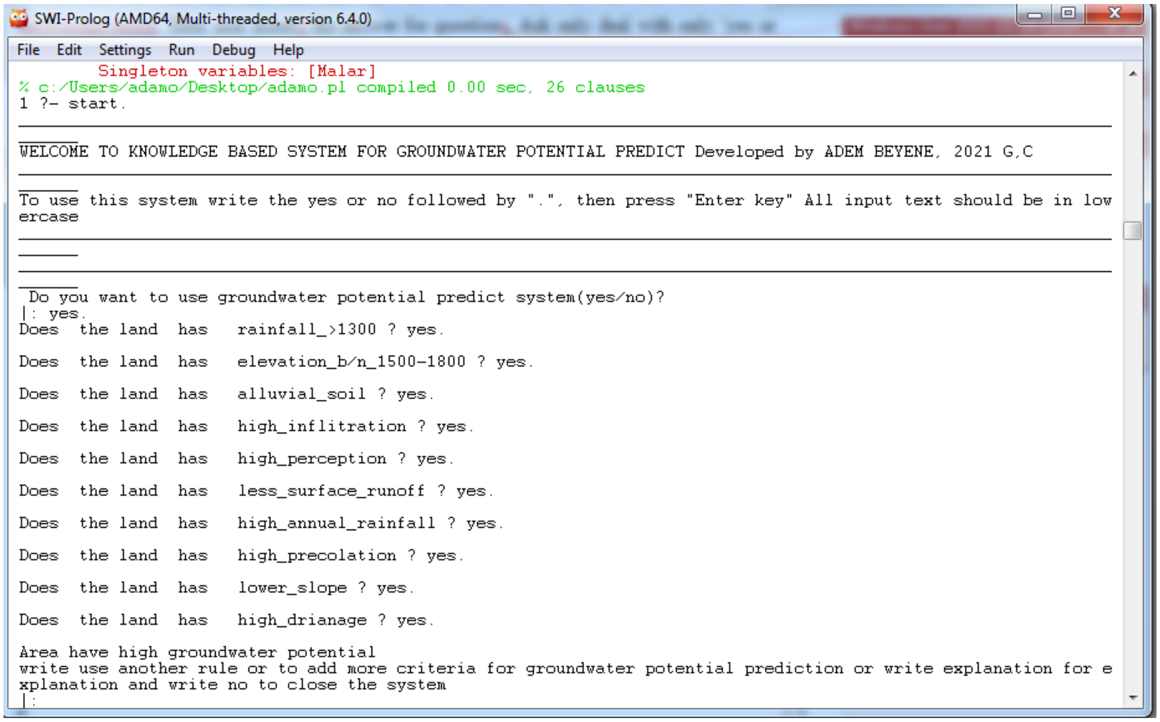


Figure: 5.8 High GWPP

According to figure 5.8 shown above ,since the area have high groundwater potential satisfies the given condition of groundwater potential availability that means the areas have some of parameters of predicting groundwater potential for high groundwater potential those are rainfall was not greater than 1300mm, elevation of the area was between 1500-1800m above sea level, and elevation of the area was between 1100-1300m above seal level and soil type in the area was alluvial, high infiltration, high perception, less surface of runoff, high percolation, lower slope and high drainage in the area so that area have high groundwater potential. System concludes by identifying level of groundwater potential availability, category and parameters of predicting of groundwater potential.

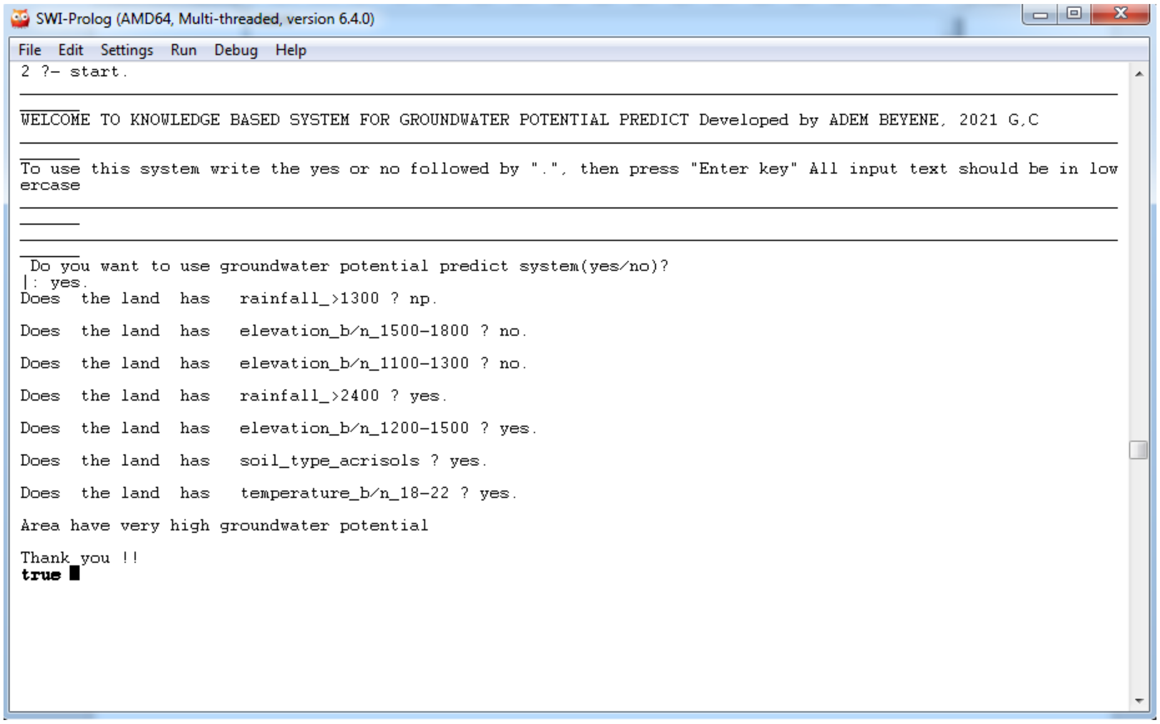


Figure: 5.9 Very high GWPP

According to figure 5.9 shown above ,since the area have very high groundwater potential satisfies the given condition of groundwater potential availability that means the areas have fulfill criteria of predicting groundwater potential depending on the parameters those were rainfall in the area was greater than 2400mm ,elevation of the area was between 1200-1500m above seal level , soil type in the area was acrisols and the temperature in the area was between 18-22 degree centigrade to verify some of parameters for this rule rainfall was not greater than 1300mm, elevation of the area was not between 1500-1800m above sea level. System concludes by identifying level of groundwater potential availability, category and parameters of predicting of very high groundwater potential in the area.

5.4. Explanation Facility

One of the interesting feature of knowledge base system components is explanation facility which is ability to explain it self. Developer of knowledge based system use this module to have more explanation between users and system dialog with system with users. Explanation facility module answer question ‘how ’ developed prototypes can be work and inference engine incorporate to solve complex problems by giving explanation how the system draw meaningfully feedback and conclusion. Explanation module provides further information with a simple “yes or no” user response.

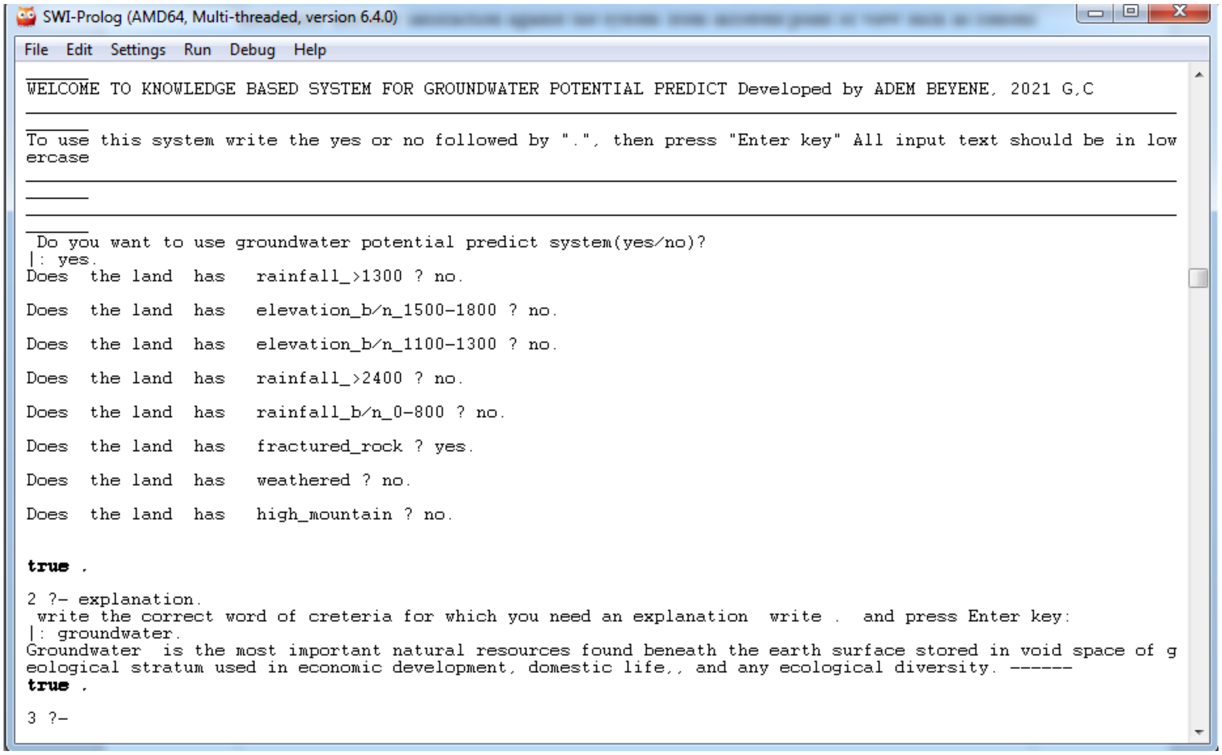


Figure: 5.10. Explanation facility of GWPP

According to figure 5.10 above indicated that explanation of system considering terms and parameters of groundwater potential predicting depending on the knowledge base . System can be identify all parameter of predicting groundwater potential depend on the knowledge base database by generating all information from inference engine that hold all data base or knowledge base then jumps to explanation part what users want known considering system and terms . During explanation execution of term system easily jump from one rule to others rules to by checking all parameters of groundwater potential prediction up to the end of all program what knowledge base hold all database and verify all information related to predicting groundwater potential . Therefor knowledge is obtained from domain expert that was represented by using set of rule and explain all terms. The rule was constructed in the prototype with if then format to draw conclusion from premises. Prototype mainly depends on the decision tree model to make any decision or explain.

CHAPTER SIX

6. System Performance Testing and User Acceptance Testing

6.1. System Performance Testing by Using Test parameters

Testing and evaluation is the final step of measuring the performance of knowledge based system implementation whether system achieve objective of or not. Testing and evaluation of prototype during development of knowledge based system is final steps that helps domain expert to measure whether system achieve the purpose of developed or objective or not. The purpose of this study knowledge based system for ground water potential prediction is tested and evaluated based on the objective of system to predict ground water potential.

Accuracy of the system measured depends on the factors that help to predict groundwater potential to achieve objective of the study or not. Performance of system measured in this study based on human expert to decision making during predict ground water potential that used validate method to predict ground water potential by using confusion matrix. The user acceptance of the system is carried out during system and user interaction.

Knowledge based system user acceptance measured based on the open and closed ended questionnaire to evaluate whether the system accepted or not. System evaluator directly interacts with the system functionality according the objective of the research study to fulfill the objective of study in properly ways. In addition to this the validation test was done by comparing solved parameters against the system conclusions on the similar issues by comparing the result obtained from the system conclusion, the evaluator determine the performance of the system. Therefore, knowledge based system performance is measured first by using open and close ended question, and second by using confusion matrix validation method to test system accuracy.

Table : 6.1 Testing the accuracy of KBS for GWPP

Selected parameters	Total number of error selected	Correct prediction	Incorrect prediction	Accuracy of prototype in percent(%)
Rainfall	5	4	1	80%
Drainage	6	4	2	66.67%
Slope	4	3	1	75%
Land use	3	3	0	100%
Vegetation	4	4	0	100%
Total	22	18	4	84.33%

From table :6.1. Above five system performance testing by using test parameters was selected to test parameters validate of the system accuracy. Those parameters occurred stored in the knowledge base and KBS suggest solution. Sample selected parameters were purposively used to challenge performance of the system error happen during prediction of groundwater potential. As result for 'rainfall' above table above 6.1. From the given five parameters four is correctly suggest by system (80%). This shows that there was others factors rainfall error happened rather than others factors two parameters which is "slope" and "drainage" knowledge obtained from domain experts which forward this for furthers research. Similarly from the given parameters two classified correctly in the "land use" and "vegetation" 100% out of five parameters selected system correctly provide suggestion toward predict groundwater potential. From the given parameters drainage is the least classified which system suggest 66.67% correctly suggested by system and 33.33% in correct suggestion by system. From the five parameters selected "slope" is also one the performance test factors which was 75% correctly suggested by system and 25% was not correctly suggested by the system. Finally all test parameters directly integrated in knowledge base and the average of the system score 84.33% KBS for GWPP.

6.2. User Acceptance Testing

Knowledge based system evaluated depend on the visual interaction between system and domain expert to evaluated the system to fulfill the given criteria to predict ground water potential in properly to achieve the objective of the research. Direct interaction between system and users show that evaluate the performance of knowledge based system according user point of view perspective. This helps user to ensure performance of prototype by assessing the feedback and suggestion acquired from domain expert towards development of knowledge based system for groundwater potential prediction. Questionnaire and semi-structured which helps to access and evaluate the develop prototype appropriate applicability of system toward domain expert area.

During the knowledge based system development these domain experts were actively involved in the different stages of knowledge acquisition, prototype development and consulting on the content of knowledge or domain expert. The informal discussion with domain experts has significant role to understand the dimension of the problem. Before the actual evaluation process conducted, some guideline and brief explanation is given to the system evaluator on how the system works.

System performance evaluation by using questionnaire closed and open ended question to test acceptance of user concerning systems. Therefore to evaluate performance on the prototype based on user evaluation after interaction within system researcher assigned numeric value for option given below. The numeric values given as follow: Excellent = 5, very good = 4, good = 3, fair = 2 and poor = 1. Based on the given scale, system evaluator provides a value for each closed ended questions. Thus, this method helps the researcher to manually examine the user acceptance based on evaluator response. The user acceptance of the system is measured by

$$\left(\mathbf{AVP} = \sum_{k=1}^{n} \mathbf{SVi}.\frac{\mathbf{NRi}}{\mathbf{TNR}}\right) \mathbf{X\ 100/NS}$$

Where AVP is average performance, SV scale value, TNR total number of respondent and NR is number of respondent. To get the result of user acceptance average performance is calculated out 100% (Aboneh, 2013).

No	Questions	Poor 1	Fair 2	Good 3	V.good 4	Excellent 5	Average	Percent(%)
1	Is the system easy to understand?	0	0	1	5	4	4.3	86%
2	Is the system incorporate sufficient knowledge to solve error during drilling wells?	0	0	2	2	6	4.4	88%
3	Is the system efficient to analyzing facts and decision making?	0	0	3	3	4	4.1	82%
4	Is the system user friendly to use?	0	0	1	2	7	4.6	92%
5	How much the system accurate in categorizing the factors into the correct groundwater potential prediction?	0	0	2	5	3	4.1	82%
6	Is the system provides the right feedback and suggestion to be followed while finding and correcting errors by human expert?	0	0	2	3	5	4.3	86%
7	Is the system having contribution for domain expert?	0	0	2	4	4	4.2	84%
	Total average	**0**	**0**	**1.85**	**3.42**	**4.71**	**4.3**	**85.7%**

Table 6.2 user evaluation performance of KBS for GWPP

As indicated table 6.2 above 10% of respondent rate the ‘system easy to understand as good. The question 50% respondent rate as very good and 40 % of respondent said excellent. The second evaluation is ‘is the system incorporate sufficient knowledge to solve error during drilling wells ’ in the same ways 20% respondent rate as good and others 20% of respondent very good and the remaining 60% respondent excellent. In similar ways 30% respondent rate for question ‘Is the system efficient to analyzing facts and decision making ‘ as good and 40% respondent score very good and the rest evaluator 40% respond excellent. As the same criteria the ‘system user friendly to use ‘10% respond rate as good and 20% respondent evaluate very good as well as the remaining 70% of respond excellent. From the criteria of ‘the system accurate in categorizing the factors into the correct groundwater potential prediction ‘ 20% respondent rate as good and 50% respondent evaluate as very good and the remaining evaluator 30% respond excellent. In similar ways ‘the system provides the right feedback and suggestion to be followed while finding and correcting errors by human expert ‘ 20% respondent rate as good and 30% of respondent score as very good and the remaining 50% respondent evaluated as excellent. 20% of respondent rate as good depending on the ‘system have contribution for domain expert and 40% respondent evaluator gives as very good and the remaining 40% of respondent evaluator as excellent.

As shown on the table 6.2 above based on the respondent which evaluator of the system average of performance obtained is 4.3 of scale given out of 5. Result obtained from values assigned for each close ended question asked respondents. About 85.7% average of the respondent satisfied by performance of the system. Open ended question provided for system evaluator to collect expert feedback and suggestion as well as for the question how much the system accurate in categorizing the factors into the correct groundwater potential prediction is related to human expert to predict ground water potential depending on the factors effect to predict ground water. Therefore open ended question helps evaluator to provide their own contribution to system and uncovered knowledge issues, system holding knowledge and limitation and strength of knowledge based system to overcome any problem depending on the feedback and suggestion given system.

However system evaluator respond open ended question how to knowledge based system support to predict groundwater potential prediction which is the knowledge based system solve problem depending on knowledge base that store knowledge in knowledge base that to save time, cost and extra human resource. Human expert use their own experience, vital sign, manual and guidelines to predict groundwater potential which extra time consuming and difficult remember but knowledge based system stored knowledge in knowledge base easy to and remember any issue to solve at the given time. Knowledge based system reply all respond at the same time that contains adequate knowledge for all rules incorporated in the knowledge base. As their suggestions indicated, the system must be update the existing knowledge and learn from the environment. To handle such issues the researcher incorporated single case to dynamically update the existed fact in working memory. This component helps knowledge engineers to design a knowledge based system that update the fact base dynamically.

6.3. Discussion

According to system evaluator indicated the proposed KBS would be applicable in the specific domain area as well as the feedback and suggestion from domain the proposed KBS was satisfactorily gain users acceptance from evaluator. System evaluators directly interact with system by using open ended question and closed ended question to check system acceptance. From table 6.2 user respond considering system performance is poor not respond from system evaluator users and fair performance considering not evaluated from respondent which zero both poor and fair performance from respond those evaluate system.

From above table 6.2 users respond good performance of the system evaluator average of total respondent (13) of was one point eight five(1.85) total average of respondent which is 18.57% percent of from total respondent from system evaluator given good performance. Based on the table 6.2 system performance evaluator from very good average of total respondent (24) were 3.42 which is 34.28% of total respondent evaluated from very good system performance. From previous table 6.2 total evaluator from excellent of respondent (33) total and average was 4.72 which are 45.71% from all evaluator respondents given excellent considering system performance.

Based on the respondent given the result of performance of the system the KBS developed for

GWPP is excellent performance to predict groundwater potential in the study area. In generally KBS is accepted by respondent total which is 85.7% of respondent system is easy, understandable, correctness, and recommended for prediction of GWPP.

Based on this system developed provided open ended question for the evaluator to get meaningful feedback and suggestion connected to close ended question. System evaluator recommended considering prototype developed was very import to save time, store knowledge in knowledge base, easy to access, correctness system to manage knowledge in specific domain area, helps fresh hydrologist and geologist in this area of predicting groundwater potential in absence of domain expert especially in remote area. In addition to this developed prototype system have play great role towards sharing knowledge and experience in the absence of domain expert what was given from system evaluator confirm the importance of the system developed to predict groundwater potential.

In generally developed prototype system of KBS have got excellent user acceptance from system evaluator. The development of KBS system helps anybody have no experience on the predicting of groundwater potential as well as not time consuming, save extra cost of domain expert payment, easy to decision making, helps policy makers to protect groundwater potential resources and planning and helps site selection of fresh geologist and hydrologist by predicting the level groundwater potential by using special parameters in the environment or environmental factors such rainfall, drainage density, slope types, soil, rocks type and vegetation in the area. In addition to this system provide special steps to predict groundwater potential and system intelligent ability learn from the environment during groundwater prediction and strength geologist and horologist in groundwater potential prediction. Finding of this study was the developed system KBS for GWPP is the better predicting groundwater potential than previous manual using groundwater prediction by indicating level of groundwater potential. Groundwater potential level measured mm whether potential was very low, low, medium, moderate, high and very high groundwater potential developed system was predict groundwater. Foreign company and fresh and senior hydrologist and geologist was used for predict groundwater potential which was 84.33% accuracy of predicting groundwater potential. The developed system encourage and increase performance of identifying groundwater potential prediction in the study area and reduced the compliance between project owner and constructor of drilling wells in the areas.

6.4. Related Worked Done

Some research conducted by using KBS as considering user acceptance and system performance as follow. According to Seblewongel (2011) Prototypes of knowledge based system for anxiety mental disorder. Aim of exploring the applicability of knowledge based system technology to the specific area. System gaining promising user acceptance tested but system performance is not registered . The researcher was used backward chaining mechanism to achieve the target objective. Final researcher recommended to fully functionality implement prototype integrated rule based with case based techniques to achieve best result. According to Solomon Abebe (2010) knowledge based system for settling Tort claims under The Ethiopian Law. Rule based and decision tree model was used by researcher develop KBS. Rule based reasoning approach adapted to represent knowledge base system. Knowledge based system developed by using SWIprolog by using backward chaining mechanism inference engine read from knowledge base. Gaining user acceptance and prototype tested but system performance test was not registered.

Dejene Alemu (2009) conducted research on the application of KBS for woody plant species Identification. Researcher used backward chaining mechanism to identifying species. KBS prototype developed by prolog using production rule and knowledge base was constructed. As compared to existing way of identification researcher was come up with new knowledge/rules with minimum features that register comparable performance. System tested and evaluates by user and the system register comparable performance but not assigned numerically. According to Redit (2006) conducted a study to investigate KBS for HIV pre-testing counseling. She used rule based reasoning techniques and pro gold expert system shell in developing prototype. Applicability of technology show satisfactory level at this area but user acceptance and system performance evaluation by users was not registered.

In additional Anteneh (2004) conducted research study to investigate the rule based reasoning approach in designing and developing knowledge based system prototype for Antiretir oval therapy in area of HIV treatment as sources of knowledge. The acquired knowledge is representing using hierarchical structure modeling .System was tested, evaluated by users and system performance registered 70%.

A monthly ground water level is predicting by using Neuro-Fuzzy and ANN algorithms in order to get a better mode by (Amir, Hossein & Mohammed, 2011). On the experimentation phase of this study different monthly variables such as air temperature, rainfall and nearest other ground water level is where used on both prediction model. As a result of the study neuro-fuzzy model where not scrod a high accuracy and performance for predicting ground water level when ANN compared to each other.

Knowledge based system developed to predict groundwater potential was excellent performance to predict groundwater potential and system was 85.7% performance of prediction groundwater potential as well as accuracy of the system was to predict groundwater potential was 84.33% acceptable by user and system performance evaluator. So that researcher finding was prototype developed 85.7% performance of user acceptance and 84.33% accurately predict groundwater potential by using forward chaining reasoning mechanism and user friendly system developed which very easy for any users to access system and predict groundwater potential update knowledge base based on theirs environment factors.

CHAPTER SEVEN

7. Conclusion and Recommendations

7.1. Conclusion

Predicting groundwater potential based on parameters and factors that was a challenge for fresh and senior hydrologist and geologist. Primary objective of this study was to develop knowledge based system for groundwater potential predicting. Relevant knowledge was acquired from domain expert, document analysis, and others related journals. Developed prototype was based on the conceptually modeled using decision tree structure depend on the logical relationship between the factors to predict groundwater potential. Prototypes of groundwater potential prediction developed by using SWIprolog programming tools which was predicting groundwater potential in the specific area very low, low, medium, moderate, high and very high output result. Drilling wells is very complex contractors and foreigner those who don't know environmental factor and using tradition methodology to predicting groundwater potential for a long period of time which lead to failure to gain groundwater potential according the agreement between contractors and project owners. This was high economically crisis and morally crisis for project owners and constructors. KBS for GWPP was easily solve problem of predicting groundwater potential when compared with (ANN), (SVM),and M5 model trees to evaluate and compare feasibility and capability of groundwater level prediction. Common mistake occurs during drilling wells is considering altitude of the land features and factors effecting the of groundwater potential was rainfall, slope, drainage density, soil, rocks and land formation which makes land sliding during drilling wells. Majorly, contributes of this was developed KBS for GWPP more predictive when comparing manual and predict accuracy 84.33%. the developed system predict groundwater based on level of groundwater which is very low, low,medium, moderate, high and very high output result, time and cost saving for fresh Geologist and Hydrologist to predict groundwater, reduce the compliance between project owner and constructor of drilling wells

Development of KBS for GWPP is helps the ways of predicting ground water potential in the given area for fresh geologist, hydrologist, contractors and others foreigner company those working on the groundwater potential and drilling wells for different purpose of irrigation and drinking. Improving the method of predicting groundwater potential and determine the factors of predicting groundwater in the selected area.

7.2. Recommendations

Development of prototype for knowledge based system for ground water potential prediction was providing improvement to groundwater potential prediction and applicable of domain expert in the area of groundwater potential prediction. KBS gaining user acceptance by giving meaningful feedback and suggestion of users.

The scope of prototypes development for KBS should be extended to incorporated different field of engineering to predict groundwater potential in the field of civil, geology, hydrology and environmental engineering and others related field of study.

Factors effect GWPP are environmental, rainfall, topography, geology, drainage density, soil, rocks and others factors. Therefore furthers investigation should be done by integrate an intelligent agent that has a capability to self-learning and updated using KBS is the best option to use.

Further studies recommended / identified by researcher was forecasting climate condition by using knowledge based system and predicting spring water potential continuity by using knowledge based system in Jimma Zone area and western Oromia region.

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Appendix I **JIMMA UNIVERSITY**

Jimma Institute of Technology

Faculty of Computing and Informatics

Master of Information Science in Information and Knowledge Management

Questionnaire

Knowledge Based System for Ground Water Potential Prediction

Information I receiver will only used for the purpose of this research and the participant name is not required write their name and your participation is voluntary, if you want you withdraw from any process at any time if you so desire.

For Jimma University Institute of Technology, Faculty of Civil and Environment Engineering,Jimma Zone and Jimma Town

1. Sex ________
2. Department ______________________
3. Educational status BSc ☐ MSc ☐ Ass.Prof ☐ PHD ☐
4. Work experience on ground water potential prediction

0-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ above 20 ☐

5.Do you have worked on ground water potential prediction? If your answer is yes what make complex for ground water potential prediction? If your answer is no what makes easy to ground water potential prediction?

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6. What makes challenge for ground water potential prediction?

7. What mechanism make easy to ground water potential prediction?

8. Work on ground water potential prediction can be require special knowledge?

9. What Technology is used for ground water potential prediction?

10. What makes complex ground water potential prediction during drilling wells?

Appendix II

Questionnaire for User Acceptance

Questionnaire for user acceptance to knowledge Based System for ground water potential prediction

1. Is the system easy to understand during ground water potential prediction ?

Poor ☐ Fair ☐ Good ☐ . Very good ☐ Excellent ☐

2. Does the system easy to update knowledge base ?

Poor ☐ Fair ☐ Good ☐ Very good ☐ Excellent ☐

3. Does the system respond user efficiently?

Poor ☐ Fair ☐ Good ☐ Very good ☐ Excellent ☐

4. Does the system support users during drilling wells?

Poor ☐ Fair ☐ Good ☐ .Very good ☐ Excellent ☐

5. Does the system handle accurate information for decision making for ground water potential prediction?

Poor ☐ Fair ☐ Good ☐ .Very good ☐ Excellent ☐

6. Does the system helps users by predicting ground water potential?

Poor ☐ Fair ☐ Good ☐ .Very good ☐ Excellent ☐

7. What makes difference knowledge based system from domain expert?

8. what the weakness of the system?

9. What the strength of the system during predicting ground water potential?

10.What makes complex system during ground water potential prediction?