



Addis Ababa University
College of Natural sciences
School of Graduate Studies
Department of computer science

Web Based Agronomy Advisory System: the Case of Cereal Crops

Prepared By
Feidu Akmel Gobena

A project paper submitted to the School of Graduate Studies of Addis
Ababa University in partial fulfillment of the requirements for the
Degree of Master of Science in Computer Science

October, 2014

Addis Ababa University
College of Natural sciences
School of Graduate Studies
Department of computer science

Web Based Agronomy Advisory System: In the Case of Cereal Crops

By
Feidu Akmel Gobena

Signature of the Board of Examiners for Approval

Name	Signature
1. Dr. Dida Midekso, Advisor	_____
2. _____	_____
3. _____	_____

October, 2014

Acknowledgements

I would like to say –Alhamdulillah Rabilalemin” for the almighty who blessed me in every :
of my life.

This work would not have been successfully completed without the supervision and excellent advice of my advisor Dr. Dida Midekso. I have learned a lot from you; thank you very much.

My beloved wife Rehi, my dear sisters Habiba and Zulfa, you are the love of my life and your contribution are great for successful completion of this work.

I would like to express my special thanks to A/resak J., Zerihun M., Ato Akmel Kemal and his wife Lubaba , thank you for your support and true friendship.

Moreover, I would like to forward my heart-felt appreciation to Ethiopia Institute of Agriculture Research center workers especially for department of crop research for their support.

Table of Contents

List of Figures	IV
List of Acronyms	V
Abstract	VI
Chapter One: Introduction.....	1
1.1. Background	1
1.2 Statement of the Problem	3
1.3 Objective of the project.....	4
1.3.1 General objective	4
1.3.2 Specific objectives	4
1.4 Scope of the Study	5
1.5. Methodology	5
1.5.1 Data Collection	5
1.5.2 Development Tools	6
1.5.3 System Evaluation.....	6
1.6 Significance of the Study	6
1.7. Organization of the Report.....	6
Chapter Two: Literature Review	7
2.1. Maize Crop.....	7
2.2 Wheat	7
2.3 Disease and Insect/Pest of Maize and Wheat crop	8
2.4 Basic Practices of Crop Production	8
2.5. Expert System.....	9
2.6. Approaches of Expert System	9
2.7 Rule Based System Architecture	13
2.8 Knowledge Based System features.....	15
2.8.1 Coping with Uncertainty	15
2.8.2 Explanation.....	16
2.9 Phases of Expert System Development.....	16
2.9.1 Knowledge Acquisition	17
2.9.2 Knowledge Representation	17

2.9.3 Evaluation.....	18
2.10 Integrated Knowledge Based and Database Management System.....	18
2.10.1 KBS - DBMS Loose coupling:	19
2.10.2 KBS - DBMS Tight coupling:.....	19
2.11 An Agent Based Approach to Expert System explanation	19
2.12 Recommender System.....	20
Chapter Three: Related Work.....	21
3.1 EXOWHEM: Expert System on Wheat Crop Management.....	21
3.2 Expert System Development for Teff Variety selection and Disorder	21
Diagnosis	21
Pakistani Wheat.....	22
3.4 Barley Expert System	22
3.5 A Web Based Decision Support System for Durum Wheat	23
3.6 Knowledge model-based decision support system for maize management	24
3.7 Expert System for Wheat Yields Protection (ESWYP)	25
3.8 NEPER: a multiple strategy wheat Expert System	25
3.9 Expert System to Detect and Diagnose the Leaf Diseases of Cereals (Wheat, Maize and Rice)	26
3.10.1 Citex, Cuptex and Tomatex	27
3.11 Summary	29
Chapter Four: Requirements Analysis.....	30
4.1 Functional Requirements	30
4.2 Non functional Requirements.....	32
4.3 System Models	35
4.3.1 Use Case diagram.....	35
4.3.2 Class Diagram.....	42
4.3.3 Sequence Diagram	43
Chapter Five: System Design.....	48
5.1 Knowledge Acquisition.....	48
5.2 Architecture of the System.....	48
5.2. Sub system Decomposition	51
6.1 Development Tools.....	54
6.2 Knowledge Representation.....	54

6.3. Prototype of the System	54
Chapter Six: Implementation	54
6.1 Development Tools.....	54
6.2 Knowledge Representation.....	54
6.3 Prototype of the System	54
6.7. Sample Graphical User interfaces of Afaan Oromo language version.....	59
Chapter Seven: System Evaluation	63
Chapter Eight: Conclusion and Future Works.....	64
8.1 Conclusion.....	64
8.2 Future Works	65
References.....	66
APPENDICES.....	71
Appendix B : Disease, Weed and Fertilizer knowledge base	71
Appendix C: System Evaluation Questionnaire.....	82
Appendix D: Result analysis of users_ feedback towards the system.....	92
Appendix E: Major wheat disease.....	83
Appendix F: Major Maize disease	85
Appendix G: Insect/Pest	87
Appendix H: Wheat and Maize Variety	88

List of Figures

Pages

Figure 2.1: The architecture of rule-based Knowledge Based System [1].....	13
Figure 2.9 knowledge engineering processes.....	17
Figure 3.5 Conceptual diagram of the DSS for durum wheat cultivation.....	24
Figure 3.8 NEPER overall structure.....	26
Figure 4.1: Replication of database server adapted from.....	31
Figure 4.2: Load balancing adapted from.....	32
Figure 4.3 Redundant web/ application servers.....	33
Figure 4.4 the business logic on separate tiers.....	34
Figure 4.3.1: Use case Diagram.....	36
Figure 4.3.2: Class Diagram.....	42
Figure 4.3: Sequence diagram for pre-cultivation.....	42
Figure 4.3: Sequence diagram for pre-cultivation.....	43
Figure 4.4 Sequence diagram for farm preparation.....	43
Figure 4.5 Sequence diagram for variety selection.....	44
Figure 4.7 Sequence diagram for fertilizer application.....	44
Figure 4.6 Sequence diagram for crop, variety, pre cultivation and farm registration form.....	45
Figure 4.8 Sequence diagram for weed management.....	45
Figure 4.9 Sequence diagram for disease diagnosis.....	46
Figure 4.10 Sequence diagram for Harvest storage and treatment.....	46
Figure 4.4: Activity Diagram of the System.....	47
Figure 5.1: The Architecture of the System.....	49
Figure 5.2: Subsystem decomposition of the system.....	51
Figure 5.3: Deployment Diagram of the system.....	53
Figure 6.1: Home page of the system.....	55
Figure 6.2: Variety selection page.....	55
Figure 6.3: Recommended variety(s) page.....	56
Figure 6.4: weed management page.....	57
Figure 6.5: weed management option.....	57
Figure 6.6: weed type selection page.....	57
Figure 6.7: Labor availability checking page.....	58
Figure 6.8: Final result.....	58
Figure 6.8: Final result.....	58
Figure 6.9: Home page Afaan Oromo language version.....	59
Figure 6.10: Administrator privilege.....	59
Figure 6.11: Crop, Variety and Pre-cultivation registration.....	60
Figure 6.12: Fertilizer application format.....	60
Figure 6.13: preparation of farm.....	60
Figure 6.14: Weed management.....	61
Figure 6.15: Preparation of the farm Registration.....	61

List of Acronyms

CBR	Case Based Approach
DBMS	Data base Management System
DSS	Decision Support System
EIARC	Ethiopian Institute of Agricultural Research Center
ES	Knowledge Based System
GDP	Gross Domestic Product
GUI	Graphical User Interface
HTTP	Hyper Text Transfer Protocol
ICT	Information Communication Technology
KB	Knowledge Base
KBDBMS	Knowledge Base Database Management System
OPV	Open Pollinated Variety
QPM	Quality Protein Maize
SMS	Simple Message System
URL	Uniform Resource Locater
WKU	Wolkite University
WM	Working Memory

Abstract

This project work presents a web-based Agronomy advisory system for Cereal Crops. Cereals, especially maize and wheat are the major crops developed in Ethiopia. These crops contribute more than 42% of the total crop production of the country and large area coverage in cultivation [12,22].

Wheat and maize are highly adapted to diverse agro-ecological zones of the country. However, these crops suffer from low productivity due to a number of biotic and non-biotic agents. These include poor agronomic practices like poor soil preparation, diseases, insect pests, weeds, and use of poor cultivars etc. Hence, controlling those agents are fundamental requirements to increase crop production.

In Ethiopia, farmers get information or consultation from extension workers who serve as mediator between farmers and experts. Extension workers obtain information from documents, manuals and during training. This information may not be enough to respond to users' question. At this time they need experts' assistance. But the experts are not always available. This system is intended to help extension workers and farmers by solving the problems they faced when experts help is not available.

This project is bilingual data base and rule-based Advisory System which covers pre cultivation, farm preparation, diseases and pest management, fertilizer application and variety selection which are necessary for crop production. It provides proper consultation and recommendation throughout crop production cycle. The system has been evaluated by domain experts and the analysis result shows that, the system is acceptable.

KEYWORDS: Web-based advisory systems, rule-based Knowledge Based System, Agronomy, Cereal crop, Knowledge base

Chapter One: Introduction

1.1. Background

Agriculture remains by far the most important sector in the Ethiopian economy for the following reasons [14]:

1. It directly supports about 85% of the population in terms of employment and livelihood.
2. It contributes about 50% of the country's gross domestic product (GDP).
3. It generates about 90% of the export earnings.

Agriculture is also the major source of food for the population and hence the prime contributing sector to food security [14]. Even though 85 percent of the country's population lives in the rural areas, the performance of the agricultural sector in Ethiopia has remained weak and it is heavily influenced by weather condition, poor agronomy practice, lack of market linkage, shortage of skilled experts who provide advice for farmers at woreda level [13]. Increasing productivity in smallholder agriculture is government's top priority, recognizing the importance of the smallholder sub-sector, the high prevalence of rural poverty and the large productivity gap.

According to [22], cereal crops cover 6.7 million hectares, which is about 80% of the total crop area and maize and wheat contributes 25.5% and 17.5% of the major cereal crop respectively. Export earnings of wheat in 2013/2014 were 38,466 tons and valued at 14 million USD. Export earnings of maize in 2013/2014 were 2,736 tons valued at about 450,000 USD. However, exports of these major crops are negligible compared to world export [12].

Wheat and maize are highly adapted to diverse agro-ecological zones of the country. However, these crops suffer from low productivity due to a number of biotic and non-biotic agents. These include poor agronomic practices like poor soil preparation, diseases, insect pests, weeds, and use of poor cultivars etc. According to [40], controlling of pests, diseases and weeds are fundamental requirements to increase crop production. However, the large number of organisms that can threaten a crop makes management challenging. In any agricultural production system, accumulation and integration of related knowledge and information from many diverse sources

play an important role. In practice, there is no substitute for knowledge and experience in identifying problems and choosing the most appropriate management technique for addressing them. The advice of a qualified agronomist can be invaluable in identifying threats to the crops and the most appropriate strategy for their control [22]. Good agronomic practices starting from pre-cultivation to post harvesting are basic to enhance production and productivity.

The Ethiopian Institute of Agricultural Research (EIAR) is responsible for conducting research and supply of improved agricultural technology and popularization of improved technologies through extension workers to enhance farmer's productivity and production.

Agricultural production has evolved into a complex business requiring the accumulation and integration of knowledge and information from many diverse sources. In order to remain competitive, the modern farmer often relies on agricultural specialists and advisors to provide information for decision making. Unfortunately, agricultural specialist assistance is not always available when the farmer needs it. In order to alleviate this problem, Knowledge Based Systems were identified as a powerful tool with extensive potential in agriculture [48].

Advisory System is a computer program designed to simulate the problem solving behavior of an expert in a narrow domain or discipline. More over it give advises for none experts to support better decision making. Expert System combines the experimental and experiential knowledge with the initiative reasoning skill of a multitude of specialist to aid users in making the best decisions for their problems [38].

Expert Systems were first used in the mid 1960s. Expert Systems have been developed and applied in many fields [43]. In agriculture, it unite the accumulated expertise of individual disciplines, e.g., plant pathology, entomology, horticulture and agriculture meteorology, into a framework that best address the specific, onsite needs of farmers. Agriculture advisory Systems are developed to give expert opinion to users on specific problems like selection of most suitable crop varieties, diagnosis and identification of plant disorder throughout crop production cycle [34, 46, 47].

1.2 Statement of the Problem

Agriculture is the mainstay of the Ethiopian economy. It accounts for the lion's share of the total GDP in foreign currency earnings and in employment creation. Both industry and services are dependent on the performance of agriculture, which provides raw materials, generates foreign currency. However, the performance of cereal crop yield by far remains weak compared to other countries. In spite of numerous merit and considerable economic significance, wheat and maize are one of the lowest yields of cereal crop in Ethiopia [22]. Yield of these crops under farmer managements is still far lower than what can be obtained under research plot. The national average grain yield of wheat is 21 and of maize is 31 quintals/hectare. However, with proper management of existing improved technology the yield can be increased up to 65 and 80 quintals/hectare [55].

Agriculture in Ethiopia is constrained by technical and socio economic factors. Among the technical factors, (1) shortage of skilled man power that advices poor farmers to increase crop production and productivity, (2) lack of supportive ICT based system which advice investors, farmers and extension workers consistently and on time and (3) poor agronomic practices like use of un-appropriate cultivar, crop diseases and pests are the major contributing factors to the low yield. These problems need sufficient and knowledgeable experts, who provide full fledged agronomic practices and identify the diseases and describe the methods of treatment and protection at early stage of infestation.

According to [22], plant disease which can cause up to 25% yield reduction and insect/pest damage which can cause up to 30% losses, as well as lack of using the right type of improved seed variety are some of the major factors which limit crop productivity. In order to manage these problems and to limit their negative impact on crop production, correct variety recommendation, fertilizer application, symptom identification and rapid diagnosis mechanism is essential.

Almost all Ethiopian farmers rely on information from agriculture extension workers [34]. Currently, there are more than 69, 000 extension workers in the country [46]. They occupy the strategic position in the agricultural production cycle. They mediate between farmers and researchers. The study conducted in 2004 [51,52] shows that the extension workers may not

have adequate knowledge as a specialist. They need refreshment courses from time to time. The few specialists may be unable to devote adequate time to assist them. These extension workers obtain information about crops productions like improved varieties when extension document are distributed [53]. These documents are not easily available and the documents give general recommendation. During this situation the extension workers look for agricultural experts' assistance. But experts are rarely able to devote adequate time to assistance of all requests. Moreover, in many instances response by an expert is too untimely for farmers.

Therefore to minimize or control these problems, there should be some mechanism that increases the availability and accessibility of expertise knowledge to extension workers and end user farmers consistently and on time. One such mechanism is a web based agronomy advisory system which is easily accessible by the extension workers. To the best knowledge of the researcher, there is no web based agronomy advisory system in Ethiopia.

1.3 Objective of the project

1.3.1 General objective

The general objective of this project work is to develop a web based agronomy advisory system which provides agronomic advices starting from pre cultivation to post harvesting for agriculture experts, extension workers and farmers and Agriculture investors.

1.3.2 Specific objectives

To achieve the general objective of the study, the specific objectives are:

- To review literature on the area.
- To asses and understand the existing agronomy practice and methods
- To study implicit and explicit knowledge on types of disease, symptoms and diagnosis techniques of cereal crops.
- To model and represent knowledge acquired from domain experts and codified sources.
- To build prototype knowledge based system which advises agriculture experts, development agents and farmers/ investors.

- To evaluating acceptance of the system using domain users like experts and extension workers.

1.4 Scope of the Study

This research focuses on development of bilingual English and Afaan Oromo language web based agronomy advisory system for wheat and maize crops starting from pre-cultivation to post-harvest.

1.5. Methodology

1.5.1 Data Collection

To conduct the research, data will be collected from different primary and secondary sources. To elicit the required knowledge for this study, purposive sampling technique will be employed. Purposive sampling would be the best way to elicit the views of persons who have expertise and knowledge about specific domain [54]. To acquire relevant knowledge for designing web based agronomy advisory system, interview and document analysis techniques will be employed. Based on thus:

1. Domain experts from Ethiopia Institute of Agriculture Research, Kulumsa and Bako center will be used because these centers have wheat and maize research sites for Ethiopia respectively. Moreover Kulumsa center is wheat research center for Ethiopia as well as East Africa.
2. Ethiopian quality seed development Enterprise: These center produce quality seed for production of maize and wheat. Her we collect information about best crop production methods will be studied
3. Wolkite University School of Agriculture: Here different experienced researcher is available in this domain. So The researcher will collects different data's about scientific application of crop production methods and techniques.
4. As a secondary source, Internet resources, books, training guides and manuals will be used.

1.5.2 Development Tools

To implement the system the following programming language were used: e2gRuleEngine Expert System shell is used to develop knowledge base, e2gRuleWriter decision table software was used to construct the knowledge bases, Java, JavaScript and PHP are used as a programming language, Microsoft Office Visio 2003 for system design, Macromedia Dreamweaver 8 for user interface design, MySQL for database building and Apache web Server to handle clients request from browser.

1.5.3 System Evaluation

To evaluate the system, a survey will be conducted to gather the user evaluation about the system. For this, a set of questionnaires will be prepared that evaluates the simplicity, usability, functionality and interface design used in the system described at Chapter Seven.

1.6 Significance of the Study

The findings of this study will benefit agricultural experts, development agent, farmers and agriculture investors in such a way that they can get easily and timely access to disease identification and recommendation; it can advice other agronomy practices like varieties selection, fertilizer recommendation etc.

Therefore, development agents who assist farmers can consult and access the system to apply different agronomic practices to make appropriate decisions on farmer daily needs.

1.7. Organization of the Report

This report is organized into eight Chapters including the current one. The Second Chapter reviews different literatures regarding wheat, maize crops and Expert Systems with special focus on rule base Expert System. The Third Chapter reviews some of the existing agricultural Expert Systems. The Fourth and Fifth Chapters discuss the requirement analysis and system design respectively. The Sixth Chapter deals with the implementation aspects of the system. The Seventh Chapter discusses system evaluation. Finally, Chapter Eight presents the conclusion and future works.

Chapter Two: Literature Review

The Chapter discusses review of literatures on cereal crops particularly wheat and maize production in Ethiopia. It also presents Expert systems concepts, architecture, knowledge acquisition and representation methods.

2.1. Maize Crop

Currently, maize has gained increasing importance as a major food source within Ethiopia. Maize serves as basic raw material for the production of starch, oil and protein, alcoholic beverages and food sweeteners [23].

To increase the yield of maize different research is done in EIARC and release different maize varieties. There are two types of maize varieties which are open pollinated variety (OPV) and Hybrids [23]. The National Maize Research Project has recommended a number of OPVs and hybrids adapted to different agro-ecology of the country. These varieties of maize include Quality Protein Maize (QPM) and None-QPM. Improved maize varieties give high yield when we apply appropriate recommendation [35].

Maize is able to grow under different agro-ecological conditions; it requires an altitude of up to 2,400m above sea level with a rainfall between 500-800mm to yield higher production. In Ethiopia, maize is a leading cereal crop with main season production totaling 2.9 million tons in 2005/06. In the past year, maize production has, on average, accounted for 25.5% of crop production [23, 24]. Crop utilization survey data shows that from the total national production of maize 76.03% was utilized for household consumption, 0.22% for sale; while the balance was used for seed; animal feed and other [25].

2.2 Wheat

Wheat is one of the most important cereal crops produced in Ethiopia. Ethiopia is the largest wheat producer in sub-Saharan Africa covering about 0.06 million hectares of land by wheat. Wheat grows at altitudes of 600-3,200 meters above sea level with suitable rainfall ranging between 200 and 400mm. Wheat widely grows in southeastern, central and northwestern

parts of the country [23,24].

As one of the major cereals produced in Ethiopia, wheat accounts for 17.5% of major crops production. The grain of wheat crop is used for consumption for food, animal feed and industrial raw material.

There are two major wheat varieties grown in Ethiopia which are: Durum and Bread wheat [23]. Durum wheat is often grown for domestic pasta fabrication. The average national wheat yields of the country is generally considered to be low particularly under farmers circumstance. To improve these problem EIARC release different improved varieties of bread and durum wheat [23, 24]. Currently, 60% of the wheat area is covered by durum and 40% by bread wheat [22].

2.3 Disease and Insect/Pest of Maize and Wheat crop

Many insect pests and diseases have been recorded attacking maize and wheat in the field and in the store in Ethiopia [35]. But only a few are economically important.

The major insect pests that attack maize are: maize stem borers, termites, maize weevils and grain moth and the major diseases are gray-leaf-spot, turicum-leaf blight, common leaf rust and maize streak virus.

The major insect pests that attack wheat crop are: armyworm, aphids and grasshopper and the major diseases are leaf rust, steam rust, yellow rust and septoria.

2.4 Basic Practices of Crop Production

Cultivation of crops involves several activities undertaken by farmers over a period of time. These activities or tasks are referred to as agricultural practices. These activities can be divided into four: pre cultivation, cultivation, harvest and postharvest.

Pre cultivation tasks can be site selection and crop selection while cultivation activities are: preparation of soil, variety selection, fertilizer application, irrigation or watering, protecting from weeds, pest and disease, finally, harvesting and storage [6, 16].

Agricultural crop production has different pre and post harvest activities [2]. These activities are classified into two categories: crop production and crop protection. Major tasks of Crop productions are: farm selection, land preparation, Variety selection, Irrigation or watering and Fertilizer application however, crop protection includes: disease diagnosis and treatment, insect and pest control and weed managements. Scientific application of crop production management called agronomy. Agronomy is basic for increasing productivity and production of the farmers. Pre-cultivation and cultivation decisions are important because they cannot be postponed, are often irreversible. These activities need a substantial allocation of resources, and great impact the farm business for years to come. There for these possible consequences must be considered by using economic and environmental indicators.

2.5. Expert System

According to [3], Expert System is a computer program that contains expert knowledge about a particular problem domain in an explicit and declarative form. A knowledge engineer collects knowledge from domain expert and transfers it into production rules and creates knowledge base. An Expert System operates as an interactive system that responds to questions, asks for clarification, makes recommendations, generally aids the decision making process and it provides expert advice and guidance.

Expert System, Knowledge Based System or decision support system are similar meanings and used interchangeably [4]. Those systems are one of the major family members of the AI group. It can act as an expert on demand without wasting time, anytime and anywhere. With the proper utilization of knowledge, the knowledge based systems increase productivity by capturing scarce expertise and enhancing problem solving capabilities in most flexible way . Such systems also document knowledge for future use and training. This leads to increased quality in problem solving process.

2.6. Approaches of Expert System

There are different methods to translate the acquired knowledge into machine-readable formats. The most popular knowledge representation approach: cases based, semantic network, frame based and rules based approaches.

According to [31], to evaluate these methods the following factors must be taken into account:

- Naturalness, uniformity, and understandability of the representation.
- Degree to which knowledge is explicit (declarative) or embedded in procedural code for further information on implicit/explicit knowledge.
- Modularity and flexibility of the knowledge base.
- Efficiency of knowledge retrieval and the heuristic power of the inference procedure.

2.6.1 Case based Representation (CBR)

Case based reasoning means using old experiences to understand and solve new problems. Case based reasoning can mean adapting old solutions to meet new demands; using old cases to explain and critique new situations or reasoning from precedents to interpret a new situation (much like lawyers do) [6,29]. Case based representations store a large set of previous cases with their solutions in the case library and use them whenever a similar new case has to be dealt with. Case-based representations all concrete cases are kept that might have led to the learning by the experts stick to recording the concrete details of each case without generalizing experience into rules. It avoids the personal influence of individual experts. By pass the expert and look directly at the information that allowed them to learn and acquire their expertise [30]

The main advantages of case-based representations are as follows.

- Naturalness of representation: Cases are a simple knowledge representation method and very comprehensible to the user.
- Modularity: Each case is a discrete, independent knowledge unit that can be inserted into or removed from the case base without any problem.
- Self-updatability: Knowledge in the form of new cases faced during real-time operation can be incorporated into the case base extending the effectiveness of the system. This self-updatability also facilitates the maintenance of the case base.
- Handling unexpected or missing inputs: A case-based system can handle unexpected cases not recorded in the system or missing input values by assessing their similarity to stored cases and reusing relevant cases.

However, according to [29], case based representations are suffered from the following problems:

- Inability to express general knowledge.
- Knowledge acquisition problems: Although knowledge acquisition is not a problem when a sufficient number of cases are available in a domain, various knowledge acquisition problems may arise when dealing with domains where cases either are unavailable or are available in a limited (insufficient) amount;
- Inference efficiency problems: The efficiency of the inference process in CBR is not always as good as desired.
- Provision of explanations: Some kind of explanation can be provided for the conclusions reached, but not in a straight forward manner. It is difficult to explain all reasoning steps.

2.6.2 Semantic Network

A semantic network is widely used as knowledge representation technique. It represents the connection between objects or class of objects. It is composed of nodes and links that show hierarchical relationships between objects. It is a directed graph consisting of vertices which represent concepts and edges which represent semantic relations between the concepts. The advantage of semantic network is easy to follow hierarchy, easy to trace associations and flexible. However, semantic networks have problems in knowledge representation which include: no internal structure of nodes, relationships between multiple nodes is not possible and no easy way to represent heuristic information, meaning attached to nodes might be ambiguous and exception handling is difficult.

2.6.3 Frame Based

Frames are a natural extension of semantic networks. A frame includes all the knowledge about an object. The knowledge in a frame is divided into slots. They consist of sets of slots-filled by values, procedures for calculating values, or pointers to other frames. Frames provide visual context to guide scene interpretation. It tells the program what to look for and where to look for it. Frames can be formalized as a set of relations between entities having certain properties. It is a collection of questions to be asked about a hypothetical situation

and specifies issues to be raised and methods to be used in dealing with them [30]. The advantage of using frame based approach is its expressive power, easy to set up slots for new properties and relations, easy to include default information and easy to detect missing values. Its drawback includes: difficult to program, difficult for inference, lack of inexpensive software.

2.6.4 Rule based Expert System

Rule-based expert system is an expert system which works as a production system in which much of the knowledge is represented as rules, that is, as conditional sentences relating statements of facts with one another [1,10]. In a typical rule-based expert system, a rule consists of several premises and a conclusion. If all the premises are true, then the conclusion is considered true. [6, 29] describes the main advantages of rule based representations as follows.

- Compact representation of general knowledge: Rules can easily represent general knowledge about a problem domain in autonomous, relatively small chunks;
- Naturalness of representation: Rules are a very natural knowledge representation method, with a high level of comprehensibility, since they look like natural language expressions. Rules can emulate the expert's way of thinking in many application domains;
- Modularity: Each rule is a discrete knowledge unit that can be inserted into or removed from the knowledge base, without having to take care of any other technical detail (as long as other rules are not affected). This characteristic grants flexibility during the development of rule-based systems, because it enables incremental development of the knowledge base as well as partial testing.

However, according to [29], the following are the main disadvantages of rule based knowledge representation:

- Knowledge acquisition bottleneck: The standard way of acquiring rules through interviews with experts is cumbersome and time consuming. The chief reasons are the inability of an expert to express his or her knowledge and the unavailability of experts.

- Brittleness of rules: It is not possible to draw conclusions from rules when there are missing values in the input data. For a specific rule, a certain number of conditional values must be known in order to evaluate the logical function connecting its conditions. In addition, rules do not perform well in cases of unexpected input values or combinations of them.
- Inference efficiency problems: In certain cases, the performance of the inference engine is not the desired one, especially in very large rule bases.

2.7 Rule Based System Architecture

The first rule-based Knowledge Based Systems were tightly integrated with the specific application they were developing for. Thus, new rule based system had been written from the scratch. The EMYCIN, a derivate from MYCIN (ES for diagnosis and therapy selection for bacterial infections of blood) was developed as a generic frame work for rule based systems, without the domain knowledge of the MYCIN. It was the first of its kind. This approach of developing a framework without a domain specific knowledge is followed by most modern rule-based systems.

Rule-based Knowledge Based System has four main components: working memory, knowledgebase, inference engine and user interface. The architecture is depicted at Figure

2.1

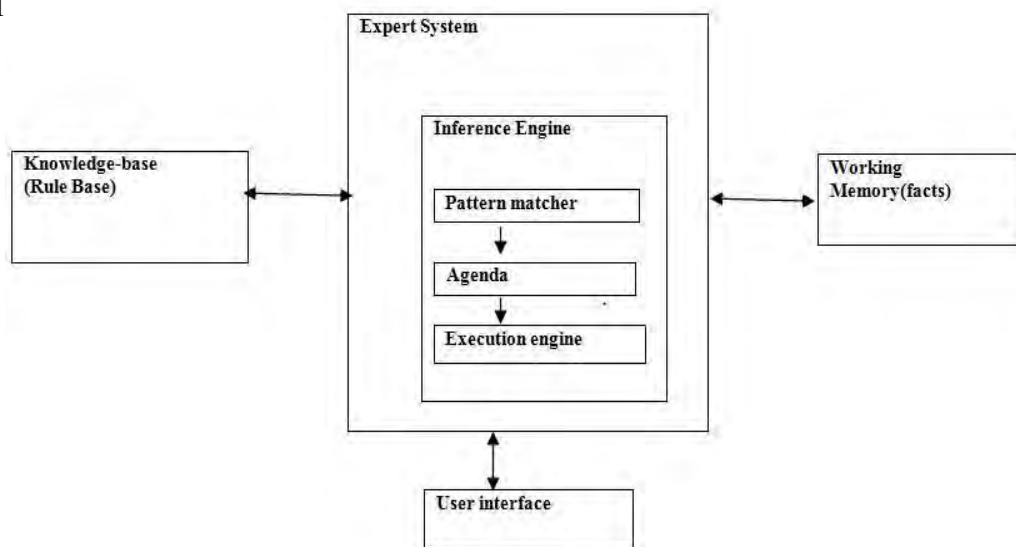


Figure 2.1The architecture of rule-based Knowledge Based System [1]

A. Working memory

The working memory (WM) represents the set of facts known about the domain. The facts are task –specific data for the problem. The contents of WM changes based on problem situation and it is the most dynamic component of Knowledge Based System. WM is used by the inference engine to get facts and match them against the rules. The facts may be added to the WM by applying some rules.

B. Knowledge Base

The knowledge base is one of the components which consist of problem-solving rules, procedures, and intrinsic data relevant to the problem domain. In rule based Knowledge Based Systems, Knowledge base is also called production memory; rules are in the form of if-then productions.

C. Inference Engine

As the name implies the inference engine makes inferences. It decides which rules are satisfied by the facts, prioritizes them, and executes the rule with the highest priority. It controls the whole process of applying the rules to the working memory to obtain the outputs of the system. According to [1, 10], an inference engine works in discrete cycles as follows:

- All the rules are compared to the working memory (using the pattern matcher) to decide which ones should be activated during this cycle. This unordered list of activated rules, together with any other rules activated in previous cycles, is called the conflict set.
- The conflict set is ordered to form the agenda—the list of rules whose right-hand sides will be executed, or fired. The process of ordering the agenda is called conflict resolution.
- To complete the cycle, the first rule on the agenda is fired (possibly changing the working memory) and the entire process is repeated. This repetition implies a large amount of redundant work, but many rule engines use sophisticated techniques to avoid most or all of the redundancy. In particular, results from the pattern matcher and from the agenda’s conflict resolver can be preserved across cycles, so that only the essential, new work needs to be done.

There are two types of inference: forward chaining and backward chaining [1, 10]. In

forward chaining the initial facts are processed first and keep using rules to draw new conclusions. While in a backward chaining, the hypothesis (or solution/goal) we are trying to achieve is processed first, and keep looking for rules that would allow concluding that hypothesis.

Pattern Matcher: helps the inference engine to decide which rules to fire and when, by matching the current contents of the working memory.

Agenda: a component that helps to store fired rules. It is responsible for using the conflict strategy to decide which of the rules, out of all those that apply, have the highest priority and should be fired first. Finally, once your rule engine decides what rule to fire, it has to execute that rule's action part.

Execution engine is the component of a rule engine that fires the rules based on the priority in the agenda.

2.8 Knowledge Based System features

In addition to working memory, knowledgebase, inference engine and user interface, features which commonly exist in Knowledge Based Systems are coping with uncertainty and explanation

2.8.1 Coping with Uncertainty

This refers to the ability of the system to reason out the probability that an event (or fact) is true or false with rules and data which are not precisely known. For Knowledge Based Systems to work in the real world, they must also be able to deal with uncertainty. Approaches used to handle uncertainty vary from system to system based on the type and cause of uncertainty. There are two types of uncertainty that we have to capture in rule based system [10, 32]. These are uncertainty in the data and uncertainty in the rule. Knowledge Based Systems typically use shallow reasoning using thumb rules or heuristics provided by the expert. These rules are not guaranteed to be correct always, which cause rule uncertainty. In most complex decision making processes, all the required information may not be accessible when required. Decisions have to be taken without knowing all the relevant parameters. This is called uncertainty with data.

2.8.2 Explanation

This refers to the ability of an Knowledge Based System to clarify its reasoning, recommendations, or other actions (e.g., asking a question). In rule based Knowledge Based System explanation is usually associated with a way of tracing the rules that are fired during the course of a problem solving session. There are two types of explanations that are used to explain the reasoning process to give recommendations [31, 32]. These are Why and How explanation. That is why a particular question is being asked and how the system came to a particular conclusion.

Asking Why?

When the system asks the user, the user may ask “why you ask me this?” at this time the system explains the reason to the user by telling the goal of the question.

Example: In medical expert system which identifies heart disease may ask the user “is the patient pregnant?” the user may say why you ask me this?”. The system then starts to explain that it is needed to confirm the possibility of heart disease in the context of the evidence available.

The medical knowledge used in defining a rule for heart disease is the following: patients with certain types of heart disease may exhibit, as one of their symptoms, a swelling of the feet. However, this symptom is also common in pregnancy.

So, the question “Is the patient pregnant?” is used to distinguish patients who have swelling feet due to cardiac problem, from those who exhibit this symptom because of pregnancy.

Asking How?

When the expert system reaches some decision, the user may ask the system, “how this conclusion is derived?”. This helps the system to explain the reasoning process and generally the problem solving strategies or how a certain conclusion or recommendation was reached by listing the sequence of rules fired to arrive at the conclusion [31].

2.9 Phases of Expert System Development

Expert system development has 3 phases: knowledge acquisition, knowledge representation and evaluation

2.9.1 Knowledge Acquisition

Knowledge acquisition is the process of obtaining facts and rules from the domain expert so that the system can draw expert level conclusions. The process of knowledge acquisition is difficult especially if the knowledge engineer is unfamiliar with the domain. There are two major sources for knowledge acquisition: experts and documents such that it extracts from an extensive literature review through related books, reports, projects and published papers. Knowledge acquisition includes identifying the knowledge, representing the knowledge in a proper format, structuring the knowledge, and transferring the knowledge to a machine. The process of knowledge acquisition can be greatly influenced by the roles of the three major participants: the knowledge engineer, the expert, and the end user [10, 31]. knowledge engineering processes depicted at Figure 2.9

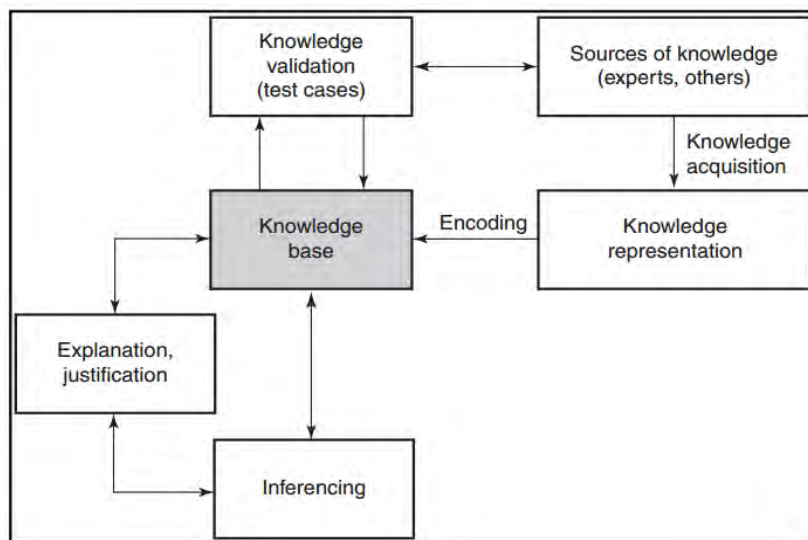


Figure 2.9 knowledge engineering processes

2.9.2 Knowledge Representation

After the domain has been identified and knowledge acquired from experts, a model for representing the knowledge must be developed for understandable by humans and executable on computers. There are many different methods for knowledge representation as described in part 2.4.

2.9.3 Evaluation

When the knowledge engineer and the expert are satisfied that the Knowledge Based System is complete, the system should be evaluated against agreed upon performance criteria. At this time other users can be invited to evaluate and use the system for testing purposes. Either the real-world case scenarios or simulated cases can be used for testing purpose [31].

According to [55], there are no universal acceptance standards for the evaluation of Expert System. However, there is a set of points that might be considered during evaluation. Issues that should be considered in evaluation are:

- Is the system user friendly and do the users accept the system?
- Does the system give correct result and is the logic of the system correct?
- Does the ES offer an improvement over the practices it is intended to supplement?
- Is the system easy to learn?
- Is the system useful as a training tool?
- Can the system be used in the intended work environment?

2.10 Integrated Knowledge Based and Database Management System

The integration of artificial intelligence (AI) and data base technologies has a new class of information systems capable of powerful and efficient knowledge based processing, called Knowledge Based Management System (KBMS). A major reason for the integration of these two technologies: the system providing highly effective management of large shared knowledge, the potential for enhancing the capabilities of AI systems with database features.

A simple knowledge based system stores most of the relevant data in main memory while processing its applications. However, as these systems grow in size and the expertise domain expands, it becomes necessary to store the data in a secondary storage such as an external DBMS. The facilities provided by the DBMS in terms of data management, concurrent access, and query optimization provide robustness for the KBS to handle large volumes of knowledge. Also, this provides flexibility for the KBS to access a central DBMS that is used for other applications in the organization. Deductive databases with enhancements to access

an external device are common examples of extension of KBS capabilities using the DBMS features [17,19].

Two basic approaches to integrate the two systems: KBS-DBMS tight coupling and KBS-DBMS loose coupling [17].

2.10.1 KBS - DBMS Loose coupling:

This approach is an attractive way of increasing the utility of an existing DBMS through enhancing its capability using a KBS or linking a KBS to a large DBMS, thereby providing an extensive knowledge base for the KBS system. The coupling process consists of a pre compilation mechanism in the KBS system, where requests for data are collected as a part of the deduction process. The collected database calls are optimized based on past history, recognition of common sub-expressions in the current queries and simplification. The optimized query is then translated into DBMS query language, executed by the DBMS, and the answer is sent to KBS.

2.10.2 KBS - DBMS Tight coupling:

The major difference between the loose and tight coupling approach is that in loose coupling, the data is retrieved from DBMS through a communication channel and stored as a “snapshot” in the KBS database and hence is static, while tight coupling provides dynamic data extraction. Tight coupling between KBS and DBMS supports dynamic access and the communication channel is open during the KBS operation. It is normally implemented when any of the following conditions exist: There is a high degree of volatility in the data stored in DBMS, there is a necessity for dynamic retrieval of data, and the KBMS is very sensitive to changes in the data stored in DBMS. Data integrity and there are substantial gains in efficiency by integrating the two subsystems.

2.11 An Agent Based Approach to Expert System explanation

This approach satisfies the addressed explanation goals, achieved knowledge re-usability, and modularity. Explanation has played a significant role to address the needs of an end user interest in learning more about the domain.

Distributing the explanation problem among a number of independent agents such as the domain justification agent, why agent, media manager agents, the Knowledge Based System agent and The GUI agent [23]. These agents have various advantages such as knowledge sharing and reusability.

Agent Task distribution

Explanation has two different phases: The dialogue phase and problem solving phase [23].

The dialogue phase, the system interacts with the user in order to collect observations/symptoms regarding a problem. Explanation that can provide definitions and illustrate the relevance of a question must be provided in this phase.

Problem solving phase, the user may want to understand the domain justification for the given conclusion. This phase provides knowledge about domain terminology and abstractions, as well as global domain information on the various terms such that queries in the form of "Tell me more about X" , –Why are you asking me about X?". These tasks solve the explanation problem from a domain oriented perspective.

2.12 Recommender System

Recommender systems [42] are a subclass of information filtering system that seek to predict the rating or preference that user would give to an item. It is a useful alternative to search algorithms since it help users to discover items they might not have found by themselves. It become extremely common in recent years, and applied in a variety of applications. The most popular ones are probably movies, music, news, books, research articles, search queries, social tags, and products in general. Recommender systems produce a list of recommendations using two approaches:

- **Collaborative filtering:** this approaches building a model from a user's past behavior (items previously purchased or selected and/or numerical ratings given to those items) as well as similar decisions made by other users; then use that model to predict items (or ratings for items) that the user may have an interest in.
- **Content-based filtering** : this approaches utilize a series of discrete characteristics of an item in order to recommend additional items with similar properties

Chapter Three: Related Work

Since 1980s, Expert System application has spread into crops cultivation management, plant disorder diagnosis and other production aspects. This Chapter presents some of the Knowledge Based Systems developed for cereal crops.

3.1 EXOWHEM: Expert System on Wheat Crop Management

EXOWHEM [33] has been developed in the Indian Agricultural Research Institute. The system holds a collection of general principles that are potentially applied to solve a problem related to wheat crop management and is capable to extend expert advice to the researchers and wheat-growing farmers.

This system has been used for variety selection, plant protection, cultural practices and one module for knowledge management. Variety selection module specifies the variety from the farmer's point of view. Plant protection module is subdivided into pathological aspects, entomological aspects. In pathology, the system identifies micro diseases such as leaf rusts, blights and bunts etc. In entomology, the system identifies pest / insects affecting plants and recommends control measures. The cultural practices module specifies the process of cultivation of the crop. The developed system extends the research done on the wheat crop to the farmers in effective way to help in getting instant solution to the problems faced by them. It encourages the dissemination of research findings and helps farmer's where services of the experts are not available. It reduces the load from the experts and facilitates qualitative research on wheat supported by the knowledge base in the system.

3.2 Expert System Development for Teff Variety selection and Disorder

Diagnosis

This Expert System [34] presents variety selection and disorder diagnosis for teff crop in Ethiopia. The system has three sub systems:

- Variety selection sub system

This subsystem helps users to select appropriate teff varieties which reflect their agro ecological zone and the interests of the farmer.

- Disorder diagnosis :

This subsystem provides the user with a diagnostic disorder which is caused by insect and

disease problems on the production of the crops.

- Disorder treatment:

This subsystem provides the user with the remediation of disorders after being verified or identified by the diagnosis subsystem. Finally, the system recommends possible measures to be taken.

3.3 A Web-based Expert System for Diagnosis of Diseases and Pests in

Pakistani Wheat

This Expert System is designed using rule-based approach [4]. It covers two main classes of problems namely diseases and pests normally encountered in wheat crop. The problem here is a diagnostic problem aimed to identify ailments in the wheat using symptoms of diseases and pests. Diagnostic problem solving is the process of understanding what is wrong in a particular situation. Thus, gathering of information and then interpreting the gathered information for determining what is wrong are of central importance in diagnostic problem solving [4].

The system is it considers only disease and pest disordered of Pakistan wheat. It does not consider other agronomy practices that are required in wheat crop production.

3.4 Barley Expert System

The development of barley Expert System for plant protection was developed in collaboration with international center for agriculture research in dry area (ICARDA) in 2003 [33]. The system contains four modules.

Variety selection module: The input parameters identified by the domain expert are plant height, row type, and the pests that the varieties need to be resistant to. So, the only output is the varieties selected.

Cultural Practice: The cultural practice module covers 7 pest classes with a total of 38 pests. Once the user chooses certain pests, the system responds by giving the cultural practices needed to be done as a preventive measure to inhibit their appearance.

Pest identification modules: The first thing that the system requests as input from the end user is the growth stage. The system covers the 8 growth stage of barley. If the user chooses one stage, say flowering the system displays a screen that contains primary observation on

plant, leaf and grain. Entering the primary observation, the suspected cause is displayed.

Pest control module: The pest control module covers the same number of pests covered by the cultural practices module. The difference is that this module is used when a disorder appears and the pest that causes this disorder is diagnosed. For example, if leaf rust is diagnosed, the system asks first about the percentage of infected plants, the available pesticide, and then gives the recommendation.

3.5 A Web Based Decision Support System for Durum Wheat

According to [9], a web-based, interactive DSS for crop management of high-quality durum wheat in the Po Valley (North Italy) is described. This DSS incorporates solutions for overcoming possible obstacles for its practical use for crop cultivation problems. The DSS for cropping high-quality durum wheat embraces the concept of the integrated approach in designing multidisciplinary decision support systems. This DSS takes into account and provides decision supports for the major elements of the production chain, from strategic choices to tactical operations. The system has strong focus on disease diagnosis and treatment in case of durum wheat in the Po Valley region, Italy.

The system considers both static-site profiles and site-specific information (data) are viewed as flowing from the environment via instrumented sensors to a database as shown in figure 3.5. The information is manipulated, analyzed, and interpreted through comparison with available expert knowledge as part of the decision process. The information is processed for producing a decision support. The decision itself is the responsibility of the user, and the DSS is not designed to replace the decision maker but to help in making choices by providing additional information. A decision results in an action to be executed within the crop environment. After the action is carried out, the environment is again monitored to begin a new cycle of information flow. Thus, information flows to and from the environment in an endless loop that begins with sensing and ends with action. The DSS provider also manages the network of weather stations and of control crops, which provide input data for the DSS. The users of the DSS are the client enterprise that stipulates an agreement with the provider for accessing the DSS.

The DSS described in this work was designed to overcome the problems that are usually limit in durum wheat crop management. The management solutions to be addressed includes: the pre-cultivation strategic choices, the tactical decisions made during the cultivation phase (including harvest), and several post-harvest decisions [9].

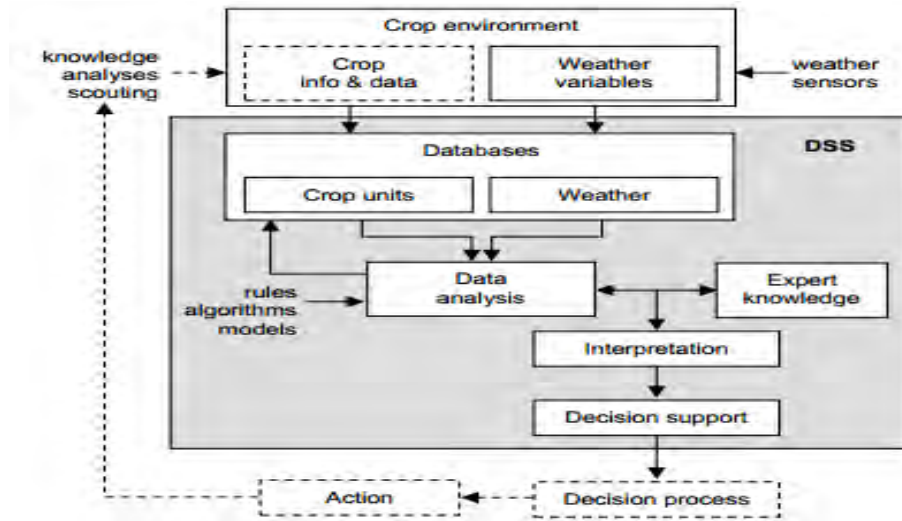


Figure 3.5 Conceptual diagram of the DSS for durum wheat cultivation (9)

3.6 Knowledge model-based decision support system for maize management

According to [8], the relationship between crops and circumstances, a dynamic knowledge model for maize management with wide applicability was developed using the system method and mathematical modeling technique. With soft component characteristics incorporated, a component and digital knowledge model-based decision support system for maize management was established on the Visual C++ platform. This system includes five sub models: target yield calculation, design of pre-sowing plan, and prediction of main regulation indices, real-time management control and production economic benefit analysis. Among them, the design of pre-sowing plan. The prediction of main regulation indices includes four sub models of suitable leaf age indices development, colony leaf area indices dynamic, and colony dry matter accumulation curve and source-sink indices as a ratio of total grain number or grain weight to leaf area. In terms of analysis of production benefit, expenditure of labour, material and financial resources throughout the whole growth process,

yield and price of maize are included [8]. The paper demonstrates yield prediction and some other agronomy activities for maize production in the cultivation stage.

3.7 Expert System for Wheat Yields Protection (ESWYP)

This Expert System diagnoses insect pests that can harm wheat crops. ESWYP is a system that enables the farmer to classify insect diseases.

Diagnose of the insect pests is a complex and sensitive task, and can only be performed by an expert of the agriculture sciences. ESWYP Knowledge Based System is designed to imitate the agricultural experts for insect pest problem diagnoses, and to enable a computer to behave like an agricultural expert to discriminate the type of pests began to affect the wheat crops and then advice the best treatment for it. The system also provides a reasoning facility that enables the user to look into the diagnoses and treatment details. It is a desktop application developed using MATLAB and SQL server [56].

3.8 NEPER: a multiple strategy wheat Expert System

This paper presents a methodology for developing a multi strategic Expert System for wheat crop production, which has been developed using a Multiple Design approach. This Knowledge Based System consists of: variety selection, land preparation, sowing, irrigation, fertilization, and harvest. These subsystems exchange data between them through a common database. Each subsystem advises wheat growers on the corresponding plan(s), comprising a set of agricultural/chemical operations before or during the growing season [14]. A knowledge acquisition form was designed to acquire the knowledge related to agricultural operations used in the system. The items in this form corresponding to the operation properties such as operation name, operation no. operation date, operation category, after the knowledge acquisition forms were completed from different experts, the knowledge engineers analyzed them and discussed their contents with domain experts to get their feedback, and complete the missing knowledge [14].

NEPER Expert System was implemented using Generic Task tool, which was built using Smalltalk language. This tool runs under Visual Works environment. It consists of three

components, namely database, agent hierarchy, and table matcher. Four types of database were developed: farm data, soil and water data, equipment data, and fertilizer data.

It has a graphical user interface that facilitates the development of expert system. The tool contains three problem solvers, namely: Routine Design, Hierarchical Classification, and Picture Classification. The Routine Design was used in developing the Strategic NEPER Expert System and it consists of three components, namely database, agent hierarchy, and table matcher. These components enable the expert systems developers to develop their expert system. The database component is used to define the required attributes, which are classified into three groups (input, intermediate, and output groups) according to their use in the system. The input attributes are used to get the required values during running NEPER from the system users. The intermediate attributes are used to store the intermediate results during NEPER reasoning. The Output attributes are used to store the final conclusions of the NEPER wheat expert system, which are displayed to the users. As shown in Figure 3.8 Four types of database were developed: farm data, soil and water data, equipment data, and fertilizer data.

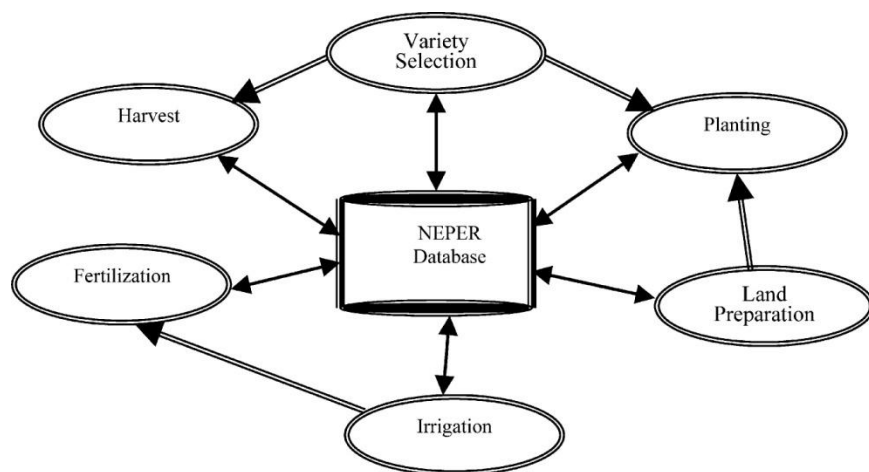


Figure 3.8 NEPER overall structures.

3.9 Expert System to Detect and Diagnose the Leaf Diseases of Cereals (Wheat, Maize and Rice)

This web based Expert System [57] is used for the registered user to update the necessary information regarding the leaf diseases of the cereals. New disease names, symptoms, precautionary measures and new images of the existing cereals as well as new cereals can

also be added. The users are authorized to view the names, symptoms, precautionary measures and images of the leaf diseases textually in case they do not have the images. The user can also upload an image of the infected cereal leaf to view the disease name, symptoms and precautionary measures. The user uploaded image is compared with the images in the database of the Knowledge Based System through the image comparison algorithm. In case the user does not find the result through image uploading, he can send that image to the administrator.

This Knowledge Based System will use the colored images of the defected cereal plant leaves as well as the textual input to identify the disease. It will enable users/ farmers to identify any disease, makes the right decision and chooses the right treatment.

3.10 Expert Systems Implemented at CLAES:

The Central Laboratory for Agricultural expert Systems (CLAES) is helping farmers throughout Egypt optimize the use of resources and maximize food production. Some of the Knowledge Based Systems developed at CLAES are:

- Citex: An Knowledge Based System for Orange Production
- Cuptex: An Knowledge Based System for Cucumber Crop Production
- Tomatex: An Knowledge Based System for Tomatoes

3.10.1 Citex, Cuptex and Tomatex

These systems provide the following services:

- Assessment of a Farm
- Irrigation Scheduling
- Fertilization Scheduling
- Disorder Diagnosis
- Disorder Treatment

Assessment of a Farm: The Assessment Subsystem: This subsystem has two functions. The first one is to evaluate a new farm in a given location for determining the possibility of cultivating citrus in it (a feasibility function). The second function is to evaluate a given farm that is already cultivating citrus in terms of its productivity and to give

recommendations concerning how to improve its conditions to get more yield.

Irrigation Scheduling: The Irrigation Subsystem: The main goal of this subsystem is to produce a schedule for irrigation of a particular farm. An irrigation schedule should demonstrate the water quantity related to each time instance. The calculated water quantity should also be adapted according to some farm characteristics such as intensity of plants, efficiency of drainage system, etc.

The Fertilization Subsystem: The main goal of the fertilization subsystem is to determine the fertilization requirements for the citrus crop. Fertilization requirements include several aspects such as the fertilizer's type, quantity, the fertilizer's application method, and the intervals between applications.

Disorder Diagnosis: The Diagnosis subsystem: This subsystem performs two primary functions. First, it concludes the causes of user complaint. Alternatively, it can verify/reject a user assumption if the user suspects a given disorder(s) and wants to obtain a treatment. This subsystem takes into account the possibility of a plant being infested with more than one disorder at a time, and so the user can select more than one value for an attribute of an observation. The system can conclude the causes of all user complaints in one session.

Disorder Treatment Subsystem: The purpose of this subsystem is to provide the user with appropriate treatment for the infected plants[20,37,36].

3.11 Summary

This Chapter discussed various Expert Systems especially on maize and wheat crops. The Expert Systems that are reviewed are designed for specific regions or countries because crop and disease managements are different from country to country. Moreover, within a country, disease/pest managements are different from area to area. Expert Systems which are reviewed like multiple strategy wheat Knowledge Based System (NEPER) and A Web-based Decision Support System for managing durum wheat crops can advice users from pre cultivation to post harvest. However, these systems cannot be tailored to customize for our specific need and they are expensive to buy. Some Expert Systems, which are freely available, can support only disease management for wheat or maize crops.

Most of the related works follow rule based architecture which is designed by EMYCIN which is described as part 2.7. Some of the related works like NEPER use data base application with three tire architecture will be used.

Hence, this work focuses on developing bilingual English and Afaan Oromo web based agronomy advisory system for wheat and maize crops. The architecture of this system is designed by integrating rule based architecture with data bases. Moreover, we used four tire architectures [39]. This integration allows the knowledge base system to be robust to support large size data and it improves its performance.

Web based agronomy advisory system can give advice for any type of crops if the administrator provides proper information to the system database.

Chapter Four: Requirements Analysis

This Chapter discusses the functional and non- functional requirements of the system and the system models (use case model, sequence diagram and activity diagram) of the system.

4.1 Functional Requirements

Functional requirement is an area of functionality that the system must support. It describes the interactions between the system and its environment independent of its implementation. The environment includes the user and any other external system which the system interacts. It also describes the specific functions and tasks of the system. The functional requirements that are supported by a web based agronomy advisory system derived from domain experts from Ethiopia Institute of Agriculture Research Centers, Ethiopia Quality Seed Enterprise and WKU moreover we use different literatures and research works, that are stated in part [2.4]. In light with this, the developed system is expected to provide the following functionalities:

- **Identify pre cultivation activities:** These activities are basic for effective crop production. The farm business profitability primarily depends on appropriate site selection. These are selection of soil types and selection of altitude of the area [2, 6]. Crops grow at different soil type and different altitudes, hence to increase production and productivity of a crop the farmers need to give great attention for site selection.
- **View farm preparation details based on specific crop:** according to [6,16,24] farm preparation means preparation of the soil to make ready planting of the crop. Thus includes ploughing and tillage operation , identifying spacing between plant and between rows , need to know how much to plant , when to plant, how to plant and amount of seed that need per hectare for specific type of crop production
- **Recommend Variety based on user need:** Ethiopia institute of agriculture research releases different varieties. Thus varieties have released based on adaptation of different agro ecologies of the country, resistant to major disease that attack the crops, giving high yield per hectare and early maturing varieties.

Hence this WAAS allows the user to recommend best varieties based on the stated criterions.

- **Recommend fertilizer dose based on cultivar:** quality seed give high yield when a farmer uses the recommended managements properly. Hence, fertilizing of a soil is one of a component to get high yield of production. According to [16, 24] Different crop types need different fertilizer type, amount and methods of application.
- **Identify wheat and maize disease that causes crop disorder:** crop yield highly reduced by disease. According to [22], crop disease can reduce yield up to 25%. To minimize the negative impact of these problems both prevention techniques and control measures will be employed, like use of resistant varieties and use of chemicals should be considered.
- **Identify weed that occur in the field:** crop yield highly reduced by weeds [22]. To minimize the negative impact of these problems control measures will be used before and after planting. Like use of hand weeding if labor available around the farm and use anti weed chemicals that are recommended by the domain experts.
- **View insect/pest detail:** insects and pests can reduce yield up to 30% [22], To minimize the negative impact of these problems both prevention techniques and control measures will be employed like use of resistant varieties and use of chemicals should be considered.
- **Provide recommendation to control and prevent the identified maize or wheat disease, insect/pest and weed.**
- **Identify harvesting, view storage condition based on crop types:** according to [16], more than 10% of crop yield loses at the time of harvesting. So that the farmers need to know when and how to harvest their crops to minimize the loses. There are different agents like rodent, weevils that attack storage. These rodents closely follow up to minimize storage lose. The store keepers need to use the recommended prevention and control techniques.
- **Allow updating the Knowledge base**

4.2 Non functional Requirements

This describes user-visible aspects of the system that are not directly related with the functional behavior of the system. Non-functional requirements include quantitative constraints [39] Usability, performance, reliability, maintainability, security etc...

❖ The system should be easy to use.

Usability is the easiness of the system a user can learn to operate, prepare inputs, and interpret outputs of system or component. To insure usability of the system there are:

- Well-structured user manuals included at help menu
- Informative error messages
- Well-formed graphical user interfaces

❖ Reliability

Reliability is the ability of a system to perform its required functions under stated conditions for a specific period of time.

Reliability of a deployment patterns represent proven design solutions to common reliability problems. The most common approach to improving reliability is to use a failover cluster to ensure the availability of the application [39], even if a server fails. A failover cluster is a set of servers that are configured in such a way that if one server becomes unavailable, another server automatically takes over for the failed server and continues processing. Figure shows 4.1 failover clusters.

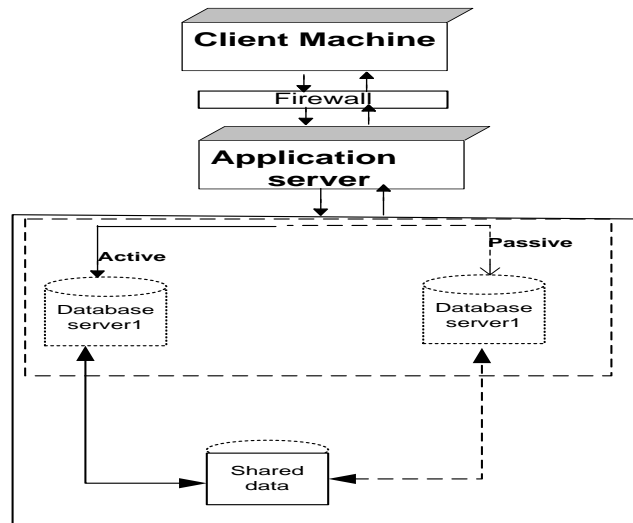


Figure 4.1: Replication of database server adapted from

❖ **The system should be available all the time.**

This WAAS is available 24 hours and 7 days in a week by replicating both the application and the database server. This replication guarantees availability there is any failure of one of the server, as shown figure 4.1 and 4.3.

❖ **Robustness**

The web based agronomy advisory system has the ability to cope with errors during execution like negative and positive numbers, text inputs. More over the system continues operating despite abnormalities in input and in case of single application failure.

❖ **The system should produce results within acceptable time.**

To process the user queries at reasonable time we integrate the kbs system with data bases as described part 2.10. More over load balancing strategy mechanisms will be employed. This is usually referred to as a load-balanced cluster or, in the case of Web servers, a Web farm [39]. It is Installed the service or application onto multiple servers that are configured to share the workload, as shown in Figure 4.2. This type of configuration is known as a load-balanced cluster.

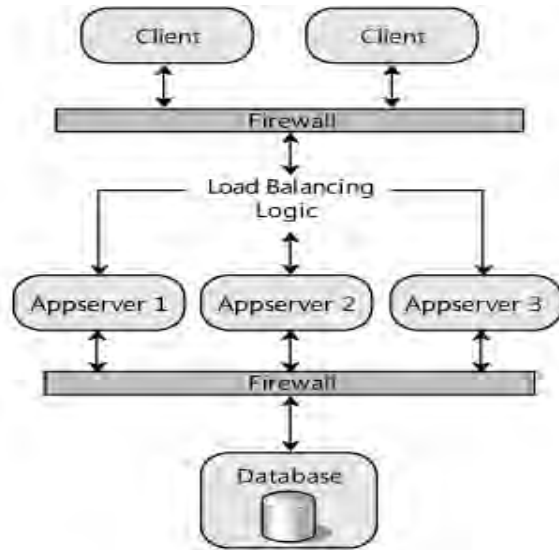


Figure 4.2: Load balancing adapted from [39]

According to [39] , Load balancing scales the performance of server-based programs, such as a Web server, by distributing client requests across multiple servers. Load-balancing technologies, commonly referred to as load balancers, receive incoming requests and redirect them to a specific host if necessary. The load-balanced hosts concurrently respond to different client requests, even multiple requests from the same client. For example, a Web

browser might obtain the multiple images within a single Web page from different hosts in the cluster. This distributes the load, speeds up processing, and reduces the response time.

Depending on the routing technology used, it may detect failed servers and remove them from the routing list to minimize the impact of a failure. In simple scenarios, the routing may be on a round robin basis where a DNS server hands out the addresses of individual servers in rotation. Figure 4.3 illustrates a simple Web farm (a load-balanced cluster of Web servers) where each server hosts all of the layers of the application except for the data store.

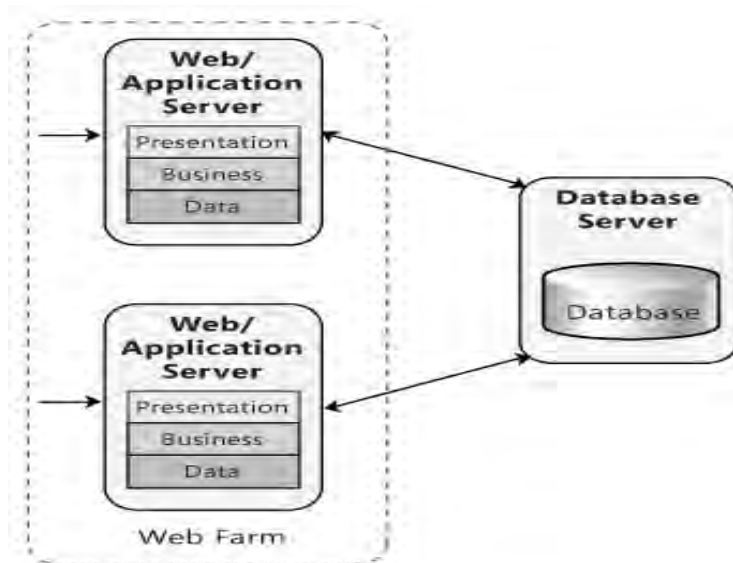


Figure 4.3 Redundant web/ application servers

According to [41], there are about 670 rural woreda in Ethiopia. We may have one active user in each woreda. There will probably at most be 100 or more concurrent requests being made at the same time. This request can be easily handled by MySQL database. Hence maximums user range of MySQL database is 4,294,967,295 (e.g. $2^{32} - 1$) [45]. More over to increase the performance scaling up and scaling out techniques will be employed.

- ❖ **The system should be easy to incorporate additional knowledge in the system.**

The knowledge base integrated with database to make the system easy to change. Hence, the authenticated user can modify by adding, removing and updating the system.

- ❖ **The system should allow access to authorized person only.**

The system authenticates the authorized persons to manage the system. The administrator requires his/her own password and user name. More over to make the system secure web server is physically separated from the application server as shown in figure 4.4. This is often done, where the Web server is deployed into a perimeter network and accesses the application server located on a different subnet. In this scenario, it possible to implement a firewall between the client and the Web tier, and another firewall between the Web tier and the application or business logic tier [39].

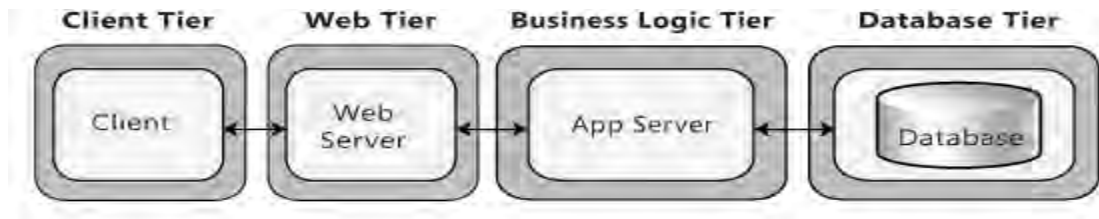


Figure4.4 the business logic on separate tiers [39]

4.3 System Models

System models consist of use case diagram, class diagram, sequence diagram and activity diagram.

4.3.1 Use Case diagram

The above functional requirements can be expressed within the “Use-Case Model”, for better understanding of requirements elicitation. The main concepts of use case modeling are actors and use cases. An actor represents an entity (human or may be system) external to the system which communicates with the system in order to achieve certain goals. On the other hand, use case describes the functionalities and a sequence of actions that provides something of measurable value to an actor. Figure 4.3.1 shows the use case diagram of the system.

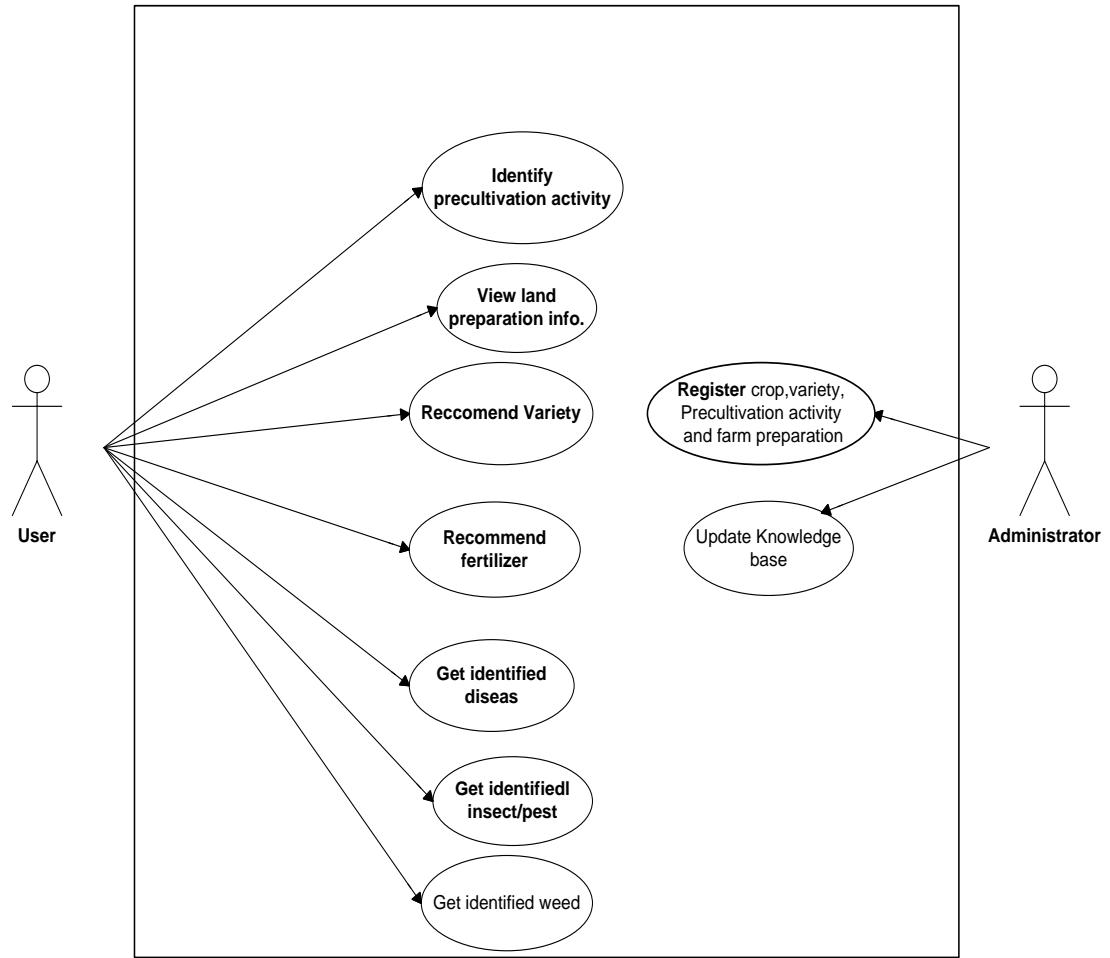


Figure 4.3.1: Use case Diagram

The next part describes the actors and flow of events for each use-case for the above use case Diagram

Actor Descriptions

Name: User

Description: A user is a person who uses the system

Name: Administrator

Description: An Administrator is a person responsible to update the system domain knowledge and insert new data to the system

Use case description

This explains how the functionalities precede using natural language in a stepwise manner to accomplish the identified use cases

Use Case Name: Get Identified pre-cultivation activity

Actor: User

Description: To identify pre-cultivation activities and view detail

Precondition: The user should know the website address of the system

Flow of Events:

1. The user selects pre-cultivation hyperlink.
2. The system requests users to enter crop-type.
3. The system displays recommended agro ecology areas and potential varieties.
4. The use case ends.

Post-condition: the user will see the potential list of varieties and altitude appropriate to cultivate the crop

Use Case Name: View detail of land preparation

Actor: User

Description: To identify land preparation activities based on selected crop

Precondition: The user should know the website address of the system

Flow of Events:

1. The user selects preparation of farm hyperlink.
2. The system requests users to enter crop-type
3. The system displays recommended farm preparation activities
4. The use case ends.

Post-condition: the user will see farm-preparation activities based on crop type

Use Case Name: Recommend fertilizer

Actor: User

Description: To identify fertilizer application based on selected crop type, altitude and variety

Precondition: the user should know the website address of the system

Flow of Events:

1. The user selects fertilizer application hyperlink.
2. The system requests to click consult in the main window.
3. The system request series of questions to answer.
4. The user response all questions
5. The system displays the fertilizer application activities
6. The use case ends.

Post-condition: the user will see dose of fertilizer and application methods

Use Case Name: Recommend variety

Actor: User

Description: To identify potential variety based on selected crop type, altitude and maturity-day, maximum yield

Precondition: the user should know the website address of the system

Flow of Events:

1. The user selects variety selection hyperlink.
2. The system requests users to select crop type, altitude and maturity-day and Maximum yield.[A]
3. The system displays recommended varieties and their basic characters.
4. The use case ends.

Alternate Flow:

3A: user failed to select crop type, altitude and maturity-day or maximum-yield.

1. System displays “please select crop type, altitude and maturity-day and Maximum yield.” error message
2. The system returns to normal flow step 2 and continue.

Post-condition: the user will see potential varieties and their characters.

Use Case Name: Get Identified weed view detail

Actor: User

Description: to identify weed occurred in the farm and management activities.

Related Use Cases: View recommendation

Precondition: the user should have address of the website.

Flow of Events:

1. The user selects weed-management hyperlink.
2. The system requests to click consult in the main window.
3. The system request series of questions to answer.
4. The user response all questions
5. The system displays the weed and management activities
6. The use case ends.

Post-condition: The user will see the potential weed that occurred in the farm and management practices

Use Case Name: Get Identified disease & view detail

Actor: User

Description: To identify diseases that is responsible for the observed disorder

Related Use Cases: View recommendation

Precondition: The user should know the website address

Flow of Events:

1. The user selects disease-management hyperlink.
2. The system requests to click consult button to proceed.
3. The system request series of questions to answer.
4. The user response all questions
5. The system displays the identified disease and management activities
6. The use case ends.

Post-condition: The user will see the potential list of diseases that causes the disorder and detail information about the disease.

Use Case Name: Get Identified insect/pest & view detail

Actor: User

Description: To identify insect/ pest those cause disorder to the plant

Related Use Cases: view recommendation

Precondition: The user should know the website address.

Flow of Events:

1. The user selects Insect/pest-management hyperlink.

2. The system requests to click consult button to proceed.
3. The system request series of questions to answer.
4. The user response all questions
5. The system displays the identified disease and management activities
6. The use case ends.

Post-condition: The user will see the potential list of insect/pest that causes the disorder and management practices.

Use Case Name: Update Knowledge base

Actor: Administrator

Description: To Register Variety

Precondition: The administrator should have an account to login in.

Flow of Events:

1. The user select admin hyper link.
2. The system requests to enter user-name and password. [A]
3. The system opens variety registration form and request to insert data.[B]
4. The user click register
5. The system displays message _data successfully registered!
6. The use case ends.

Alternate Flow

2A: user failed to provide correct user name and/or password.

1. System displays ~~“Incorrect user Id or Password”~~ error message
2. The use case returns to normal flow step 2 and continues.

Alternate Flow

3B: User failed to insert correct data type and/or empty data

1. System displays ~~“the field accept number only”~~ or ~~“The field accept text only”~~ or ~~“the field cannot be empty”~~ error message.
2. The use case returns to normal flow step 3 and continues.

Post condition: The knowledge base and the system should be updated.

Actor: Administrator

Description: To Register Crop

Precondition: The administrator should have an account to login in.

Flow of Events:

1. The user select crop register menu hyper link.
2. The system opens crop registration form and request to insert data.
3. The user click register.[A]
4. The system displays message 1-data successfully registered!‘
5. The use case ends.

3A: User failed to insert correct new crop type and/or empty data

1. System displays ~~“Crop already registered in the data base”~~ or ~~“You have not entered all the required details please go back and try again.”~~ error message.
2. The use case returns to normal flow step 2 and continues.

Post condition: The crop is registered in the data base.

Actor: Administrator

Description: To Register Pre cultivation activity

Precondition: The administrator should have an account to login in.

Flow of Events:

1. The user select Register Pre cultivation activity menu hyper link.
2. The system opens registration form and request to insert data.
3. The user click register
4. The system displays message 1-data successfully registered!‘.[A]
5. The use case ends.

4A: User failed to insert correct new crop type

3. System displays ~~“Crop already registered in the data base and try again.”~~ Error message.
4. The use case returns to normal flow step 2 and continues.

Post condition: Pre cultivation activity registered in the data base.

Actor: Administrator

Description: To Register Farm preparation activity

Precondition: The administrator should have an account to login in.

Flow of Events:

1. The user select Register Farm preparation menu hyper link.

2. The system opens registration form and request to insert data.
3. The user click register
4. The system displays message `_1-data successfully registered!'`. [A]
5. The use case ends.

4A: User failed to insert correct new crop type

1. System displays `“Crop already registered in the data base and try again.”` Error message.
2. The use case returns to normal flow step 2 and continues.

Post condition: Farm preparation activity registered in the data base.

4.3.2 Class Diagram

Class diagrams are used to describe the structure of a system in terms of classes, attributes, operations and association of objects in the class. The class diagram of the system is depicted in figure 4.3.2.

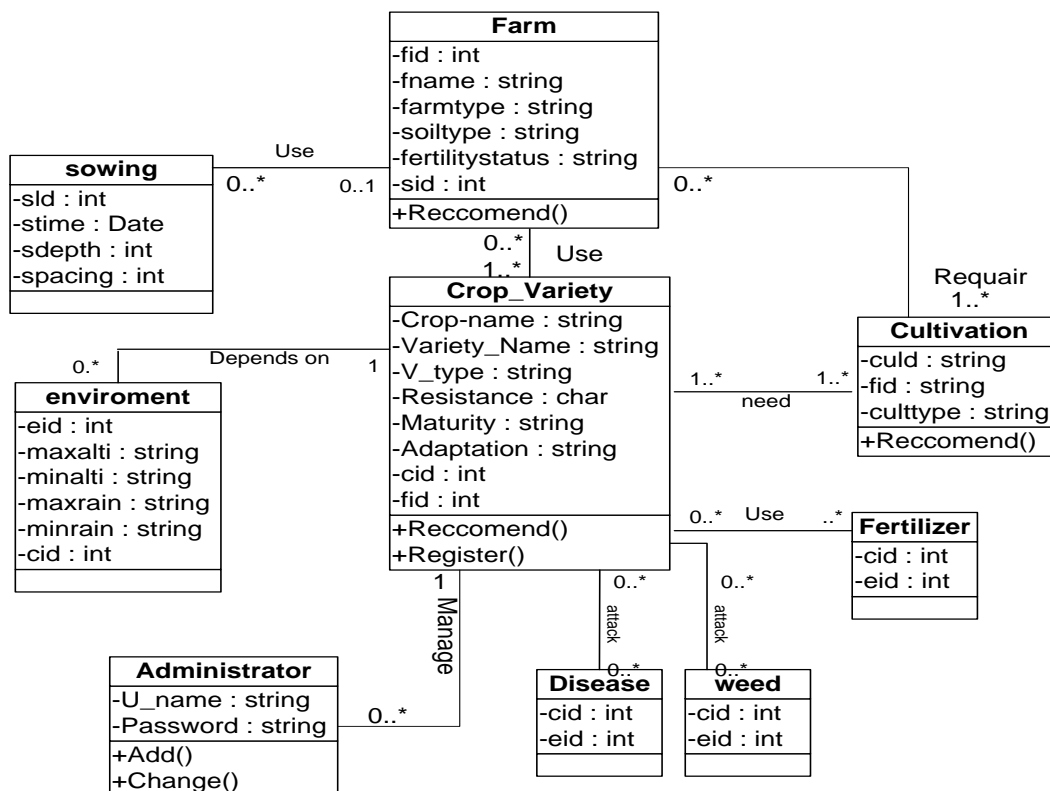


Figure 4.3.2: Class Diagram

4.3.3 Sequence Diagram

A sequence diagram is used to model the behavior of use cases by describing the way how objects interact to complete a task. The sequence diagrams of the system are depicted at Figure: 4.3,4.4.4.5.4.6,4.7,4.8,4.9 and 4.10.

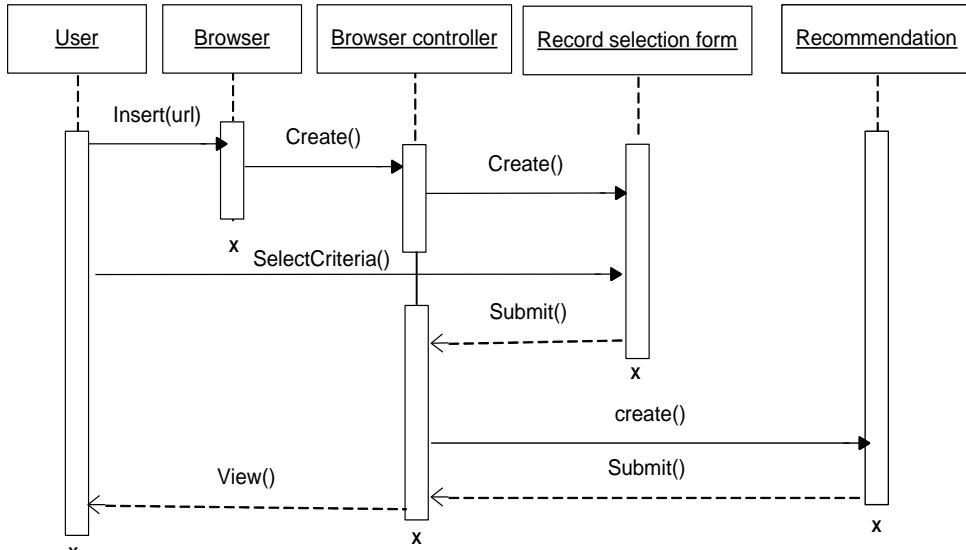


Figure 4.3 Sequence diagram for pre-cultivation

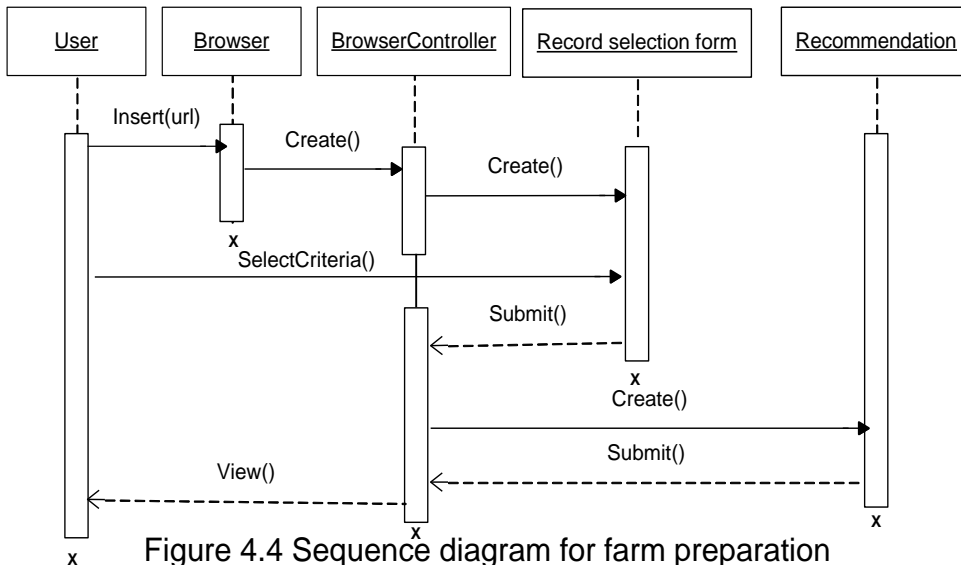


Figure 4.4 Sequence diagram for farm preparation

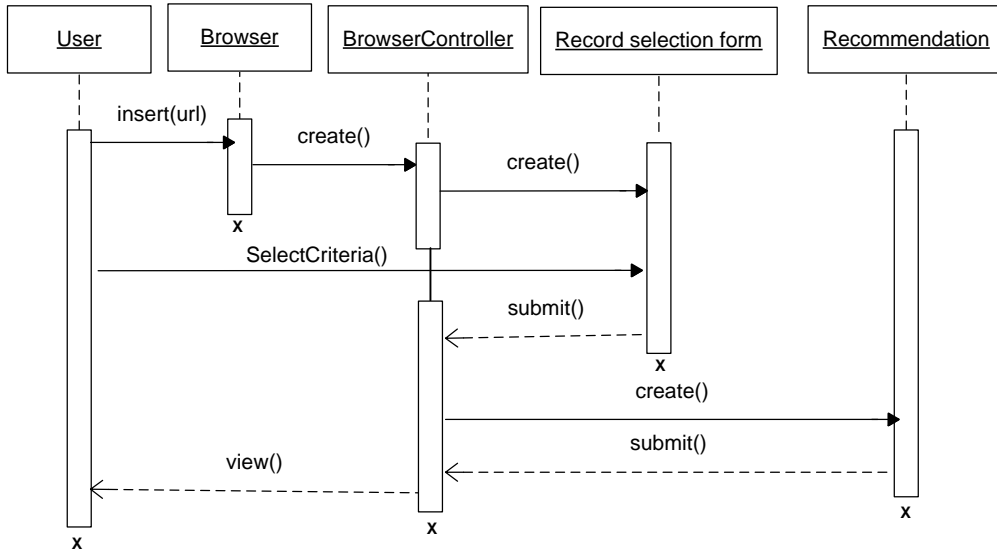


Figure 4.5 Sequence diagram for variety selection

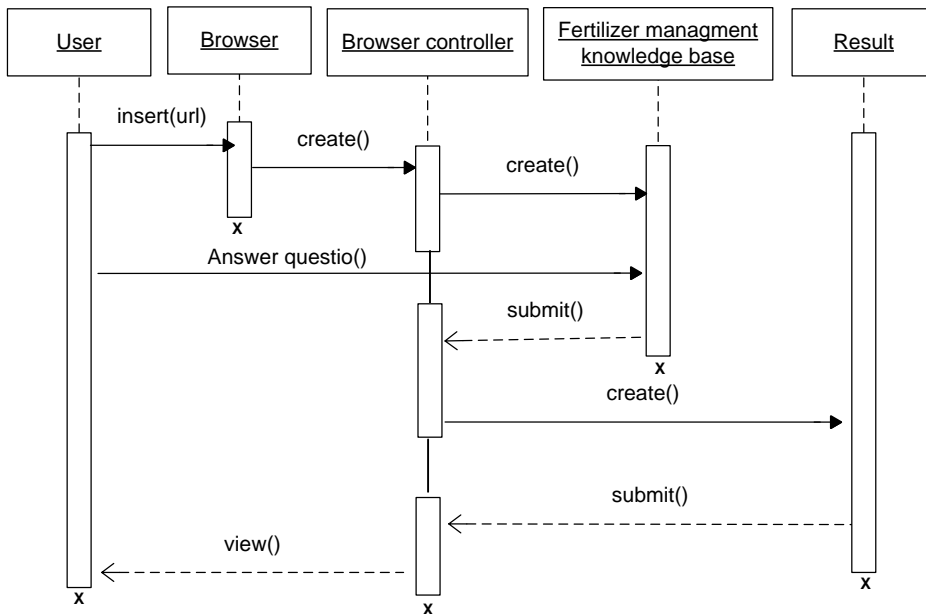


Figure 4.7 Sequence diagram for fertilizer application

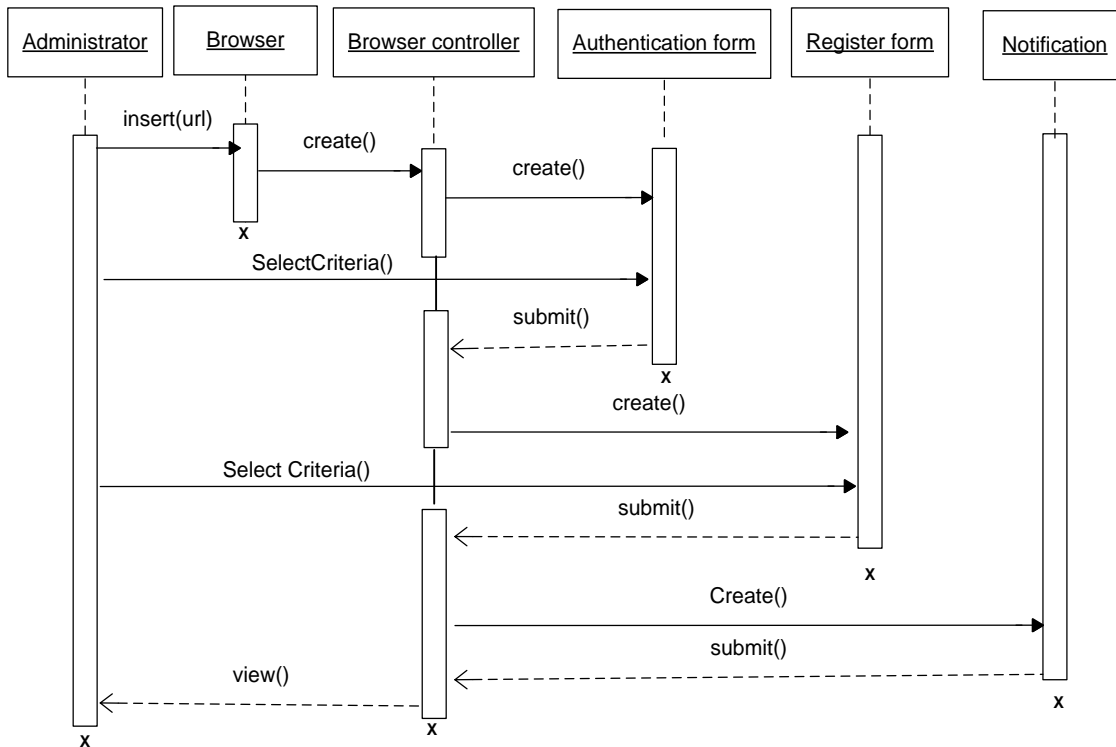


Figure 4.6 Sequence diagram for crop, variety, pre cultivation and farm preparation registration form

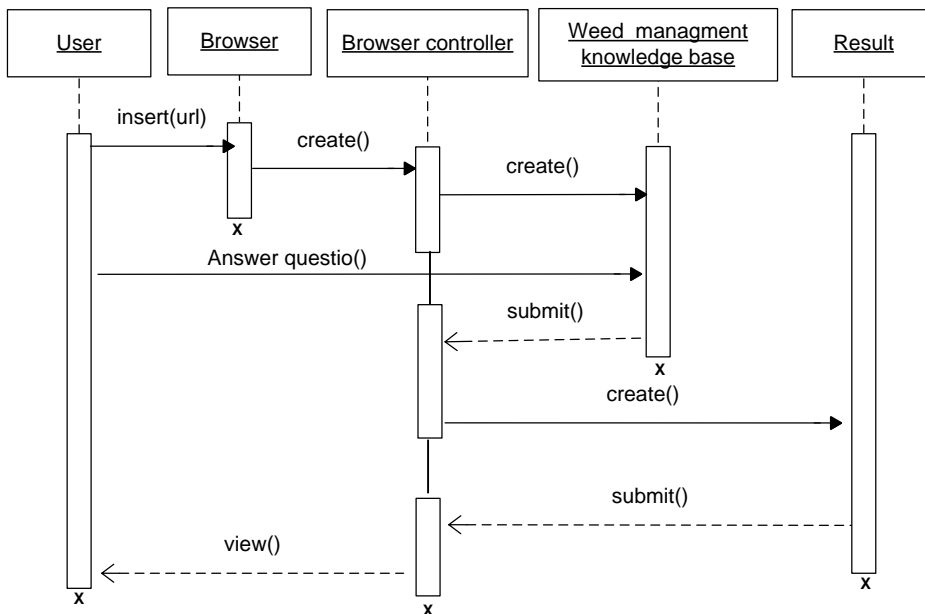


Figure 4.8 Sequence diagram for weed management

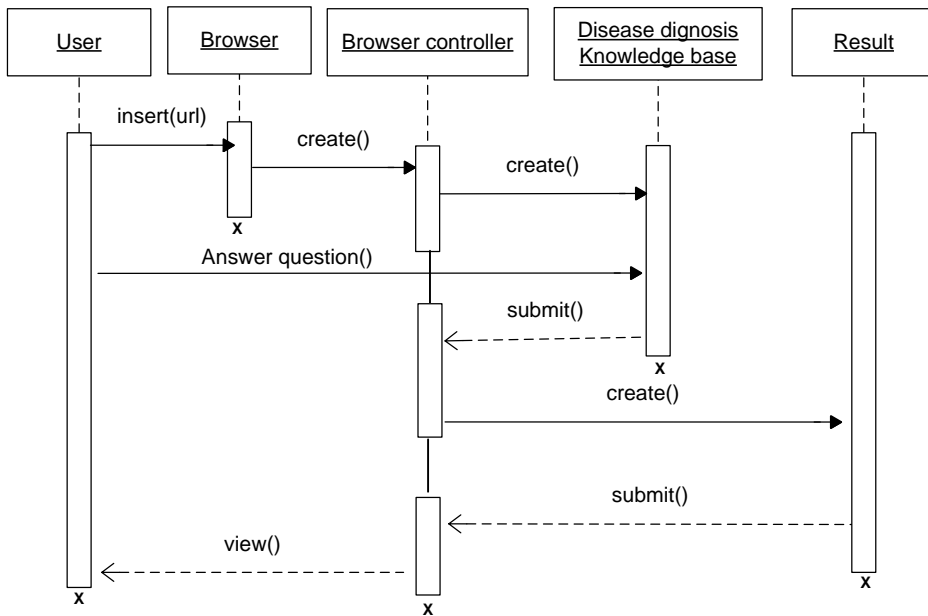


Figure 4.9 Sequence diagram for disease diagnosis

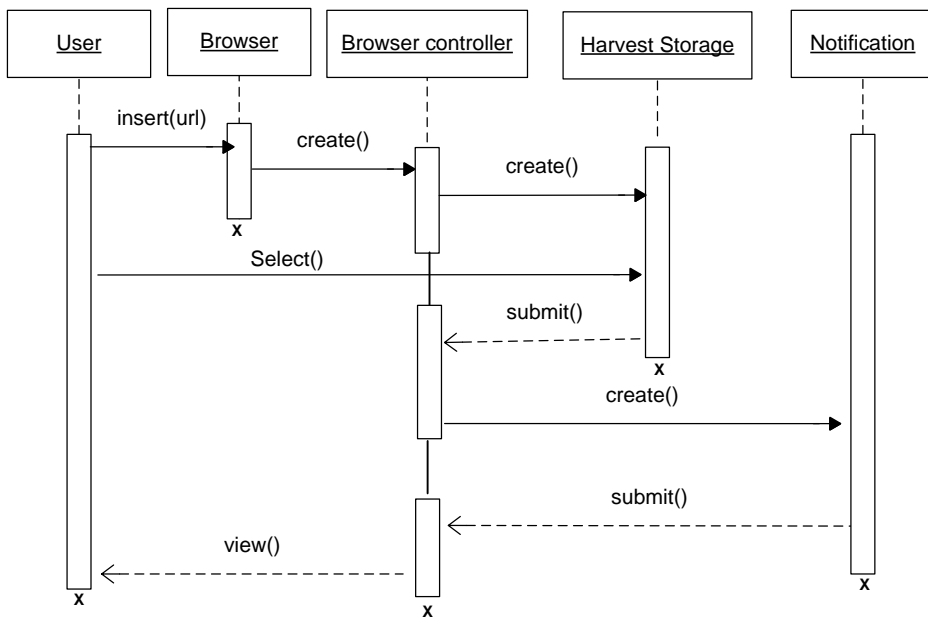


Figure 4.10 Sequence diagram for Harvest storage and treatment

4.3.4 Activity Diagram

Activity diagram describe the workflow behavior of a system. The diagram that is depicted in figure 4.4 show the activity diagram of the system.

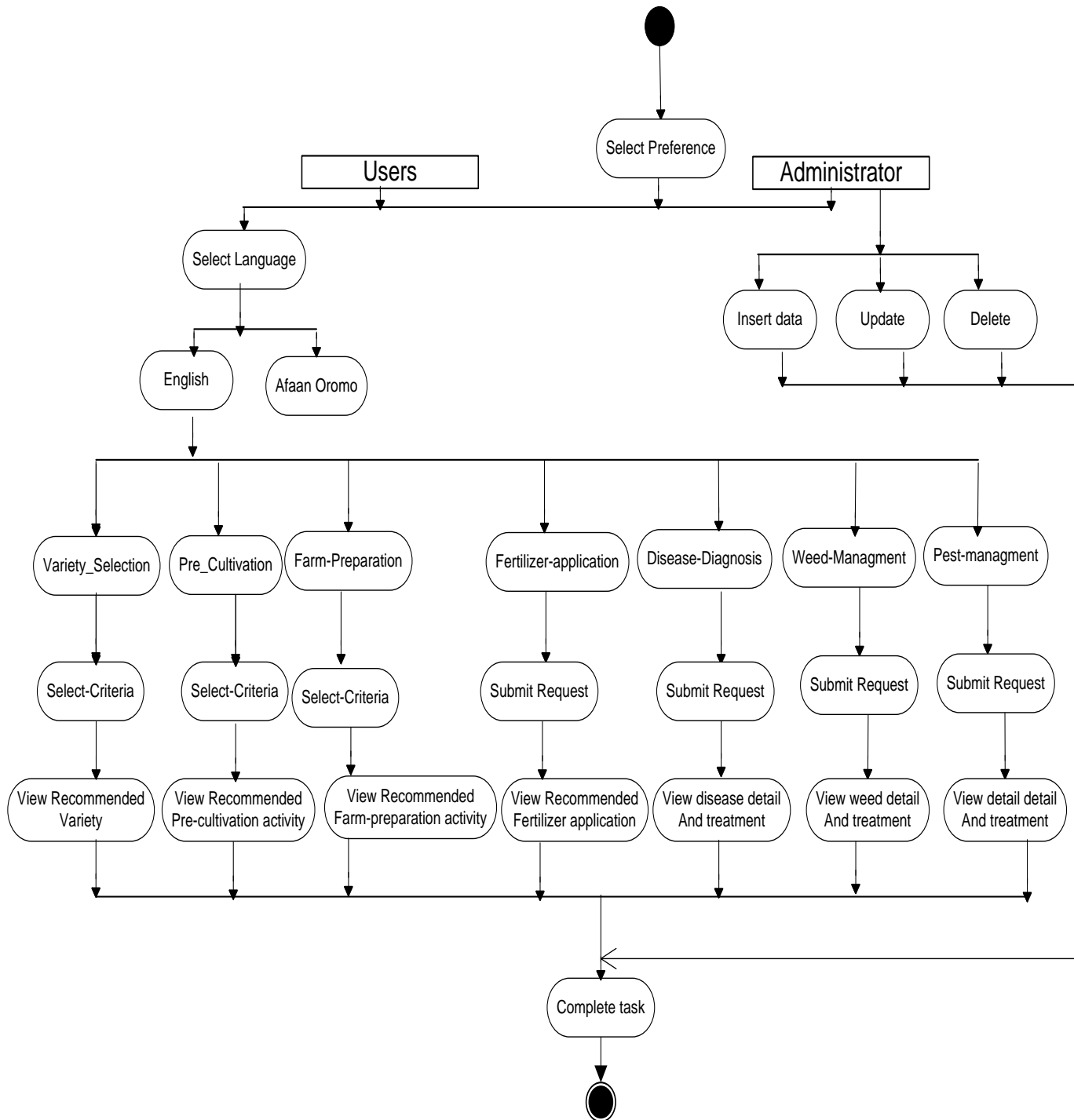


Figure 4.4: Activity Diagram of the System

Chapter Five: System Design

In this chapter, how the knowledge is acquired, the architecture and subsystem decomposition of the system will be discussed briefly.

5.1 Knowledge Acquisition

Knowledge acquisition is the process of obtaining facts and rules from the domain expert so that the system can draw expert level conclusions.

To acquire the knowledge for our system we followed the knowledge acquisition procedures discussed in [31, 20] and the knowledge of various ailment of wheat and maize and their symptoms were obtained from various literatures [6,16,17,18,22] and rules from domain experts that helps to identify specific disorder.

After the interview with the experts and a thorough review of the literatures, we design different factor tables (refer to Appendix E, F, G and H). For example insect/pest factor table provides information about the affected part, symptom, insect color and suitable weather condition for production and attack.

The acquire knowledge is represented as rules that the system can understand in the Knowledge base and in data bases. In our system there are three main knowledge bases: weed management knowledgebase, Fertilizer Knowledge base and disease Knowledge base while the data base can handle variety-selection, Pre cultivation, Farm management and Registration application Figure 5.1.

5.2 Architecture of the System

The general architecture of the agronomy advisory system is shown in Figure 5.1. The architecture presents the main components of the system. These are: Graphical user-interface, the application and the knowledgebase. User-system interaction takes place via user interface that runs on client's machine.

The user interface sends user response to the system based on user request weather to the database application or to the working memory. When a user selects application like variety selection recommendation the system will recommend according to crop types, expected

yield, altitude and maturity through the database. While a user selects knowledge base like Disease diagnosis the user interface sends user response (answer to question) to the working memory. The working memory holds all the responses as temporary data. The inference engine matches the data and rule's premises from the knowledge base. Finally the solutions are delivered to the user.

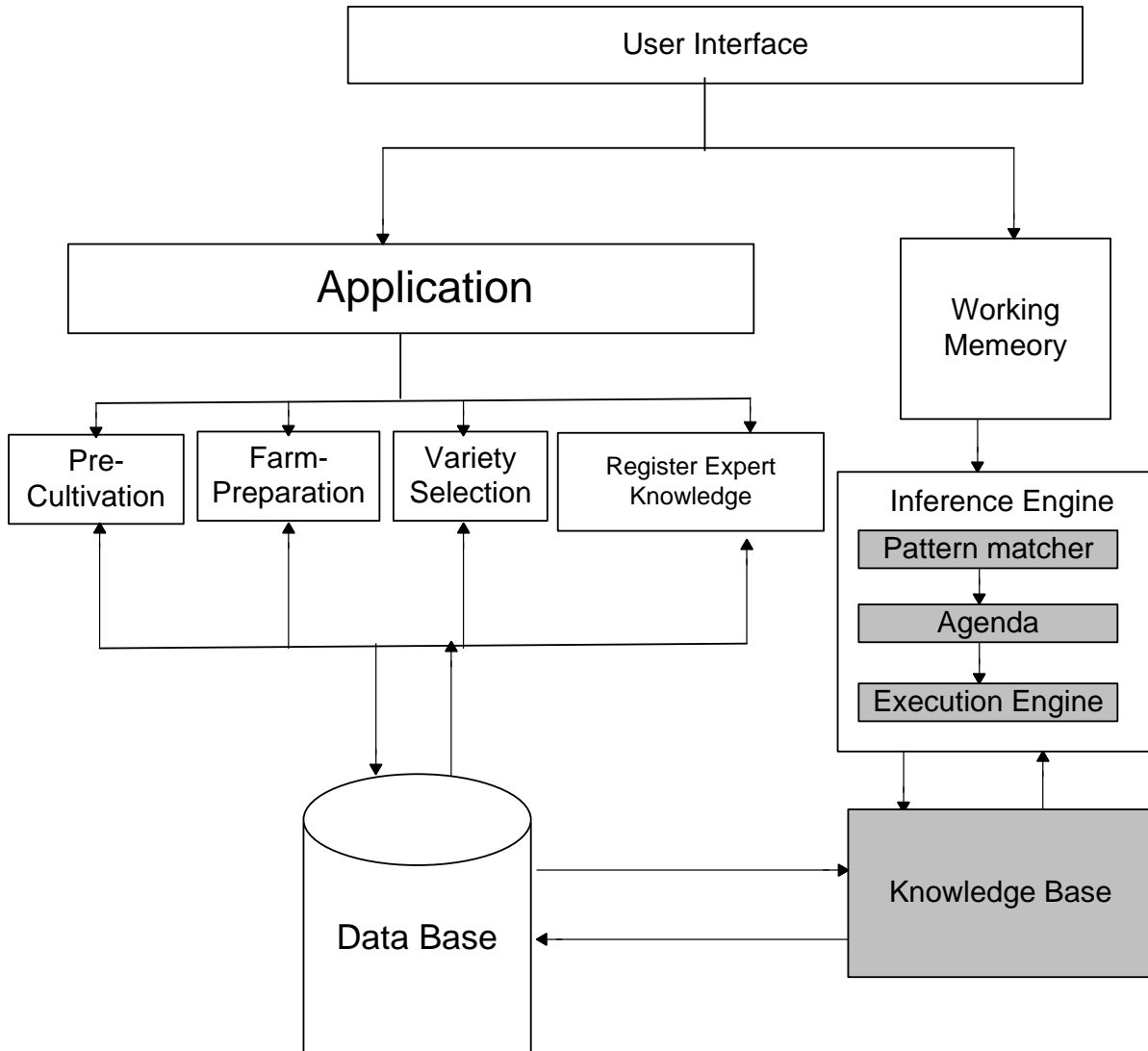


Figure 5.1: The Architecture of the System

The knowledge base

The knowledge base contains all the rules the system knows like: disease knowledge base, weed knowledge base, pest knowledge base and fertilizer knowledge base. The inference engine compares these rules antecedent part with that of the users response which is stored in the working memory. The system request a user to respond a series of questions to reach conclusion.

The inference engine

The main objective of the inference engine is to forward/backward chaining to respond to user query with appropriate reasoning. It controls the whole system and it is the central part of the system.

The system collects relevant information from users and stores this information in the working memory by using pattern matcher. The inference engine matches all the rules in the Knowledge base to the stored data in working memory to decide/identify which rules should be activated. All activated rules are ordered to form agenda and fired by execution engine in order.

All the data that the inference engine uses to compare the rules' antecedent part are stored as a fact in working memory. The fact may be user response or other information that the system is working with. Here, the user responses to systems question are stored as fact in it, and then the inference engine uses it.

Pre-cultivation

The main objective of this module is to give recommendation about appropriate agro ecologies of crop production and appropriate soil type based on the user selected crops.

Farm preparation

This module helps to give recommendation about land preparation and tillage operation on the farm, planting depth, sowing time, planting density and seed rate based on the user selected crops.

Variety selection

The main objective of this module is to give experts advice about the most suitable varieties based on the user selected requirements like crop-type, altitude of the area, expected maximum yield and maturity days of the crop.

Registration: These modules allow the administrator to register crop type, new released crop varieties, pre-cultivation and farm management activities to the data base.

5.2. Sub system Decomposition

To reduce the complexity, the system is decomposed into simpler parts called subsystems. The subsystem can be considered as packages that hold related class/objects. Web-based Agronomy advisory System is the aggregation of different subsystems. As shown in Figure 5.2. The main subsystems are disease management, insect/pest management, weed management, Pre-cultivation, Variety-selection, Fertilizer application, harvest and storage management these components clearly described at part 2.4 .

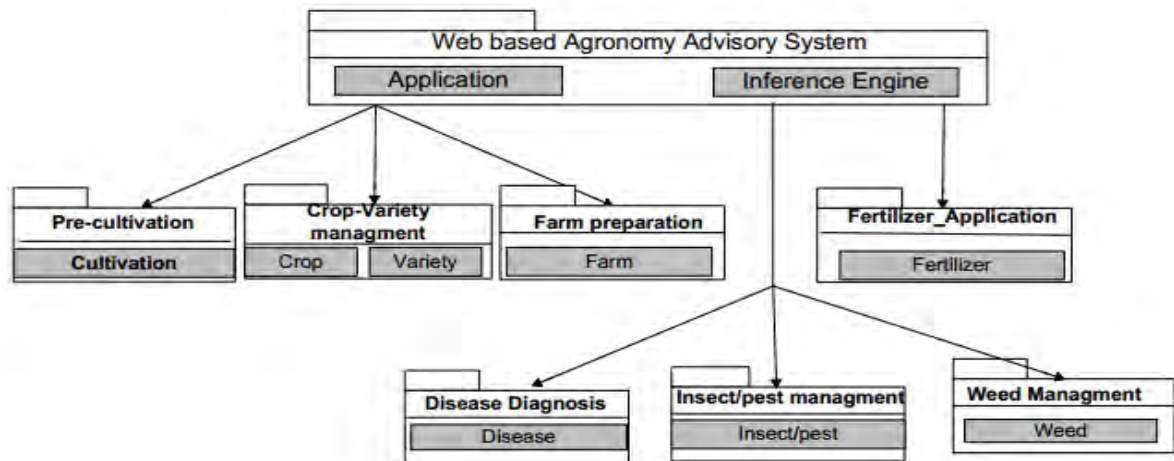


Figure 5.2: Subsystem decomposition of the system

5.3. Deployment Diagram

One of the major tasks in system design is hardware/software mapping. This helps the physical relationship between hardware and software in the system.

Web based agronomy advisory system is 4-Tier Deployment architecture to make the system security. In this architecture the Web server is physically separated from the application server. In this scenario, it allows to implement a firewall between the client and the Web tier, and another firewall between the Web tier and the application or business logic tier shown as Figure 5.3.

More over Performance deployment patterns represent proven design solutions to common performance problems. When considering a high performance deployment according to [39], you can scale up or scale out. Scaling up entails improvements to the hardware on which you are already running. Scaling out entails distributing your application across multiple physical servers to distribute the load, which are described at part 4.2. When planning to use a scale out strategy, you will generally make use of a load balancing strategy. This is usually referred to as a load-balanced cluster or, in the case of Web servers, web farm.

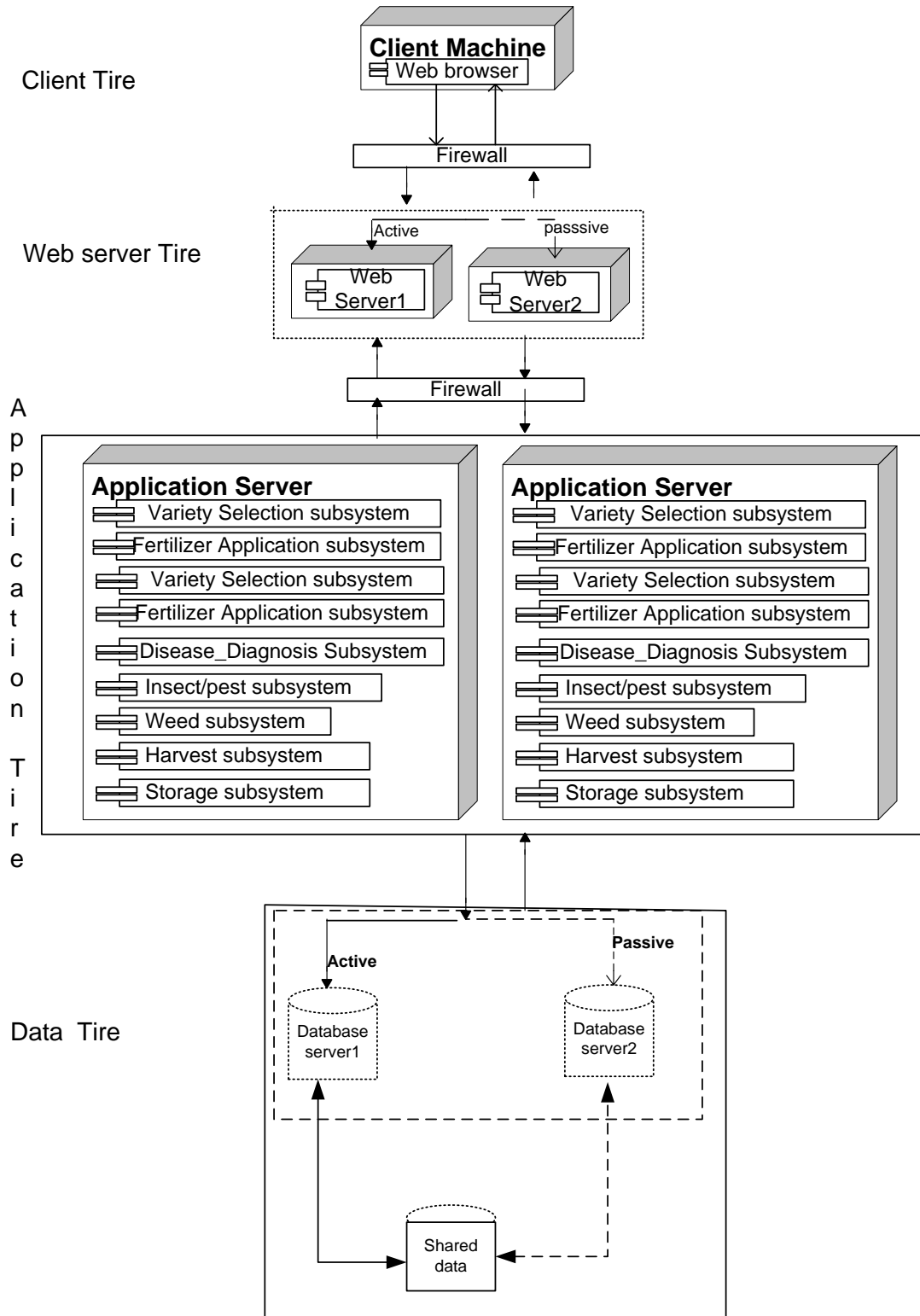


Figure 5.3: Deployment Diagram of the system

Chapter Six: Implementation

This Chapter discusses the implementation of the system. The sub-topics includes: development tools, knowledge representation and prototype of the system.

6.1 Development Tools

To implement the system the following programming language were used: e2gRuleEngine Knowledge Based System shell is used to develop knowledge base, e2gRuleWriter decision table software was used to construct the knowledge bases, Java and PHP are used as a programming language, Microsoft Office Visio 2003 for system design, Macromedia Dreamweaver 8 for user interface design, MySQL for database building and web Server to handle clients request from browser

6.2 Knowledge Representation

The acquired data and knowledge are represented in the knowledge base as rules. The rule is defined by the key word `_RULE` with some description about it in square bracket. This is followed by the rule premises with the key word `_If`. The logical expression consists of an attribute name, relational operators and comparison operators. The rule consequent is represented with key word `_Then`. The rules developed for the system Annexed at appendix B.

6.3. Prototype of the System

In this section of the chapter, how the user interacts with the system and some of the interaction results with screen shots are described.

To start the application the user inserts the `-URL` (*http://localhost/expert/farm.php*) then home page of the system is open as shown in Figure 6.1. The user then selects one of advisory links.

The Knowledge Based System includes four database applications pre-cultivation activity, preparation of farm, variety registration and variety selection. The knowledge base applications include: weed management, disease diagnosis and fertilizer application.

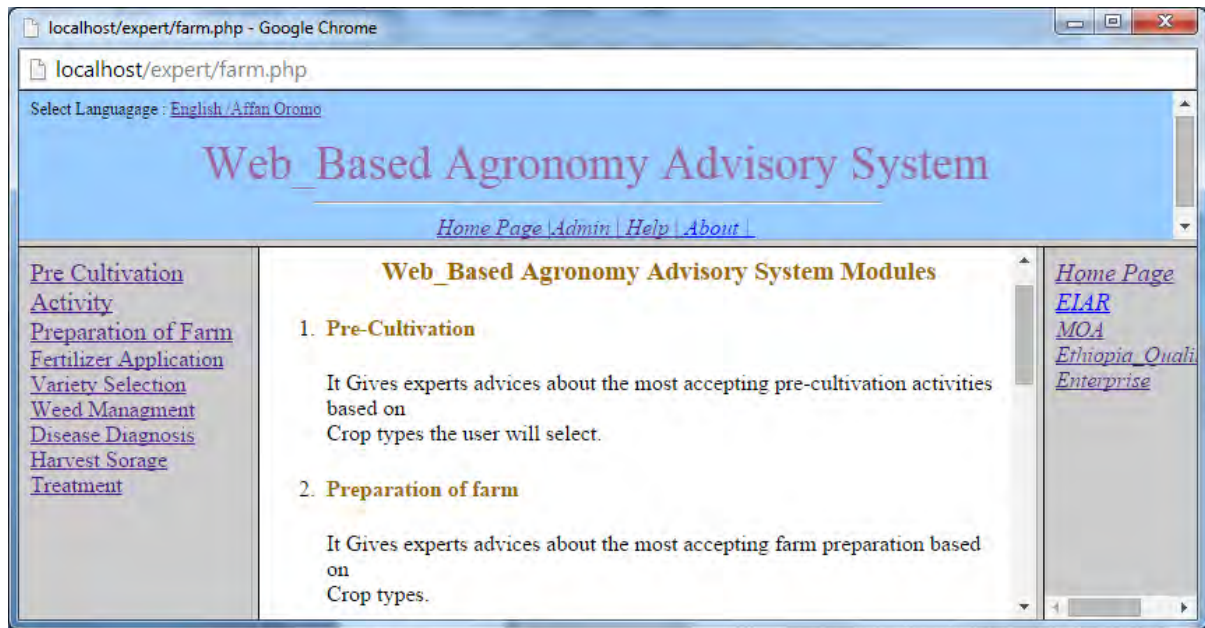


Figure 6.1: Home page of the system

When a user selects like variety selection, he/she will get Figure 6.2



Figure 6.2: Variety selection page

Variety selection menu helps to know best recommended varieties. The menu request a user to respond crop-type, altitude of the area, maximum yield expected to gain and maturity

condition of the crop. If a user answer the request and click recommend button the system will display best recommended varieties shown in Figure 6.3

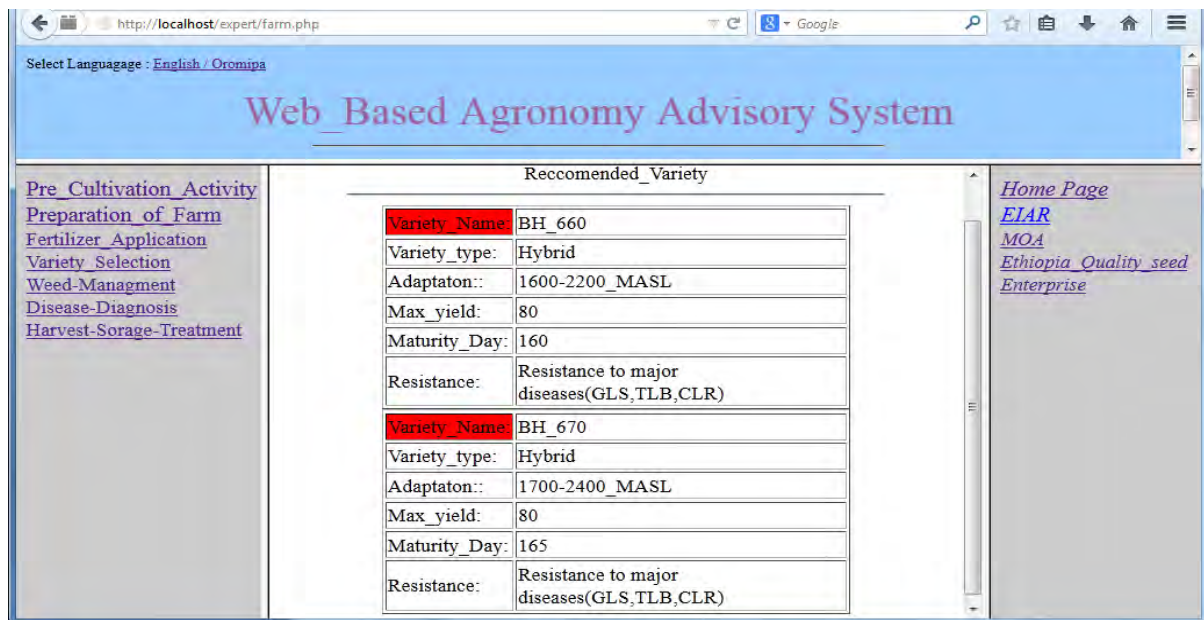


Figure 6.3: Recommended variety(s) page

From the home page if a user selects weed management option and clicks on `_consult` button the system will prompt sequence of questions to determine the weed type, crop type and whether labor is available or not. The following page shown in Figure 6.4 will be displayed to ask users to enter crop type with user's certainty level. Whenever a user clicks on why ask buttons to see why such a question has been asked, the user will see the goal or sub goal the inference engine is currently working on, the attribute it is trying to find and the rule that needs the value of this attribute.

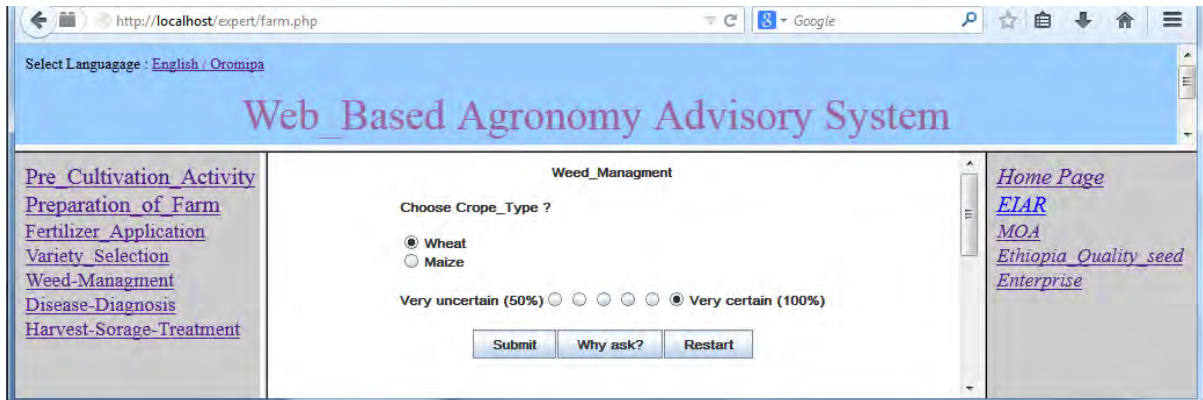


Figure 6.4: weed management page.

After selecting crop type and clicking submit button, the following page as shown in Figure 6.5 will be displayed to prompt users to answer the next question.

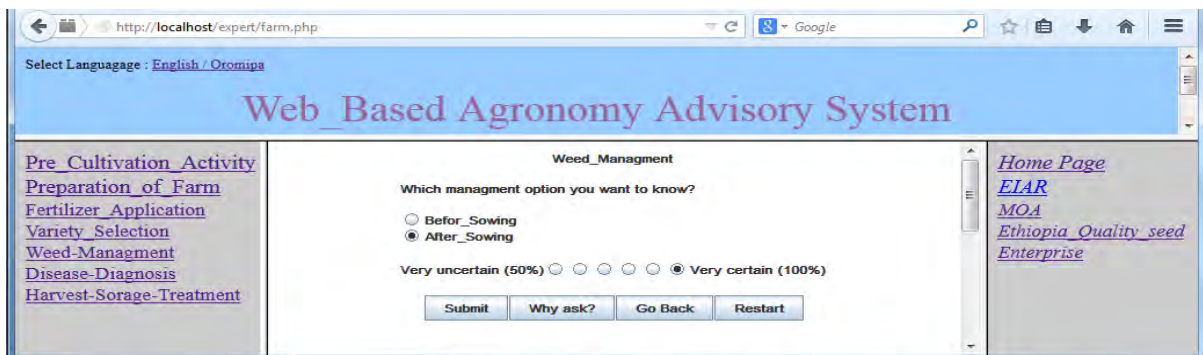


Figure 6.5: weed management option

After selecting the appropriate options, the user clicks on submit button which Figure 6.6 to prompt the users to answer the next question.

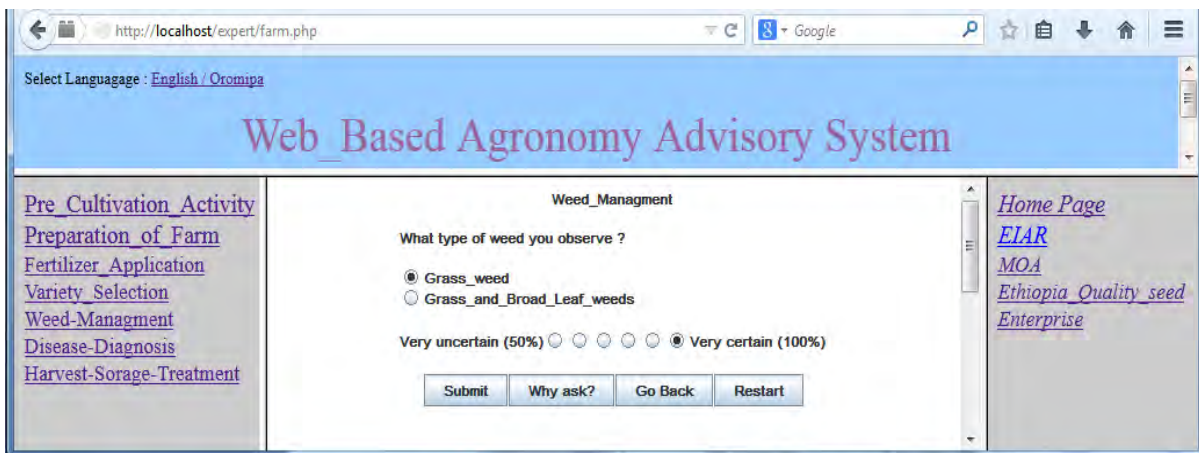


Figure 6.6: weed type selection page

A user answer weed type and click submit button, Figure 6.7 will be displayed to prompt users to answer the next question.

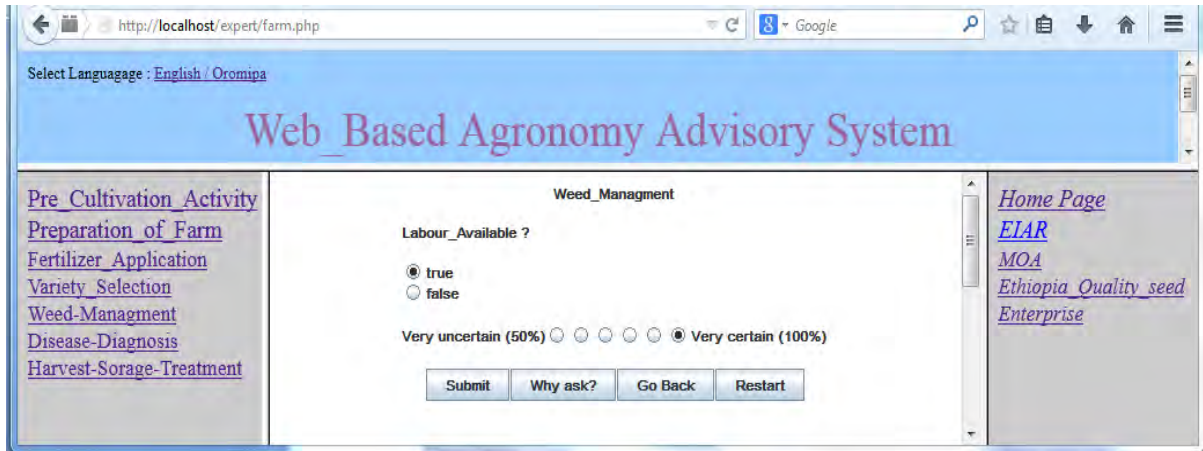


Figure 6.7: Labor availability checking page

A user answer labor availability and click submit button, the system will display final result as shown Figure 6.8.

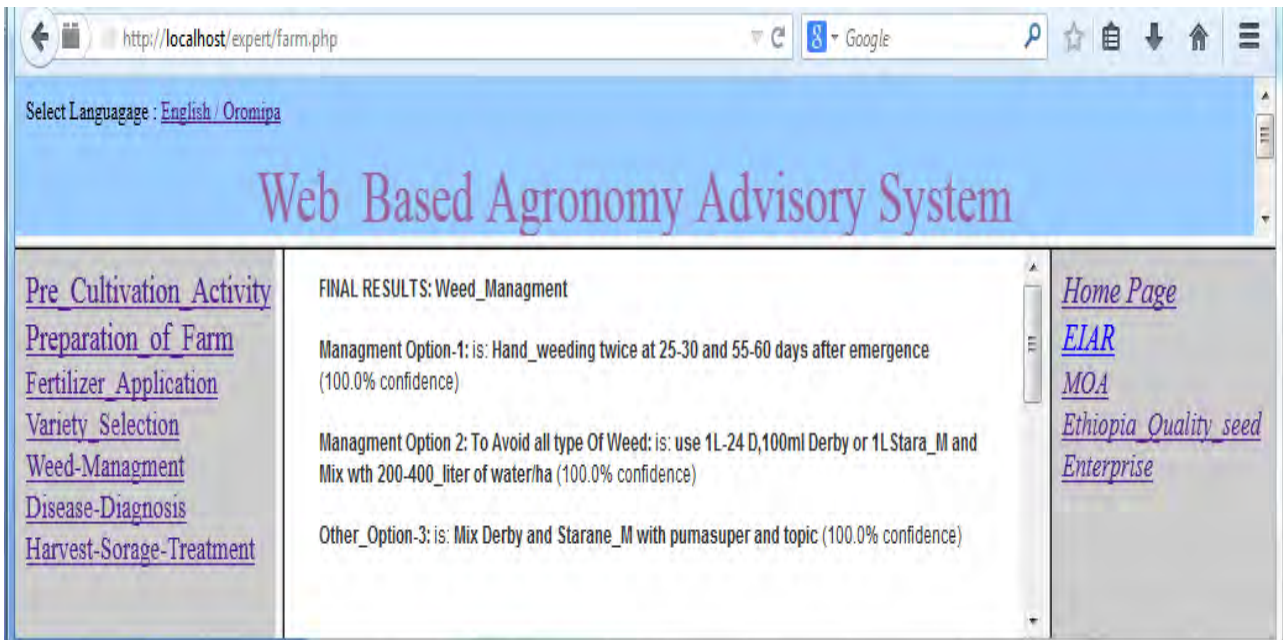


Figure 6.8: Final result

6.7. Sample Graphical User interfaces of Afaan Oromo language version



Figure 6.9: Home page Afaan Oromo language version



Figure 6.10: Administrator privilege

Qoqa (afan) | filadhu: [English](#) / [Afaan Oromo](#)

Web_Based Toftaa Gorsa Odeeffannoo Biqiltoota

[Sanvicha Galmeessi](#) | [Gosa midhaanii Galmeessi](#) | [Odeeffannoo duraa Galmeessi](#) | [Odeeffannoo aopii vfaa Galmeessi](#)

[Hal-duree Qophii Maasii](#)
[Oyruu Qopheessuu](#)
[Ittfayyadama Xaa'oo](#)
[Filanno Sanyii](#)
[To'annoo Aramaa](#)
[To'annoo-Dhibee](#)
[Omishuu-Kuusuu-Kununsuu](#)

Formata Gosa Sanyii Ittigalmeesan/ New Variety Entry Form

Maqaa Sanyii	Haayibiridii_QPM ▾
Gosa Sanyii	<input type="text"/>
Qilleensa Dandamachuu danda'u:	Baddaa Olka'aa ▾
Callaa laanaa	<input type="text"/>
olka'insa gadi ana	<input type="text"/>
olka'insa gudda	<input type="text"/>
Guyyaan Itti Gahu	<input type="text"/>
Dhibeenwan dandamatu	Dhibee gurguddoorraa hafuu nidandaa(CLR,TLB) ▾
Guyyaa itti gadhifa	<input type="text"/>
Abba qabenyaa	<input type="text"/>
Gosa Sanyii	Qamadii ▾

[Home Page](#)
[ELAR](#)
[MOA](#)
[Ethiopia Quality Seed Enterprise](#)

Figure 6.11: Crop, Variety and Pre-cultivation registration

Qoqa (afan) | filadhu: [English](#) / [Afaan Oromo](#)

Web_Based Toftaa Gorsa Odeeffannoo Biqiltoota

[Seensa](#) | [Administratorii](#) | [Gargarsa](#) | [Ibsaa](#)

[Hal-duree Qophii Maasii](#)
[Oyruu Qopheessuu](#)
[Ittfayyadama Xaa'oo](#)
[Filanno Sanyii](#)
[To'annoo Aramaa](#)
[To'annoo-Dhibee](#)
[Omishuu-Kuusuu-Kununsuu](#)

Itti fayyadama Xaa'oo

Jalqabuuf Mari'achiis kan jeddhu tuqi

[Home Page](#)
[ELAR](#)
[MOA](#)
[Ethiopia Quality seed Enterprise](#)

Figure 6.12: Fertilizer application format

Qoqa (afan) | filadhu: [English](#) / [Afaan Oromo](#)

Web_Based Toftaa Gorsa Odeeffannoo Biqiltoota

[Seensa](#) | [Administratorii](#) | [Gargarsa](#) | [Ibsaa](#)

[Hal-duree Qophii Maasii](#)
[Oyruu Qopheessuu](#)
[Ittfayyadama Xaa'oo](#)
[Filanno Sanyii](#)
[To'annoo Aramaa](#)
[To'annoo-Dhibee](#)
[Omishuu-Kuusuu-Kununsuu](#)

Sochii Maasaa qopheessuu

Gosa Midhanii	Qamadii ▾
<input type="button" value="Gorsa keenii"/>	<input type="button" value="Bakka Duraatti Deebisi"/>

[Home Page](#)
[ELAR](#)
[MOA](#)
[Ethiopia Quality seed Enterprise](#)

Figure 6.13: preparation of farm

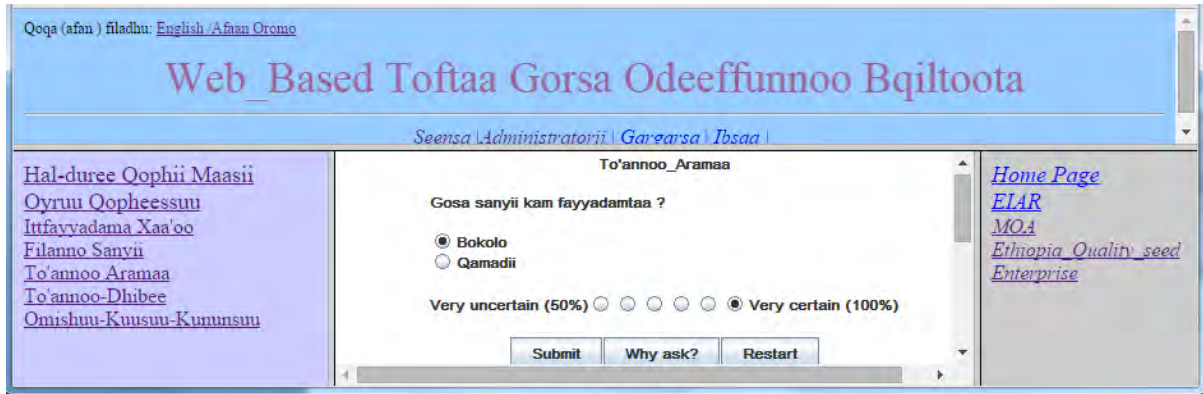


Figure 6.14: Weed management



Figure 6.15: Preparation of the farm Registration

When the “Restart” button is pressed anywhere during a consultation, control transfers to the home page of the diagnosis knowledge base

If the user clicks on the *explain* button detail explanation of the recommendation will be displayed. The explain button and restart button are used to see how the system arrives at a particular conclusion and clears all temporary data stored on the working memory.

When a user clicks on “Return” button in the page which display detail description of the recommended management options, control transfers to the page which displays the rule will be invoked in detail.

User uncertainty

Users might not be sure about their responses. The user interface of this Knowledge Based System provides users to represent their degree of confidence in a response with a numerical scale whenever necessary. They are given an option to enter their certainty about the response which ranges from 50% to 100%. If the user omits the certainty level, the system takes the default level which is 100%. The inference engine, before giving recommendation, compares all users' confidence level about the response with that of the minimum certainty factor (threshold level) which is 70%, set for the system to accept user response as valid.

Another approach used in this system to manage uncertainty is based on using simple input in the form of "Yes", "No" and "I don't know". For example, in weed management, the user is first prompted with a question asking whether labor is available or not in the area. Selecting one of the answers (Yes, No, I don't know) will increase the accuracy of the management recommendation by reducing the list of possible cause. The value "Yes or No" is used to decide one of management options either use of labor or use of herbicide while "I don't know" helps to consider both options.

Chapter Seven: System Evaluation

Knowledge Based System Evaluation is the process of determining the quality of the Knowledge Based System and the advice it provides. It is important for any software development effort to ensure correctness of the out puts and user satisfaction with the product in solving the given problem.

To evaluate the usability of the system we used 7 domain experts, 3 extension workers and 3 computer science students. We provided 14 different system evaluation questions for the respondents. The respondents are required to evaluate the system using ordinal scale from strongly disagree (rating 1) to strongly agree (rating 5).

We divide the evaluation questions into four categories as a criterion: usability, impact of the system in the behavior and decisions of the user, impact of the quality of the information provided to the user and usefulness.

From the result analysis diagram shown in Figure 7.1, we concluded that the respondents agreed that the system satisfies all the criteria's. On the average, overall the system performance was rated as acceptable. System evaluation questionnaires are annexed in the *appendix C* and result of system evaluation by the respondents *in appendix D*.

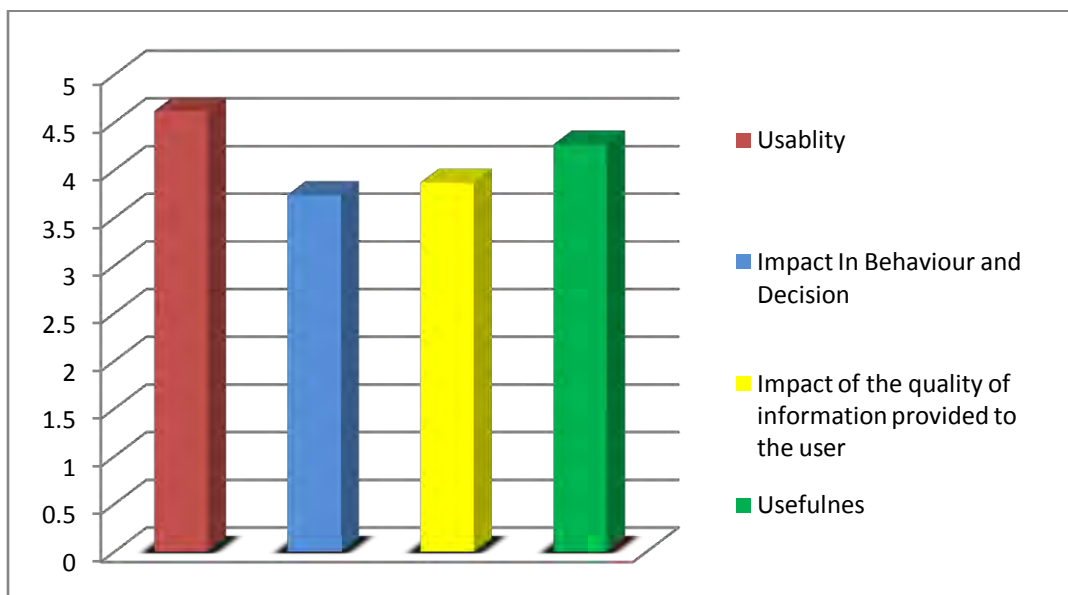


Figure 7.1 Result analysis of users' feedback towards the system

Chapter Eight: Conclusion and Future Works

8.1 Conclusion

Combining agricultural expert knowledge with ICT gives valuable advantage for farmers to enhance the yield of crop production. Knowledge Based System can be one of the most useful tools to provide farmers with day-to-day, integrated decision support needed to grow their crops. Countries like Egypt, India, Italy and Pakistan have used Knowledge Based System as a better mechanism to disseminate agricultural expert knowledge.

However, in Ethiopia agricultural experts' assistance is not easily available. There should be a mechanism to make this assistance available to users. One of such mechanism is web-based agronomy advisory system may fill this gap especially in wheat and maize crop production.

This system will help users' especially agricultural extension workers in Ethiopia who are mediator between farmers and agricultural researchers to provide immediate experts' assistance easily and quickly. To build the system appropriate knowledge has been acquired and represented from the agricultural experts and also from related literatures. The system includes pre-cultivation up to post harvest in case of wheat and maize crop production. The system solves problems like site selection, farm preparation, variety selection, fertilizer application, diagnosis and treatment of disease, insect/pest and weed. It is also used to transfer new technology in agro management to farmers. This will lead to increasing the production and the national income, on one hand, and reducing the production cost on the other hand.

8.2 Future Works

In order to improve the quality and to extend the system, the following points should be considered:

- The system concerns only the two major crops wheat and maize, so that it needs to incorporate other cereal crops like sorghum, teff, barley and rice crops, fruit and vegetable crops.
- Customize the system for other local language other than Afaan Oromo.
- The system don't answer deficiency problem it need to incorporate in the system
- For Simple Message System (SMS) based Weather forecast and Pest attack warnings, and Query response through voice, Mobile based application need to be consider.

References

- [1] Robert, S. E. and Edward, F. (2003). *Fundamentals of expert system*. Available: www.media.wiley.com/product_data/excerpt/8/0472933/04729338.pdf , accessed at february, 08/2014 .
- [2] Rossi, V., Meriggi, P., Caffi, T., Giosué, S. and Bettati, T. (2010). *A Web-based Decision Support System for Managing Durum Wheat Crops*, ISBN 978-953- 307-069-8, Intech Publisher, India.
- [3] Buchanan, B.G. and Duda, R. O.(2005). *Principles of Rule-Based Expert Systems*, available at <ftp://reports.stanford.edu/pub/cstr/reports/cs/tr/82/926/CS-TR-82-926.pdf>, accessed at february, 08/2014
- [4] Poole, D., Mackworth, A. and Goebel, R.(1999). *Computational Intelligence*”, vol. 1, Oxford University Press, USA.
- [5] Holland, A.,(2012). *Rule Based System: Intelligent Systems*, retrieved on February 6, 2014 from http://www.4c.ucc.ie/~aholland/udg/Girona_Lec2.pdf.
- [6] Ejigu, T.(2010). *Developing knowledge based system for cereal crop diagnosis and treatment*. MSc thesis, Addis Ababa University, Ethiopia.
- [7] Owaied, H. Malek, A. and Farhan, H.(2000)..*Application of Knowledge Based System*, International Journal of Computer Science and Network Security, VOL.1, No.3,pp 1-24.
- [8] Hayes-Roth, F. and Jacobstein, N.(2004). *The State of the art Knowledge Based System*, Communication of the Association of Computing Machinery, Vol 37, No.3,pp .
- [9] Abraham, A., Peter, H., Sydenham and Richard, T.(2005) . *Rule-based Expert Systems: Handbook of Measuring System Design*, John Wiley & Sons, USA.
- [10] Ruth, G.(2012). *A Web based Expert System for Diagnosis of Disease and Pest in Ethiopian Coffee*, MSc thesis, Department of Computer Science, AAU.
- [11] Sajja, P. and Akerkar, R. (2000). *Advanced Knowledge Based System: Models, Applications & Research*, Vol 1, Jones & Bartlett publisher, USA.
- [12] Ethiopian commodity exchange website (2013), *Crop production statics*, available at <http://www.ecx.com.et/commodities.aspx> , accessed feb,08/2014.
- [13] Peter, B. et al. (1990). *CALEX/ Cotton: an integrated expert system for cotton production and management*, Computers and Electronics in Agriculture, Vol. 44, No. 5.

California.

- [14] Soliman, A. Edrees, A, Ahmed R. ,Ibrahim, F. and Mohamed, Y.(2003). *NEPER: a multiple strategy wheat expert system*, Computers and Electronics in Agriculture, vol. 40, , pp 27-43 .
- [15] Praveen, K. G., Ramesh B. K and GaneshKumar M.(2012). *Maize Expert System*, Computer Science & Engineering: An International Journal , Vol.2, No.3,pp 43-54.
- [16] Excel Up (2009).*CROP PRODUCTION AND MANAGEMENT*, available at https://www.google.com.et/?gws_rd=cr&ei=oiwHU77YCKnmywPX4YCACw#q=crop%20production%20and%20management%20pdf,accessed, at feb2, 2014 at 8 AM.
- [17] Premkumar, G.(1991). *Knowledge Based System and Database Management System:An Integrative Framework*, Journal of Database Administration, Iowa State University.
- [18] Lòpez-Bellido, L., Lòpez-Bellido, R. and Loòpez-Bellido, F. (2006). *Fertilizer Nitrogen Efficiency in Durum Wheat under Rainfed Mediterranean Conditions: Effect of Split Application*, Agronomy Journal, Vol. 98, pp. 55-62.
- [19] Premkumar, G. (1991). *Knowledge Based Database Management for Expert Systems*, Journal of Database Administration. Vol. 2, No. 4,pp 12-27.
- [20] Bachman, B. G. and Smith R.(2008). *Fundamentals of Expert Systems.*, Annual Review of Computer Science: Vol. 3, ISBN:0-8243-3203-2 , USA.
- [21] Abdurazak, H. (2003). *Development of intelligent decision support system for crop management*”, Available at http://www.afita.org/files/web_structure/200302547_70535/200302547_70535_27.pdf , last accessed November 4,2013
- [22] Calu F.(2009). *Major Pests, Diseases and Weeds of Cereal Crops*, available at, <http://www.pesticides.gov.uk/.7>, last accessed November 4, 2013
- [23] Samhaa, R., Ahmed, R., Ahmed, S.(1999). *An Agent Based Approach to Expert System Explanation*, American Association for Artificial Intelligence, The American University in Cairo, Egypt.
- [24] Hailu, G.(2003).*Wheat Production and Research in Ethiopia*, available at

- www.eap.gov.et/sites accessed at february, 2014.
- [25] Central statistics agency website available at (2013/2014). *Agricultural sample survey report on farm management practices.*, accessed February 5, 2014.
- [26] Harvinder, S. Saini, R.K. and Sharma, A. N. (2002). *Web Based Fuzzy Expert System For Integrated Pest Management in Soybean*, International journal Of Information technology, Vol 8, No. 2, Kayro.
- [27] Wang, Z., Chen, Z.(2010). *A Web-based Agricultural Decision Support System on Crop Growth Monitoring and Food Security Strategies*, Proceedings of the Third International Symposium on Computer Science and Computational Technology, vol.10, ISBN 978-952-5726-10-7, pp. 487-49, China.
- [28] Soliman, A. Edrees, E. El-Azhary, A., Rafea A.(2003). *expert system for paddy production management*, available at www.arc.sci.eg/narims_upload/claesfiles/3772.pdf. accessed in February 5, 2014.
- [29] Prentzas, J. and Hatzily, G.,(2007). *Categorizing approaches combining rule-based and case-based reasoning: Expert Systems*. Blackwell Publishing Ltd, vol 24,2 , UK.
- [30] Crowley, L.(2011). *Intelligent Systems: Reasoning and Recognition*, available at www.prima.imag.fr/jlc/Courses/2011/ENSI2.SIRR/ENSI2.SIRR.S1.pdf. accessed at January 6,2014.
- [31] Turban,(2014). *Knowledge Acquisition, Representation, and Reasoning*, available at wps.prenhall.com/wps/media/objects/.../Turban_Online_Chapter_W18.p. march 15,2014.
- [32] Raman, S.(2007). *A practical introduction to Rule Based Expert Systems*, Available at <http://sigai.cdacmumbai.in/files/ESBook.pdf> , march 15,2014
- [33] Central laboratory for Agricultural expert system,(2014). *Barley Expert System*, available: <http://iasri.res.in/barley/> accessed on march 15,2014.
- [34] Daniel, Y.(2011). *Expert system on development for teff varieties selection and disorder management*, MSc. Thesis project, Computer Science Department, Addis Ababa University.
- [36] Rafea, A.(1994). *Agriculture Expert system on development in Egypt*, In proceeding of International conference on Expert system for development, Bangkok, Thailand.
- [37] Rafea A., El-Azhari, Ebrahim, S.(1998). *Experience with the development and*

- deployment of Expert system in Agricultures*, In proceedings of IAA-95, Canada.
- [38] Sarma, S. Robindro, K. and Singh, A.(2010). *An Expert system for diagnosis in rice plant* , International journal Of AI and Expert system,vol 1,No. 2.
- [39] Microsoft (2014). *Physical Tiers and Deployment*, available at, msdn.microsoft.com/en-us/library/ee658120.aspx, accessed at November, 2014
- [40] Bethlehem, A.(2010). *Exploring Pest management Practices and Development of Knowledge Base system for Pepper Disease Diagnosis*, M.Sc. thesis, Information Science Department, Addis Ababa University.
- [41] Yilmaz, S., Venugopal, V.(2010, *Local Government Discretion and Accountability in Ethiopia.*, available at <http://aysps.gsu.edu/isp/files/ispwp0838.pdf>,accessed November,2014.
- [42] Francesco, R., Lior R. and Bracha, Sh. (2011). *Introduction to Recommender Systems Handbook*, Recommender Systems Handbook, pp. 1-35 available at , [www.cs.bme.hu/nagyadat/ Recommender_systems_handbook.pdf](http://www.cs.bme.hu/nagyadat/Recommender_systems_handbook.pdf), accessed November,2014
- [43] Leigh, A. (2010)..*Accelerating Ethiopian Agriculture Development for Growth, Food Security, and Equity*, the Bill & Melinda Gates Foundation, University of Washington.
- [44] Fahad, S., Saad, R., Kashif, I., Fahad, M., Ahmad, F., Inam, I., Tauqeer ,I.(2008). *Dr. Wheat: A Web-based Expert System for Diagnosis of Diseases and Pests in Pakistani Wheat*, Proceedings of the World Congress on Engineering , Vol I, London, U.K.
- [45] MSDN,(2014)., *MySQL Server manual* , available at www.dev.mysql.com/doc/refman/5.0/en/server-system-variables.html#sysvar_max_user_connections , accessed November,2014.
- [46] Grove, R,(2000). *Internet-based expert system, expert system*, journals of knowledge engineering, vol.17, No.3, pp 129-135.
- [47] Ahmed, R., *Expert system application in agriculture*, aivable at www.arc.sci.eg. Accessed on accessed feb,08/2014
- [48] Prasad, G.N.R., Vinaya, B.A. (2006). *A Study on Various Expert Systems in Agriculture*, electronic Scientific Journal: Computer Science and Telecommunications, vol 11,No.4,Georgian.
- [49] Ethiopia ATA (2013).*Ethiopian Agriculture*, available at, <http://www.ata.gov.et/> , last accessed, November 03, 2013.
- [50] Ethiopian Institute of Agriculture (2014). research, *የጤና ቴክኖሎጂዎች አጠቃቀም*,” available: <http://www.EIA.gov/teff.pdf> ,accessed on feb,08/2014.

- [51] Ethiopian Agriculture products (2014). *Cereal crop agricultural commodities*; available <http://www.eap.gov/Agricultural-commodities/crop/cereals.asp>, Accessed on accessed feb,08/2014
- [52] Kassa, B. and Degnet, A. (2004). Challenges Facing Agricultural Extension Agents: Case Study from South-western Ethiopia,, available <http://www.ethiopiagateway.com/eportal/sites/default/files/Challenges-Facing-Agricultural-Extension-Agents.pdf>, Accessed on accessed feb,08/2014.
- [53]Samual, G.(2014). *Intensification of small holder agriculture in Ethiopia: Opinions and scenario*,available, <http://www.future-agricultures.org/index.php> Accessed on accessed feb, 08/ 2014
- [54] Tongco M.(2007). *Purposive sampling as a tool for informant selection*. Ethnobotany Research & Applications, vol. 5, 1547-3465, pp 147-158.
- [55] Global Yield Atlas (2013).*Description of cropping systems, climate, and soils in Ethiopia* .available at <http://www.yieldgap.org/ethiopia>, accessed feb,08/2014
- [56] Nermin, K. (2014). *Expert System for Wheat Yields Protection in Egypt (ESWYP)*, International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-3, No.3.
- [57] Ramanjeet, K., Salam, D. (2013). *Expert System to Detect and Diagnose the Leaf Diseases of Cereals*, International Journal of Current Engineering and Technology, Vol.3, No.4.

APPENDICES

Appendix B : Disease, Weed and Fertilizer knowledge base

REM: Disease Management

RULE [LB]

If [Crop-Type] = "Maize" and [Lesion] = "true" and [Lesion-Color] = "Gray-Green" and
[Affected-part] = "Leaf" and [Weather] = "High humid" and [Lesion-Shape] = "Cigar-Shape" and
[Pustel] = "false" and [Spore] = "false"
Then [Option 3] = "Use anti fungus chemical Mankozep 2 kg per hectare, apply 2-3 times." and
[Option 2] = "Use resistant variety like BH-660,BH-670,BH-543" and
[Option 1] = "Use crop rotation ,Burn infected plants" and
[Recommendation] = "Use the following Managment Options" and
[The Problem] = "The disease that identified is Leaf Blight to know more click the underlined part."

RULE [GLS]

If [Crop-Type] = "Maize" and [Lesion] = "true" and [Lesion-Color] = "Yellow-tan" and
[Affected-part] = "Leaf" and [Weather] = "High humid" and [Lesion-Shape] = "Rectangular" and
[Pustel] = "false" and [Spore] = "false"
Then [Option 3] = "Use anti fungus chemical Binomil 0.5 kg per hectare" and
[Option 2] = "Use resistant variety like BH-660,BH-670,BH-543" and
[Option 1] = "Use crop rotation ,Burn infected plants" and
[Recommendation] = "Use the following Management Options" and
[The Problem] = "The disease that identified is Gray leaf spot to know more click the underlined part."

RULE [LRM]

If [Crop-Type] = "Maize" and [Lesion] = "false" and [Affected-part] = "Leaf" and [Pustel] = "true"
and
[Pustel-color] = "Orange" and [grainy-orange-dust-on-the- leaf] = "true" and
[Spore] = "true" and [Spore-color] = "Dark-Black"

Then [Option 3] = "use anti fungus chemical mancozep and propikonazol 2 kg/ha apply 2-3 times"
and

[Option 2] = "Use resistant variety like BH-660,BH-670,BH-543" and

[Option 1] = "Use crop rotation ,Burn infected plants" and

[Recommendation] = "Use the following Management Options" and

[The Problem] = "The disease that identified is Leaf rust to know more click the underlined part."

RULE [LRW]

If [Crop-Type] = "Wheat" and [Lesion] = "true" and [Lesion-Color] = "Orange-Brown" and [Affected-part] = "Leaf" and [Weather] = "Mild-Warm" and [Lesion-Shape] = "Round" and [grainy-orange-dust-on-the- leaf] = "false" and [Spore] = "false"

Then [Option 2] = "Use 1/2 litter anti fungus chemical peropikonazol-TLT 250 and 1/2 litter Ryadimafon- vayleton 25 and mix with water for a hectar." and

[Option 1] = "Use resistant variety." and

[The Problem] = "The disese that identified is Leaf rust to know more click the underlined part."

RULE [SR]

If [Crop-Type] = "Wheat" and [Lesion] = "false" and [Affected-part] = "leaf and steam" and [Weather] = "Warm" and [Pustel] = "true" and [Pustel-color] = "Dark-Orange" and

[Spore] = "true" and [Spore-color] = "Reddish-Brown" and [Stem-completely-girdled] = true

Then [Option 2] = "Use 1/2 litter anti fungus chemical peropikonazol-TLT 250 and 1/2 litter Ryadimafon- vayleton 25 and mix with water for a hectar." and

[Option 1] = "Use resistant variety." and

[Recommendation] = "Use the following Managment Options" and

[The Problem] = "The disese that identified is Steam Rust to know more click the underlined part."

RULE [ST]

If [Crop-Type] = "Wheat" and [Lesion] = "true" and [Lesion-Color] = "Yellow" and

[Affected-part] = "Leaf" and [Pustel] = "false" and [Spore] = "false" Then [Recommendation] = "Use the following Managment Options" and

[The Problem] = "The disese that identified is Septoria-Tritici to know more click the underlined part."

RULE [CBD]

If [Crop-Type] = "Wheat" and [Lesion] = "false" and [Affected-part] = "seed" and
[Weather] = "cool Temperature" and [Pustel] = "false" and [Spore] = "true" and
[Spore-color] = "Dark-Brown" Then [Recommendation] = "Use the following Managment Options"
and
[The Problem] = "The disese that identified is Common bunt Disease to know more click the
underlined part."

RULE [Strip]

If [Crop-Type] = "Wheat" and [Lesion] = "true" and [Lesion-Color] = "Yellow-Orange" and
[Affected-part] = "Leaf" and [Lesion-Shape] = "Round-blister-like" and [Pustel] = "false" and
[Spore] = "false"

Then [Recommendation] = "Use the following Managment Options" and

[The Problem] = "The disese that identified is Strip Rust to know more click the underlined part."

RULE [CRR]

If [Crop-Type] = "Wheat" and [Lesion] = "true" and [Lesion-Color] = "Yellow" and [Affected-part] =
"Leaf" and [Weather] = "High humid" and [Pustel] = "false" and [Spore] = "false"

Then [Recommendation] = "Use the following Managment Options" and

[The Problem] = "The disese that identified is Common bunt Disease to know more click the
underlined part."

PROMPT [Crop-Type] ForcedChoice CF

"Select Crop type ?"

"Maize"

"Wheat"

PROMPT [Lesion] ForcedChoice

"Wold you observe lesion on the plant ?"

"true"

"false"

PROMPT [Lesion-Color] ForcedChoice CF

"What is the color of the lession ?"

"Gray-Green"

"Yellow-tan"

"Orange-Brown"

"Redish-brown"

"Yellow"

"Yellow-Orange"

"Light-Brown"

PROMPT [Affected-part] ForcedChoice CF

"In which part of the plant you observe the symptom ?"

"Leaf"

"leaf and steam"

"seed"

PROMPT [Weather] ForcedChoice CF

"Weather condition of the enviroment is:"

"High humid"

"cool Temperature"

"Mild-Warm"

"Warm"

PROMPT [Lesion-Shape] ForcedChoice CF

"Would you identify the shape of the lession ?"

"Cigar-Shape"

"Rectangular"

"Round"

"Diamond-Rectangular"

"Round-blister-like"

PROMPT [Pustel] ForcedChoice

"Would you observe Pustle on the plant?"

"true"

"false"

PROMPT [Pustel-color] ForcedChoice CF

"Pustel-color is:"

"Orange"

"Dark-Orange"

PROMPT [grainy-orange-dust-on-the- leaf] ForcedChoice CF

"Grainy orange dust on the leaf ?"

"true"

"false"

PROMPT [Spore] ForcedChoice

"Wold you observe spores ?"

"true"

"false"

PROMPT [Spore-color] ForcedChoice CF

"Spore-color is:"

"Dark-Black"

"Reddish-Brown"

"Dark-Brown"

PROMPT [Stem-completly-girdled] YesNo CF

"Stem completly girdled ?"

DEFAULT [The Problem] = "Not select the right sysmptom please try again!" @ 80

GOAL [Option 3]

GOAL [Option 2]

GOAL [Option 1]

GOAL [Recommendation]

GOAL [The Problem]

MINCF 80

REM : Fertilizer Managment

RULE [m1]

If [crop name] = "maize" and [altitude] = "Highland" and [fertilizer type] = "DAP"

Then [Method of Application:] = "Apply the whole fertilizer at planting" and

[Recommendation] = "Use100 kg of DAP"

RULE [mm]

If [crop name] = "maize" and [altitude] = "Midland" and [fertilizer type] = "DAP"

Then [Method of Application:] = "Apply the whole fertilizer at planting" and

[Recommendation] = "Use100 kg of DAP"

RULE [m3]

If [crop name] = "maize" and [altitude] = "Low moisture stress" and [fertilizer type] = "DAP"

Then [Method of Application:] = "Apply the whole fertilizer at planting" and

[Recommendation] = "Use150 kg of DAP"

RULE [m4]

If [crop name] = "maize" and [altitude] = "Highland" and [fertilizer type] = "Urea"

Then [Method of Application:] = "Apply at 3 splits- 1/3 at planting, 1/3 at knee height and 1/3 at flowering" and

[Recommendation] = "Use 50 kg of Urea"

RULE [m6]

If [crop name] = "maize" and [altitude] = "Midland" and [fertilizer type] = "Urea"

Then [Method of Application:] = "apply half at planting and half at knee height." and

[Recommendation] = "Use 100 kg of Urea"

RULE [m7]

If [crop name] = "maize" and [altitude] = "Low moisture stress" and [fertilizer type] = "Urea"

Then [Method of Application:] = "apply the whole fertilizer at knee heght." and

[Recommendation] = "Use 200 kg of Urea"

RULE [maize]

If [crop name] = "maize" and [fertilizer type] = "Manuer"

Then [Method of Application:] = "apply 10-15 days Before planting." and

[Recommendation] = "16 tone per hactar"

RULE [maize1]

If [crop name] = "maize" and [fertilizer type] = "all"

Then [Recommendation] = "5tone compost plus 50 kg DAP at plantin and 35 kg Urea at knee height per hectar."

RULE [w1]

If [crop name] = "wheat" and [altitude] = "Highland" and [fertilizer type] = "DAP"

Then [Method of Application:] = "Apply the whole fertilizer at planting" and

[Recommendation] = "Use100 kg of DAP"

RULE [w2]

If [crop name] = "wheat" and [altitude] = "Midland" and [fertilizer type] = "DAP"

Then [Method of Application:] = "Apply the whole fertilizer at planting" and

[Recommendation] = "Use150 kg of DAP"

RULE [w3]

If [crop name] = "wheat" and [altitude] = "Low moisture stress" and [fertilizer type] = "DAP"

Then [Method of Application:] = "Apply the whole fertilizer at planting" and

[Recommendation] = "Use100 kg of DAP"

RULE [w4]

If [crop name] = "wheat" and [fertilizer type] = "Urea"

Then [Method of Application:] = "Apply at 3 splits- 1/3 at planting, 1/3 at knee height and 1/3 at flowering" and

[Recommendation] = "apply 50 kg urae 1/3 at sowing and 2/3 at mid tillering"

PROMPT [crop name] ForcedChoice CF

"what is the name of the crop ?" "maize" "wheat"

PROMPT [altitude] ForcedChoice CF

"What is the altitude of the area ?"

"Highland""Midland""Low moisture stress"

PROMPT [fertilizer type] ForcedChoice CF

"What type of fertilizer whould you use ?"

"DAP""Urea""Manuer""all"

GOAL [Method of Application:]

GOAL [Recommendation]

MINCF 50

B3: Weed Managment

RULE [wm]

If [Crop_Type] = "Wheat" and [Managment_Time] = "Befor_Sowing"

Then [Other_Option-3:] = "Mix Derby and Starane_M with pumasuper and topic" and

[Managment Option 2: To Avoid all type Of Weed:] = "Use 1-L-24 D, 100ml Derby or 1LStara_M and mix with 200-400_liter of water/ha" and

[Managment Option-1:] = "Use crop rotation, Use clean seed."

RULE [wm1]

If [Crop_Type] = "Wheat" and [Weed_Type] = "Grass_weed" and [Managment_Time] = "After_Sowing" and [Labour_Available] = "false"

Then [Other_Option-3:] = "Mix Derby and Starane_M with pumasuper and topic" and

[Managment Option 2: To Avoid all type Of Weed:] = "use 1L-24 D,100ml Derby or 1LStara_M and Mix wth 200-400_liter of water/ha" and

[Managment Option-1:] = "Use hrbicide 0.8-1_Liter pumasuper or use 0.75 -1_Liter Topic and Mix wth 200-400_liter of water/ha"

RULE [wms1]

If [Crop_Type] = "Wheat" and [Weed_Type] = "Grass_weed" and [Managment_Time] = "After_Sowing" and [Labour_Available] = "true"

Then [Other_Option-3:] = "Mix Derby and Starane_M with pumasuper and topic" and

[Managment Option 2: To Avoid all type Of Weed:] = "use 1L-24 D,100ml Derby or 1LStara_M and Mix wth 200-400_liter of water/ha" and

[Managment Option-1:] = "Hand_weeding twice at 25-30 and 55-60 days after emergence"

RULE [wm2]

If [Crop_Type] = "Wheat" and [Weed_Type] = "Grass_and_Broad_Leaf_weeds" and

[Managment_Time] = "After_Sowing" and [Labour_Available] = "true"

Then [Other_Option-3:] = "Mix Derby and Starane_M with pumasuper and topic" and

[Managment Option 2: To Avoid all type Of Weed:] = "use 1L-24 D,100ml Derby or 1LStara_M and Mix wth 200-400_liter of water/ha" and

[Managment Option-1:] = "Hand_weeding twice at 25-30 and 55-60 days after emergence"

RULE [wm6]

If [Crop_Type] = "Wheat" and [Weed_Type] = "Grass_and_Broad_Leaf_weeds" and

[Managment_Time] = "After_Sowing" and [Labour_Available] = "false"

Then [Other_Option-3:] = "Mix Derby and Starane_M with pumasuper and topic" and

[Managment Option 2: To Avoid all type Of Weed:] = "Use 1-L-24 D, 100ml Derby or 1LStara_M and mix with 200-400_liter of water/ha" and

[Managment Option-1:] = "Use hrbicide 0.8-1_Liter pumasuper or use 0.75 -1_Liter Topic and Mix wth 200-400_liter of water/ha"

RULE [wm3]

If [Crop_Type] = "Maize" and [Managment_Time] = "Befor_Sowing"

Then [Other_Option-3:] = "Mix Derby and Starane_M with pumasuper and topic" and

[Managment Option 2: To Avoid all type Of Weed:] = "Use 1-L-24 D, 100ml Derby or 1LStara_M and mix with 200-400_liter of water/ha" and

[Managment Option-1:] = "Use crop rotation, Use clean seed."

RULE [wm4]

If [Crop_Type] = "Maize" and [Weed_Type] = "Grass_weed" and [Managment_Time] = "After_Sowing" and [Labour_Available] = "true"

Then [Managment Option 2: To Avoid all type Of Weed:] = "Use hrbicide primagram or Gesaprim 4-5Liter pumasuper and Mix wth 200-400_liter of water/ha" and

[Managment Option-1:] = "Hand_Weeding at 25-30 days and second at knee height and or Slashing at flowering stage."

RULE [wm5]

If [Crop_Type] = "Maize" and [Weed_Type] = "Grass_weed" and [Managment_Time] = "After_Sowing" and [Labour_Available] = "false"

Then [Managment Option 2: To Avoid all type Of Weed:] = "Use 1-L-24 D, 100ml Derby or 1LStara_M and mix with 200-400_liter of water/ha" and

[Managment Option-1:] = "Use hrbicide primagram or Gesaprim 4-5Liter pumasuper and Mix wth 200-400_liter of water/ha"

RULE [wm6]

If [Crop_Type] = "Maize" and [Weed_Type] = "Grass_and_Broad_Leaf_weeds" and

[Managment_Time] = "After_Sowing" and [Labour_Available] = "false"

Then [Managment Option 2: To Avoid all type Of Weed:] = "Use hrbicide primagram or Gesaprim 4-5Liter pumasuper and Mix wth 200-400_liter of water/ha" and

[Managment Option-1:] = "Hand_Weeding at 25-30 days and second at knee height and or Slashing at flowering stage."

RULE [wm7]

If [Crop_Type] = "Maize" and [Weed_Type] = "Grass_and_Broad_Leaf_weeds" and

[Managment_Time] = "After_Sowing" and [Labour_Available] = "true"

Then [Managment Option 2: To Avoid all type Of Weed:] = "Use hrbicide primagram or Gesaprim 4-5Liter pumasuper and Mix wth 200-400_liter of water/ha" and

[Managment Option-1:] = "Hand_Weeding at 25-30 days and second at knee height and or Slashing at flowering stage."

PROMPT [Crop_Type] ForcedChoice CF

"Choose Croke_Type ?""Wheat""Maize"

PROMPT [Weed_Type] ForcedChoice CF

"What type of weed you observe ?""Grass_weed""Grass_and_Broad_Leaf_weeds"

PROMPT [Managment_Time] ForcedChoice CF

"Which managment option you want to know?""Befor_Sowing""After_Sowing"

PROMPT [Labour_Available] ForcedChoice CF

"Labour_Available ?""true""false"

DEFAULT [Other_Option-3:] = "No more better option"

GOAL [Other_Option-3:]

GOAL [Managment Option 2: To Avoid all type Of Weed:]

GOAL [Managment Option-1:]

MINCF 100

Appendix C: System Evaluation Questionnaire

Web based agronomy advisory system System evaluation Questionnaire

Objective:

This survey is conducted to gather data for the evaluation of Web based agronomy advisory system.

Instruction: Choose and circle the most appropriate score for each question given below.

Score	
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

No	Evaluation Questions	Rating Scales				
1	The system is easy to learn	1	2	3	4	5
2	The system is easy to use	1	2	3	4	5
3	Instructions are easy to understand	1	2	3	4	5
4	The system enables user to take decision and provide advice	1	2	3	4	5
5	The navigation links are easy to understand					
6	The system provides appropriate explanation for users (why and how)question	1	2	3	4	5
7	The system is complete enough to provide intended advice	1	2	3	4	5
8	The system increases users confidence	1	2	3	4	5
9	The system response is quick	1	2	3	4	5
10	The decision made by the system is correctly compared to what the experts consider to be right	1	2	3	4	5
11	The system can be used as a training tool to transfer experts knowledge to middle level agriculture extension workers and others	1	2	3	4	5
12	The user interface design has consistent look and feels	1	2	3	4	5
13	Navigations are easy to use.	1	2	3	4	5
14	The system helps users to save time	1	2	3	4	5

Appendix D: Result analysis of users' feedback towards the system

Evaluation Criteria	Q No	Questions	Rating Scale					Total score	Average Score	Overall
			1	2	3	4	5			
Usability	1	The system is easy to learn			1	7	5	56	4.31	4.62
	2	The system is easy to use				4	9	61	4.69	
	3	Instructions are easy to understand				5	8	60	4.62	
	4	The navigation links are easy to understand			1	5	7	58	4.46	
	5	The user interface design has consistent look and feels					13	65	5.00	
Impact of the system in the behavior and decision of the user	6	The system increases users confidence			4	8	1	49	3.77	3.74
	7	The system enables user to take decision and provide advice			5	7	1	42	3.23	
	8	The system helps users to save time			3	10		47	3.62	
Impact of the quality of the information provided to the user	9	The system provides appropriate explanation for users (why and how) question			4	8	1	49	3.77	3.87
	10	The system is complete enough to provide intended advice		2	5	6		43	3.31	
	11	The decision made by the system is correct compared to what the experts consider to be right				5	8	60	4.62	
	12	The system responses is quick			4	8	1	49	3.77	
Usefulness	13	The system can be used as a training tool to transfer experts knowledge middle level agriculture extension worker and others			3	7	3	52	4.00	4.27
	14	The system is helpful to the user				6	7	59	4.54	
Overall evaluation = 4.12										

Appendix E: Major wheat disease

Type of Crop Disease	Major identified symptoms	Favorable condition	Control method/ management
----------------------	---------------------------	---------------------	----------------------------

Leaf Rust	Small, orangish-brown lesions of the leaves Blister-like lesions are most common on leaves of the wheat Smaller, more round lesions, and cause tearing of the leaf tissue	Mild warm temperature (70s-80F°)	Use resistant variety and crop rotation else Spray ½ liter Tilt 250Ec mixed in 150-200 liter of water /hectare. The second spray may be done after 3-4 weeks
Stem rust	Blister-like lesions on leaves of wheat Reddish-brown spores of the fungus Bright yellow streaking	Moisture for night time dews	Use resistant variety and crop rotation else Spray ½ liter Tilt 250Ec mixed in 150-200 liter of water /hectare. The second spray may be done after 3-4 weeks
Powdery Mildew	White lesions on leaves and leaf sheaths. White, cottony growth of the fungus	Cool and wet weather	
Barley yellow dwarf	Wheat leaves to have a yellow or red discoloration A flame-like appearance of wheat leaves Shorter length of the wheat crop than neighboring healthy wheat	Vectored by an aphid	
Loose smut (Ustilago tritici)	Heading crop taller and mature earlier than surrounding healthy crops Black powdery spores blow away to leave a bare stalk	Crop residue in the farm	
Take-All Root Rot	Development of white heads during the grain filling period. soil Roots changed from dark brown to black color as of fungal invasion Plant can be easily pulled from the soil	Cool and moist	

Common Root Rot	Premature death of wheat Patches of white heads scattered throughout a field	Crop Residue in the farm	
Septoria tritici blotch (Septoria tritici)	Tan, elongated lesions on wheat leaves lesions may have a yellow margin darker color leaf blotch or tan spot	High moisture and high humidity	
Stripe rust	Small, round, blister-like lesions that merge to form stripes Yellow-orange color of lesions	High moisture	Use resistant variety and crop rotation else Spray ½ liter Tilt 250Ec mixed in 150-200 liter of water /hectare. The second spray may be done after 3-4 weeks
Bacterial streak	Water soaked areas between leaf veins Water-soaked areas become tan streaks within a few days Lesions dry to form a clear, thin film on leaf	Wheat curl mite	

Appendix F: Major Maize disease

Type of Crop Disease	Major identified symptoms	Favorable condition	Control method/ management
Gray Leaf Spot	yellow to tan in color and look similar to those produced by other diseases except they have a faint watery halo which can be seen when held up to the light. After about two weeks the lesions appear tan to brown in color and rectangular in shape, bordered by the veins of the leaf. When fully expanded, individual	warm, wet, humid weather	<ul style="list-style-type: none"> • Select hybrids with moderate resistance. • A two-year crop rotation away from corn Fungicides are recommended Control weeds - this will help to

	lesions may be 3 to 4 inches long and 1/16 to 1/8 inch wide, depending on the distance between veins		increase airflow and dry the canopy faster.
Leaf Rust	Leaf rust causes very small (about 1/32 inch long by 1/64 inch wide), orange pustules that erupt through the leaf surface. In some cases, pustules are surrounded by a narrow yellow or white halo. The pustules contain masses of powdery orange spores of the rust fungus. Spores may spill out of pustules and form a grainy orange dust on the leaf surface around the pustule. As leaves age, pustules begin to produce dark black spores instead of orange spores. These black pustules look like tars spots and are most easily seen on the lower leaf surface and leaf sheaths. Leaf rust pustules occur randomly across the leaf; this distinguishes leaf rust from stripe rust, which has narrow yellow stripes of pustules. Leaf rust typically occurs uniformly across a field.	avored by moisture and cool temperatures (59-72 F)	<ul style="list-style-type: none"> • Resistant varieties, • seed treatment fungicides, and • Plant early-maturing cultivars.
leaf blight	Long cigar-shaped gray-green or tan lesions. As the disease develops, the lesions spread to all leafy structures, including the husks.	Wet, cool, humid weather, minimum tillage, and continuous corn.	<ul style="list-style-type: none"> • Choose resistant varieties. • plant disease-free seed, • As the disease is seed borne. Do not plant maize after maize in the same field.
Stalk rot and ear rot	Whitish-pink cottony fungal growth develops on and between the kernels and sometimes on the silks. Infected plants are weakened and can break easily during strong winds and rains.		<ul style="list-style-type: none"> • use of resistant varieties • the use of optimum plant populations and nitrogen applications
maize dwarf mosaic virus	Light and dark green patches form a mosaic pattern on leaves, with some ring spots. Highly susceptible varieties may have many yellow leaves as well. Plants infected early are very stunted, with significant yield loss		<ul style="list-style-type: none"> • The spread of the virus is due to aphids transmitting the virus from one infected plant to another. Control volunteer grasses such as Johnson grass, which is a host for

			the virus. • Use tolerant varieties.
Corn rust	Small round to oval, brown or orange pustules distributed uniformly over the upper leaf surface. Brown to black circles may appear around the pustules. Severely affected leaves turn yellow and die early. Ears on severely affected plants are much lighter than normal and the seeds are pinched and loose on the cob		Control volunteers and other grass weeds that may act as a host to the fungus. Avoid planting two maize crops in a row. Plant resistant varieties if available
Downy mildew	Maize is most susceptible to downy mildew from seedling to anthesis stages. Symptoms include white and yellow striping of leaves and leaf sheaths and stunting of the whole plant, which produces no yield. The other major symptom is downy growth on or under the leaf due to conidia formation		Choose resistant varieties. Late plantings also favors the disease, so plant on time. Avoid planting maize after maize in the same field

Appendix G: Insect/Pest

Name	Affected part	Color of pest	Symptom on affected part	Management
Termites	Roots of the plant	White and honey	Patches of crop death	Use Diazinon 60% EC at 2.5li/ha,GUFOS at 200ml/ha and fipronil at 10-11.7 ml/kg
Maize stem borer	Stem and leaves	Young larvae- pink or yellow grey with black head Older larvae-whitish and spotted	Eggs are laid in cluster at top side of leaves	Use Diazinon 60%(1-2li/ha),Ethiosulfan 35%(2-2.5li/ha), carbayle 1.28kg/ha
Maize weevil	grain	Reddish spots in the	Large irregular hole	

		wing or dark brown	in the kernel	
Aphids				1kg of primor and 1.5kg chlorimyphos mix with 300-500 liter of water/hectar
Army worm				Spray 2-3 liter of malathion or 1.5 of carbaryl powder in 250-400 liters of water/ha.
Grasshoppers				250g carbaryl 85% WP mixed with 25-30 kg barley bran or wheat bran spread on one hectare or 1.5 liter of malathion 95%ULV/hectar
Grain moth				

Appendix H: Wheat and Maize Variety

Wheat variety

Variety type	Variety name	adaptation	Altitude	rainfall	Seed rate kg/ha	Fertilizer in kg/ha		Maturity-day	Resistance	yield	Owner	Protein Content
						DA P	Urea					
Bread	Danda's	Mid-highland area	2000-2600	>2600	150-175	150	50	110-145	Stem Rust	25-50	EIAR	12
Bread	kakaba	Low-mid-highland	1500-2200	500-800	150-175	100	50	90-120	LR, SEP	25-47	' =	14.6
Bread	galili		1800-2400	>550				113				11.5
Drum	toltu	Sinana,agarfa, adaba,gasser a	23-2600	500	150	46	41	125-135	YR,SR,LR	30-42	SARC/OARC	9.4
Drum	shorima	Hiland-arsi,holeta,debrezeit,gojama,esternwelega	2100-2700	700-1100		100	50	98-157	yellowrust SR,SEptoria,LR	23-44	KARK	13.62
Drum	hoggana	Arsi,bale,hol eta	2200-2800	800-1200	150			121-175	yellowrust SR,SEptoria	28-54	' =	11.55

									a,LR			
Drum	Tsehay	North shewa	2600-3100	>900	175	225	300	138	YR	28-35	ARARI(amararegion)	10.5
Drum	hulluka	highland	22-2600	500-800	150-175	100	50	133	Sr,lr,yr	38-60	KARC/EIAR	11.7
Drum	ogolcho	l-midaltitude	1600-2100	400-500	125-150	100	50	102	'	23-35	'	12.5

Maize Variety

Variety type	Variety name	Altitude	Rainfall	Maturity-day	Resistance				Yield
					MSV	GLS	TLE	CLR	
Hybrid	BH-660	1600-2200	1000-1500	160	-	T	T	R	60-80
	BH-540	1000-2000	1000-1200	145	-	MT	MT	MT	50-56
	BH-140	1000-1700	1000-1200	145	-	MT	MT	MT	47-60
	BH-543	1000-2000	1000-1200	148	-	MT	MT	T	55-65
	BH-670	1700-2400	1000-1500	165	-	T	T	R	60-80
	BHQP-545	1000-1700	1000-1200	144	-	T	MT	MT	55-65
	BHQP-542	1000-1800	1000-1200	145	-	T	MT	MT	50-60
OPVs	Hora	1800-2400	1000-1200	170	-	T	T	T	40-45
	Gibe-1	1000-1700	1000-1200	145	-	MT	MT	T	40-45
	Gutto	1000-1700	800-1200	126	-	MT	MT	MT	25-30
	Melkasa-1	Low-moisture stress	600-1000	90	-	-	T	T	25-35
	Melkasa-2	Low-moisture stress	600-1000	130	-	-	T	T	45-55
	Melkasa-3	Low-moisture stress	600-1000	125	-	-	T	T	45-50
	Melkasa-4	Low-moisture stress	600-1000	105	-	-	T	T	30-35
	Melkasa-5	Low-moisture stress	600-1000	125	-	-	T	T	35-40
	Melkasa-6	Low-moisture stress	600-1000	120	-	-	T	T	30-40
Melkasa-7	Low-moisture stress	600-1000	115	-	-	T	T	30-40	
Abo-Bako	300-1000	900-1200	112	T	T	T	T	35-45	

Declaration

This project is my original work and has not been presented or submitted as a partial requirement for a degree in any other university.

Declared by:

Name: Feidu Akmel

Signature _____

Date: _____

Confirmed by advisor:

Name: Dida Midekso (PhD)

Signature: _____

Date: _____

Place and date of submission: Addis Ababa, October, 2014