DESIGNING CLOUD BASED AGRICULTURAL FRAMEWORK FOR ETHIOPIA

Fetene Birhanu Beyene
GSR/1519/08

A Thesis submitted to the Department of Computer Science and Engineering

School of Electrical Engineering and Computing

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Software Engineering

Office of Graduate Studies

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Declaration

I declare that this study is my original work submitted in partial fulfillment of the requirement for the degree of Master of Science in software engineering and has not been submitted for any Degree or Diploma in any University or conference. To the best of my knowledge, all source of materials used for the study has been duly acknowledged. I have undertaken the study with the guidance and support of the research advisor.

Fetene Birhanu

Signature ___________________________ Date ___________________

Advisor: Dr.RavindraBabu. B

Signature ________________________ Date __________________

Approval of Board of Examiners

We, the undersigned, members of the Board of Examiners of the final open defense by **Fetene Birhanu Beyene** have read and evaluated his/her thesis entitled "**Designing cloud-based agricultural framework for Ethiopia** the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master's in Software Engineering.

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External Examiner	Signature	Date

Acknowledgment

This thesis represents the peak point of my studies, so far, and it incorporates knowledge gathered from different sources, academics and professionals alike. First of all, I would like to express my deepest gratitude to the almighty God for his mercy, guidance, support; Glory to God. Next, I would like to express my sincere gratitude to my research advisor Dr. RavindraBabu. B (Ph.D. professor in Adama Science and Technology University) for his advice, patience and constructive criticisms of this work. Thirdly, my thanks go to all those participating on questioner; a ministry of agriculture mainly IT staff and marketing expert for their honest suggestion, cooperation in questioner and their voluntariness in explaining their view on the current agricultural sector. Finally, I would like to express my thanks to my father, mother, sisters, brothers, friends, and Samara university computer science staff members for their encouragement and suggestion that helped me to accomplish this thesis.

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List of Acronyms

ALSE- Agriculture Land Suitability Evaluator

CBA- cloud-Based agricultural framework

CPU – Central Processing Unit

DSS - Decision Support System

DFLMS- cloud-based Disease Forecasting and Livestock Monitoring System

EAS -Ethiopian agricultural sectors

GDP – Gross Domestic Product

FMIS - Farm Management Information System

GIS -Global Information System

ICT - Information and communication technology

IT - Information Technology

IaaS- Infrastructure as a Service

MOA- ministry of agriculture

NGOs- Non-Governmental Organizations

NIST- National Institute of Standards and Technology

PaaS- Platform as a service

SaaS- Softwareas a Service

SOA- Service-oriented architecture

WASS -Web-used Agricultural Support Service System

WSDL- Web Services Description Language

Abstract

Food security in the developing world, especially in Ethiopia, need to be more information concentrated than resource concentrate. This is achievable by considering and incorporating factors such as policy, legal framework, technology, knowledge, markets, research among others, in addressing food security. Millions of farm families and the rural poor require exact information and facts for their agricultural survival. Arguably, famine and poverty are concentrated in developing countries due to poor capacity to develop, to access and to manage agricultural information and facts about agricultural production. To address this, there is a need to integrate information required by the farmers and all stakeholders in agriculture into a single access point to access anywhere-anytime and by any device information.

To solve the existing problem in Agricultural sector we have proposed to design a cloud-based framework that integrate the agricultural services and minimize the technological costs, through interview and literature review on cloud computing as the research methodology The study used 14 experts' as participants from the ministry of agriculture whose were selected through sampling techniques. The result obtained from the interview shows that no single systems in Ethiopia agriculture that can afford enough access channel to serve the farming community.

The proposed framework is based on a hybrid cloud deployment model because of its suitability for an organization which wants to gain the benefits of both securities as well as cost-effectiveness. The framework also uses PaaS (Platform as a Service) as a service delivery model in the way that the user has full control over application and data. The integration of agricultural services will be based on SOA concepts with web services via cloud computing. The single access point will allow the stakeholders to interact and increase the benefit of shared and accessible information. By putting the farmer at the center of attention, the framework enables the farmers to get access to all services they required such as crop cultivation services, weather-related services, and agricultural extension services. Finally, the prototype of the designed framework has been developed using ASP.net to show the validity of the framework.

Keyword: Cloud Computing, Agriculture Sector, SOA, Web services

CHAPTER ONE

1. INTRODUCTION

In this chapter, background of the research and motivation to do this research has been presented. It presents an overall objective, methodology, the significance of the study, scope, and limitation of the thesis and problem that has to be addressed. Finally, an organization of the thesis is presented.

1.1. Background

Agriculture is the backbone of the Ethiopian economy and therefore this particular sector determines the growth of all the other sectors and, consequently, the whole national economy. On average, crop production makes up 60% of the sector's outputs whereas livestock accounts for 27% and other areas contribute 13% of the total agricultural value added. The sector is dominated by small-scale farmers who practice rain-fed mixed farming by employing traditional technology, adopting a low input and low output production system. The land tilled by the Ethiopian small-scale farmer accounts for 95% of the total area under agricultural use and these farmers are responsible more than 90% of the total agricultural output[1].

The small-scale farmers produce 94% of the food crops and 98% of the coffee, the latter being the leading export item for the country. The private and state commercial farms produce just 6% of food crops and 2% of the coffee production. These commercial farms use about 5% of the total cultivated land. Coffee, cotton, tea, fruits, and vegetables are the major crops grown by the few commercialized state farms, although with very minimal return despite huge investments in them [2]. With these statistics, one can easily infer to what extent the small-scale farmers are the key element in strengthening the effort towards agricultural growth and consequently to the overall economic growth.

Typically, the rural areas which depend on agriculture are information-poor and deficiency of facilities to apply recently invented technologies. It is a greaterimplication to apply Information technology to agricultural modernization and for the rapid growth of income of the farmers, for achieving the agricultural economy leap-forward development. In the past, Information technology is available only to some higher sections of society, but due to globalization, IT is rapidly available in all the corners of the world at less cost. In Agriculture, Information communication and technology (ICT) plays a vital role in fetching up-to-date information regarding weather reports, prices, usage fertilizer, sowing of crops etc., to farmers in rural areas. Currently, the government is pushing for improved technology delivery schemes even to remote rural areas by contribution telecom services which will help farmers to cultivate quality crops and to compete with the market.

Commonly improvement and development of technology would help Agriculture for picking the actual and expected benefits of Information Communication Technology (ICT). Cloud computing is one of the advancements in technology that increasingly becoming an essential component of any organization's computing strategy. Cloud computing enables small businesses to access ICT-related capabilities that were previously available only to businesses with the capacity to invest large amount of money in IT software and hardware and hire the necessary staff to service and maintain it. Sector including agriculture now understands that cloud computing offers the possibility of being able to effortlessly change Information Technology (IT) without expending the time and resources in setting up, configuring, and deploying new systems. This technology offers more efficient use of resources such as storage, memory, processing, applications, and bandwidth ensuring high availability, scalability, security, and quality.

Farmers make critical decisions throughout the year. These decisions include those based on choice of inputs (crop varieties and seeds, water, power, fertilizers and pesticides) and market connections related to them, farm operations (tillage, sowing, water management, fertilizer management, pest management, harvest), post-harvest operations and transactions (including storage, transport, marketing and processing) and others. Typically, farmers depend on gatheredskill and the support of local organizations (for instance, input suppliers, rural credit agencies, extension services, NGOs) for information related to both farm and non-farm decisions. They also receive information from radio and television broadcasts by experts and professionals from more distant sources. Together, these form the local information system accessible to a small farmer for making decisions. Often, this system is insufficient and various decisions are made with limited information. The decisions are also subject to high transaction costs and time delays. The role of ICT in such a scenario is to offer timely information, increase choice, reduce transaction costs, and contribute to improving the efficiency of decision making to increase rural incomes and improve the quality of life of the rural populations.

Cloud computing has application in almost all domains, scientific, engineering, commercial, social etc. Agriculture is another field which is vastlybenefitingfrom the applications of cloud computing. Farmers around the globe are using the IT resources for easy distribution and management of their crop-related data. Additional different hardware and software resources for monitoring the temperature, humidity, soil moisture, and luminosity measurement are also being deployed by the farming community [3]. Cloud computing increased productivity for agriculture and achievement the agricultural technology by directly connects the farmers to the operation through the cloud and shares their experience with communication and information sharing [4]. The benefits of cloud computing technology in agriculture can answer the issues of agricultural transformation and agricultural information, and also breakdown agricultural producers' limitations in technology, decrease duplication, improve consumption of existing resources to make up for dispersed, small-scale, regional differences agricultural production and the strong dependence on the natural climate for agricultural production [5].

By deploying information technology infrastructure and services over the network, an organization can be obtaining these resources on an as-needed basis and avoid the capital costs of software and hardware. With cloud computing, IT capacity can be used to speedily and easily to accommodate changes in demand. Though remotely hosted, control services have long been a part of the IT landscape, a sensitive interest in cloud computing is being powered by ubiquitous networks, growing standards, the increment of hardware and software virtualization, and push to make IT costs variable and transparent [6].

The benefits of cloud computing technology in agriculture can answer the issues of agricultural transformation and agricultural information, and also breakdown agricultural producers' limitations in technology, decrease duplication, improve consumption of existing resources to make up for dispersed, small-scale, regional differences agricultural production and the strong dependence on the natural climate for agricultural production [7].

1.2. Statement of the problem

Most farming activities in Ethiopia are on small scale and the problems of these farmers are complicated includingsub-divisions and small farm sizes, leading to low productivity; insufficient information and skills in up-to-date farming techniques and best methods of management; storage problems and insufficient farmer experience with the marketing of agricultural products, poor relationships between farmers, government, markets, researchers and extension workers. Also, Ethiopia farmers often lack adequate information on inputs, markets, improved technologies, commercial farming and other aspects of rural development, and the use of ICT to deliver training and information is a critical part for improving access to markets, production and productivity. Farmers want information on trending cropping techniques for pre-harvest, harvest, and post-harvest activities in an integrated and comprehensive platform to assist farmers in making a decision.

The development of modern technologies from time to time is changing the way of organization handle their business process and the need to adopt these technologies is becoming for a businessorganization to be competitive in the market. However, decision-makers are a challenge when it comes to the decision of adopting or not adopting these technologies. The decision to adopt cloud computing or new IT technologies for that matter is usually based on experts', experiences, vendor's recommendation, pre-adoption analysis to determine whether those particular technologiesmeet the strategic goal of the organization or not.

Ethiopian agriculture has been suffering from several external and internal problems. It has been inactive due to poor performances as a result of factors such as: Low resource utilization, Low farming techniques, Over-reliance on fertilizers and underutilized techniques for soil and water conservation, inappropriate farming policy, inappropriate land tenure policy, ecological degradation of potential arable lands, increase in unemployment rate due to increase in the population. Farmers in the rural areas depend on climate, use traditional method for cultivation crop, low use of modern agriculture equipment, machinery, agriculture planting and breeding technology, weather observation, and forecasting and do not have access to major marketplaces in the country. In addition, farmers do not have the option of getting climate conditions, good agricultural practices and market information of agricultural products in the major marketplaces other than their localities. Another major problem in our country is rural to urban migration as the unemployment ratio is constantly increasing. Generally, Ethiopian agriculture is dominating by subsistence, low input-low output; rain-fed farming system and droughts periodically reverse agricultural sector performance gains with devastating effects on household food security and poverty levels.

The main problem that this study focuses on the lack of a mechanism to collect information, lack of a formal mechanism to provide information for farming community, lack of an integrated system or mechanism to contain different services related to agriculture together, which mean service such as climate change, crop-related information, market status for crop, productivity, soil and pesticide detail, fertilizer information and the others. Therefore, the study was aimed to answers for the following research questions.

Research Question

1. Is the current ICT usage strategy efficient in Ethiopian agriculture?
2. Could cloud computing be an alternative solution for effective ICT service provision for agriculture?
3. Is it possible to develop a cloud-based framework that helps to integrate services related to agriculture?

1.3. Objective of the Study

1.3.1. General Objective

The main objective of this study is to examine the existing ICT infrastructure usage intheEthiopian agricultural sector and to design cloud-based framework for integrating service related to Agriculture.

1.3.2. Specific Objectives

The specific objectives of the study are:

- ✓ Identify the existing on-premise computing and cloud computing technologies and building a case for the agricultural sector to integrate service related to agriculture.
- ✓ Identify the main concerns and challenges that Agricultural sectors are likely to face when considering to integrate services through cloud computing technology
- ✓ Identifying the agricultural activities which need to be integrated together as a single access point.
- ✓ To design a cloud-based framework that integrated service of the agriculture sector.
- ✓ To evaluate framework by evaluating prototype to check its importance in helping farmers with discovering information at any time anywhere using any devices.

- ✓ To identify and recommend future research directions for further investigation of the benefits of the cloud for the agriculture sector.

1.4. Scope and Limitation

The study mainly covered examining the current ICT service delivery strategies to support Ethiopian agriculture industries, to show the applicability of cloud computing in the field of agriculture, designing Cloud Computing based framework for the Ethiopianagriculture sector and developing a prototype for the framework. This study did not consider the full implementation of the framework.

1.5. The significance of the Study

This study enables Ethiopian agricultural sectors to consider alternative ways of deploying information and communication technology (ICT) infrastructures for effective and efficient cultivation. In addition, gives insight into the ministry of agriculture (MOA) and concerned government sectors on how to invest ICT budget on Ethiopian agricultural sectors (EAS). In addition, serve as a bridge for the information gap between farmers, agricultural experts, soil testing labs, agriculture market, and other agriculture-related institutions. Additionally, the study will be used as a baseline for further studies of this new emerging ICT utilization to be considered in the different governmental and nongovernmental organization of Ethiopian in the flied of agriculture. The proposed cloud-based framework will be used as a baseline for Ethiopian agricultural sectors ICT managers on how to integrate service through cloud computing technology, implemented and used in Ethiopian agricultural sectors.

1.6. Organization of the Thesis

The rest of this study is organized as follows: Chapter two covered related literature on the basic concept of cloud computing: service types, deployment models, cloud challenges and benefits for agricultural sector, Challenges in ICT adoption by farmers to support Agriculture, Why the future of agriculture will depend much on ICTand related works done on cloud-based service frameworks locally and abroad in order to understand how it used in agriculture sectors. Chapter three describes the research methodology and strategy that aims to identify the potential cloud solutions that could be provided to the agricultural sector. Primary data collection and analysis technique were described as information acquisition method. Validity and reliability requirements also identified. In Chapter four, backgrounds of a framework for building the proposed Cloud-based Framework, the detail elements of the proposed cloud-based framework, the architectural components of the proposal for implementing a framework are given. Chapter five presents the results of the interview described in chapter three. The data collection method utilized was the semi-structured interview that provided both control and direction through a list of the question under the interview. Additionally, technological requirement identification for EAS also presented the implementation of the prototype and tools used to develop the framework have discussed. Finally, in chapter six conclusions about the research and suggestions for future research direction were presented.

CHAPTER TWO

2. LITERATURE REVIEW

This chapter reviews the different literatures that are related to the objective of the study. Literatures covered in this section are the basic concept of cloud computing: service types, deployment models, cloud challenges and benefits for agriculture sector, different publications about EAS (Ethiopian agricultural sector) existing ICT usages and related works done on cloud-based service frameworks locally and abroad in order to understand how it is used in agriculture sectors.

2.1. Cloud computing

Over the last few years, many IT professionals, business managers, and researchers have started to talk about a new phenomenon called cloud computing. Each of these groups defined cloud computing differently according to their understanding of its offerings. Although there was no agreement about what precisely constituted cloud computing, it still offered a promising paradigm that could enable businesses to face market volatility in an agile and cost-efficient manner [8].According to [9], Cloud computing is a system, where the resources of a data center are shared using virtualization technology, which also provides elastic, on-demand and instant services to its customers and charges customer usage as a utility bill.

The most widely accepted definition NIST [10], defined Cloud computing as" a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". Regarding its relations to other pre-existing computing models, cloud computing can be used in principle to deliver computing services, including grid computing services, high-performance computing services, etc. This does not imply that cloud computing is a replacement for grid computing, high-performance computing, or any other pre-existing computing model. Instead, cloud computing should be thought of as a new business model that aims at service delivery in a highly scalable and highly flexible manner. The difference between cloud computing and other pre-existing computing models can be better demonstrated by ways of using the characteristics, service, deployment models and its key enabling technologies of virtualization.

2.2. Characteristics of Cloud Computing

According to NIST, [10] and Chaudhry, [11], cloud computing exhibits its own essential characteristics such as; on-demand service, wide network approach, resource pooling, fast elasticity and measured service which demonstrate their relation to, and differences from, traditional computing approaches:

On-demand self-service means a consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider. Cloud computing focuses on IT services which are driven by users' requests. It provides a means of delivering computing services that make the underlying technology, beyond the user device, almost invisible.

Wide network approach permits customers to acquire computing resources IT services anytime, anywhere, and through the user-chosen device (e.g., mobile phones, tablets, laptops, and workstations). Users accessing services via Internet technologies expect a secure, "always-on" computing infrastructure that delivers as easily and reliably as electricity from a wall outlet.

When we say resources pooling the provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location-independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth.

A cloud service has characteristics of fast elasticity means that provides the quick and self-regulating raise and reduces to the quantity of present computer transforming, storage,and network bandwidth as request by customer requirement. It is assumed that changes in the resource infrastructure needs are announced first to the middleware manager and then that such changes can be maintained automatically.

Cloud computing resource usage can be measured, controlled, and reported providing transparency for both the provider and consumer of the utilized service. Cloud computing services use a metering capability which enables to control and optimize resource use. This implies that just like airtime, electricity or municipality water IT services are charged per usage metrics – pay per use. The more you utilize the higher the bill. Just as utility companies sell power to subscribers, and telephone companies sell voice and data services, IT services such as network security management, data center hosting or even departmental billing can now be easily delivered as a contractual service.

Cloud system automatically control and optimize resource usage by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, or active user accounts). Resource usage can be managed, measured and reported to provide for both the provider and consumer of the service. Based on this metering and accounting capability of cloud computing, users pay only for the service they are used. Thus, billing is based on resource consumptions such as CPU hours used, the volume of data moved, or gigabytes of data used.

Cloud allows the dynamic integration and extraction of computing resources. Cloud services exist for provisioning, often look to be limitless and can be obtained in any quantity at any time. Elasticity is an essential feature of cloud systems and circumscribes the capability of the underlying infrastructure to adapt to changes. This cloud capability allows service users to create an elastic environment that can expand and target performance parameters. In general, it assumed that changes in the resource infrastructure needs are announced first to the middleware manager and then such changes can be maintained automatically.

The cloud provider’s computing resources such as storage, processing, network bandwidth, and virtual machines are shared to serve many consumers using a multi-tenant model, thus, different physical and virtual resources dynamically allocated and reallocated according to consumer demand. Even private clouds tend to share resources between different parts of the same organization. There is no location dependence in that the customer commonly has no management over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter).

2.3. Cloud Computing Service Model

Cloud computing means using infrastructure as a service and that service may beanything from renting raw hardware to using third-party APIs. In practice, cloud service providers tend to offer services that can be grouped into three categories: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

2.3.1. Infrastructure as a Service (IaaS)

The capability provided to the customer of IaaS is raw storage space, computing, or network resources with which the customer can run and execute an operating system, applications, or any software that they choose. The cloud customer is not able to control the distribution of the software to a specific hardware platform or change parameters of the underlying infrastructure, but the customer can manage the software deployed (generally from the boot level upward). Thus, dynamic scaling, usage-based pricing, reduced costs and access to superior IT resources are some of the benefits of IaaS.

2.3.2. Software as a Service (SaaS)

SaaS is one of the service deployment mechanisms which enable users'access to different software from the cloud wherever they are, and whenever they need without installing it on their machine. Instead of installing, maintaining and managing complex software and hardware task, SaaS allows to simply accessing the application through a thin client interface, such as a web browser., the consumer uses an application without having hardware or software to buy, install, maintain, update, and manage the infrastructure on which the applications running. SaaS applications run on a SaaS provider's servers and the provider manages access to the application, including security, availability, and performances using open standards apply at the application level [12].

2.3.3. Platform as a Service (PaaS)

The Platform as a Service model describes a software environment in which a developer can create and deploy cloud application customized solutions within the context of the development tools that the platform provides. These applications could be for use by the client or accessible as a service to others. Creating applications using PaaS means that they are inherently cloud-enabled and the PaaS provider also provides the service upon which these applications run [13].

In the traditional model of software development applications are written in one environment, tested in another environment and deployed elsewhere [14]. PaaS is a combination of a development platform and a solution stack, delivered as a service on demand.

In the case of PaaS, the cloud provider not only provides the hardware, but they also provide a toolkit and a number of supported programming languages to build higher-level services (i.e. software applications that are made available as part of a specific platform). The users of PaaS are typically software developers who host their applications on the platform and provide these applications to the end-users. Programming platforms and tools (such as .NET, java or python) and APIs for building cloud-based applications and services are exposed to developers who can create applications for testing or for commercial purposes for a minute fraction of the cost of provisioning server infrastructure for themselves. The difficulty with PaaS is that it locks the developer and the customer into a solution that is dependent upon the platform vendor. An application written in Python against Google's API using the Google App Engine is likely to work only in that environment. There is considerable vendor lock-in associated with a PaaS solution.

<table>
<tr><td rowspan="3">Software as a service</td><td>Application</td><td rowspan="3">Application and Information Centric
Allow the consumer to use provider’s application running of cloud infrastructure.

Provides various business models and application processes
Ex. Amazon web services,salesforce.com CRM, Google APP</td></tr>
<tr><td>Runtime</td></tr>
<tr><td>Hardware</td></tr>
<tr><td rowspan="3">Platform as a service</td><td>Application</td><td rowspan="3">Development Centric
Provide a cloud platform to deploy consumer application created using software development kits and tools supported by the provider.
Provide web based runtime development and operating environment
Ex. Amazon EC2, Google APPs, Google Engines</td></tr>
<tr><td>Runtime</td></tr>
<tr><td>Hardware</td></tr>
<tr><td rowspan="3">Infrastructures as a service</td><td>Application</td><td rowspan="3">Infrastructure Centric
Provide virtual hardware resources such as server, storage, network and other fundamental computing resources
EX. Amazon S3, IBM,HP</td></tr>
<tr><td>Runtime</td></tr>
<tr><td>Hardware</td></tr>
</table>

Table 2.1: Service delivery model

2.4. Cloud Computing Deployment Model

Deployment models broadly characterize the management and disposition of computational resources for the delivery of services to consumers, as well as the differentiation between classes of consumers. Clouds can also be classified based upon the underlying infrastructure deployment model as Public, Private, Community, or Hybrid clouds. The different infrastructure deploymentmodels are distinguishing by their architecture, the location of the datacenter where the cloud is realized, and the needs of the cloud provider's customers (for example, due to regulatory, legal, or other requirements).

2.4.1. Public cloud services

A public cloud's physical infrastructure is owned by a cloud service provider. Such a cloud runs applications from different customers who share this infrastructure and pay for their resource utilization on a utility computing basis. The cloud services are available for anyone to subscribe and to use in a pay-as-you-go manner, a public cloud customer can access these services over the internet from a third-party provider who may share computing resources with many customers.
The public cloud model is widely accepted and adopted by many enterprises because the leading public cloud vendors as Amazon, Microsoft, and Google, have equipped their infrastructure with a vast amount of data centers, enabling users to freely scale and shrink their rented resources with low cost and little management burden [16]. [17] Lists some of the advantages and drawbacks of the public cloud.

The advantages of public cloud computing include:

1. Data availability and continuous uptime
2. 24/7 technical expertise
3. On-demand scalability
4. Easy and inexpensive setup
5. No wasted resources

Drawbacks of the public cloud:

- Data security
- Privacy

2.4.2. Private cloud service

Private cloud infrastructure may be set-up On-Premise or off-premise and may be managed either internally or by third-party service providers. Private clouds offer the highest level of security and control but are expensive. A private cloud is built for the exclusive use of one customer, who owns and fully controls this cloud. Additionally, there are variations of this in terms of ownership, operation, etc. The fact that the cloud is used by a specific customer is the distinguishing feature of any private cloud. A private cloud might be owned by the customer, but built, installed, and managed by a third party rather than the customer. The physical servers might be located at the customer's premises or sited in a collocation facility. The difference between a private cloud and a public cloud is that in a private cloud-based service, data and processes are managed within the organization, a third party, or some combination of them, and it may exist on or off premises. A private cloud provides more security than public clouds because in public cloud the user may not know where their data is stored or how it is backed up and whether unauthorized users can get access to it.

2.4.3. Community cloud service

A community cloud falls between public and private clouds with respect to the target set of consumers. It is somewhat similar to a private cloud, but the infrastructure and computational resources are exclusive to two or more organizations [17]. The cloud infrastructure is provisioned for exclusive used by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises. A community cloud provides many of the benefits of the scale of the public cloud while retaining greater control over compliance and data privacy. The advantages [17] of community cloud include: The cost of setting up a communal cloud versus individual private cloud can be cheaper due to the division of costs among all participants.

1. Management of the community cloud can be outsourced to a cloud provider. The advantage here is that the provider would be an impartial third party that is bound by contract and that has no preference for any of the clients involved other than what is contractually mandated.

2. Tools residing in the community cloud can be used to leverage the information stored to serve consumers and the supply chain, such as return tracking and just-in-time production and distribution.
3. Since it is managed by contract with an impartial third party or by one of or the combined expertise of the whole community, it has the advantage of security and privacy over the public cloud. Drawbacks of community cloud are costs higher than public cloud.

2.4.4. Hybrid Cloud service

The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds). A hybrid cloud is typically offered in one of two ways: a vendor has a private cloud and forms a partnership with a public cloud provider, or a public cloud provider forms a partnership with a vendor that provides private cloud platforms. In a hybrid cloud, an organization provides and manages some resources in-house and some out-house. Hybrid clouds [17] offer the cost and scale benefits of public clouds, while also offering the security and control of private clouds. The advantages of the hybrid cloud include:

1. Reduces capital expenses as part of the organization's infrastructure, needs are outsourced to public cloud providers.
2. Improves resource allocation for temporary projects at a vastly reduced cost because the use of the public cloud removes the need for investments to carry out these projects.
3. Helps optimize infrastructure spending during different stages of the application lifecycle. Public clouds can be tapped for development and testing while private clouds can be used for production. More importantly, public clouds can be used to retire applications, which may be no longer needed because of the move to SaaS, at much lower costs than dedicated on-premise infrastructure.
4. Offers both the controls available in a private cloud deployment along with the ability to rapidly scale using the public cloud.
5. Supplies support for cloud-bursting.
6. Provides drastic improvements in the overall organizational agility, because of the ability to leverage public clouds, leading to increased opportunities.

Drawbacks of the hybrid cloud are:

1. As a hybrid cloud extends the IT perimeter outside the organizational boundaries, it opens up a larger surface area for attacks with a section of the hybrid cloud infrastructure under the control of the service provider.
2. An easier approach to solving the identity, needs of hybrid clouds is to extend the existing enterprise identity and access management to the public clouds. This opens up concerns about how this approach will affect enterprise identity and its impact on the organization's security.
3. When organizations manage complex hybrid cloud environments using a management tool, either as a part of the cloud platform or as a third-party tool, organizations should consider the security implications of using such a tool. For example, the management tool should be able to handle the identity and enforce security uniformly across hybrid cloud environments.
4. A hybrid cloud makes the data flow from a private environment to a public cloud much easier. There are privacy and integrity concerns associated with such data movement because the privacy controls in the public cloud environment vary significantly from the private cloud.
5. There are risks associated with the security policies spanning the hybrid cloud environment such as issues with how encryption keys are managed in a public cloud compared to a pure private cloud environment.

2.5. Related Technologies

These technologies are the key technologies supporting the evolution and success of cloud computing because these technologies paved the way for the platform from which cloud computing is launched. They provided the technology and infrastructure that cloud computing relies on. They also provided the theoretical and practical experiences which cloud computing capitalize for its success and adoption in business organizations. These technologies are Grid, cluster, virtualization and SOA computing, ancestor of cloud computing.

2.5.1. Grid Computing

It is a form of distributed computing that implements a virtual supercomputermade up of a cluster of networked or internetworked computers acting in unison to perform very large tasks.

Thus, grid computing offers to cloud the capabilities for resource sharing, heterogeneity and ability to decentralize resource control.

2.5.2. Computer Clusters

A cluster is a set of multiple interconnected computers. Classifying a set of computers as a cluster requires software that makes that computers work together. A couple of very reason for clustering is performance and high availability, which means a fault-tolerant hardware and software configuration. Performance clustering is a natural way to add performance if one node configuration is not enough. High availability configuration adds reliability by avoiding a single point of failure. These configurations are also used together in an active cluster configuration.

2.5.3. Virtualization

Virtualization is the representation of real machine using software that provides an operating environment which can run or host a guest operating system. It is an essential technological characteristic of clouds which hides the technological complexity from the user and enables enhanced flexibility (through aggregation, routing, and translation). By creating a virtual version of a device or resource, virtualization can improve computing efficiency, reduce the need for expensive hardware and cut overall IT costs. As new innovations continue to emerge, this technology is promising to change IT infrastructure and streamline management. Virtual machines are created and managed by a virtual machine monitor. More concretely, virtualization supports the following features:

- Ease of use: through hiding the complexity of the infrastructure (including management, configuration etc.) virtualization can make it easier for the user to develop new applications, as well as reduces the overhead for controlling the system.
- Infrastructure independence: in principle, virtualization allows for higher interoperability by making the code platform independent.
- Flexibility and Adaptability: by exposing a virtual execution environment, the underlying infrastructure can change more flexible according to different conditions and requirements (assigning more resources, etc.).
- Location independence: services can be accessed independently of the physical location of the user and the resource.

Two basic concepts of virtualization

1. Making multiple physical resources (such as storage devices or servers) appears as a single logical resource.
2. making a single physical resource (such as a server, an operating system, an application, or storage device) appear to function as multiple logical resources

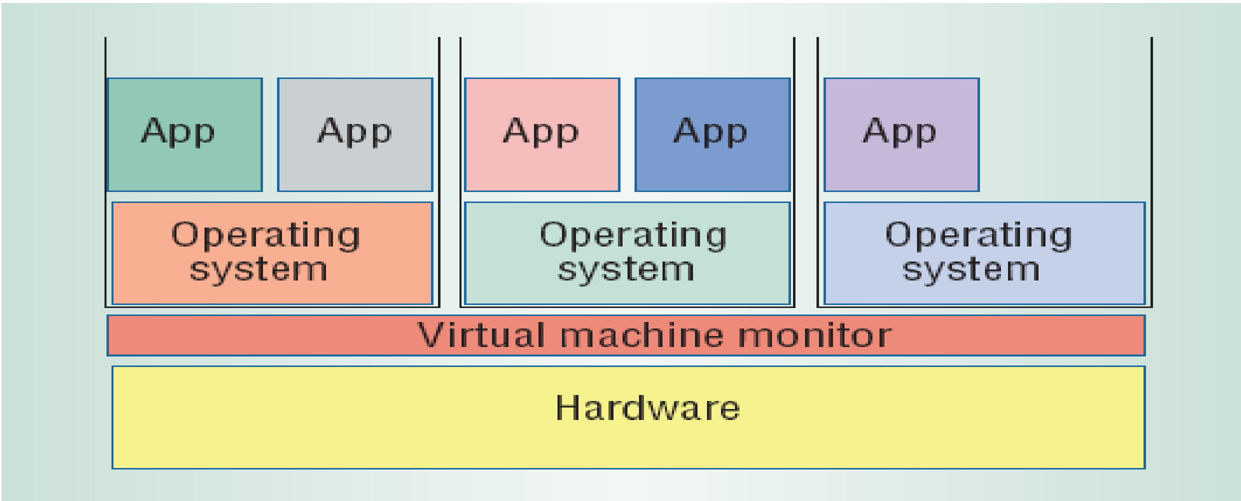

Figure 2.1: Virtualization architecture

Virtualization has three characteristics that make it ideal for cloud computing [18]:

1. **Partitioning:** In virtualization, many applications and operating systems (OS) are supported in a single physical system by partitioning (separating) the available resources.
2. **Isolation**: Each virtual machine is isolated from its host physical system and other virtualized machines. Because of this isolation, if one virtual instance crashes, it doesn't affect the other virtual machines. In addition, data isn't shared between one virtual container and another.

2.5.4. Service Oriented Architecture

Service Oriented Architecture (SOA) is a design approach to developing a network of integrated, simplified and highly flexible IT resources from a variety of distributed, complex systems and applications in a cost-effective way. This is done by making information resources, applications and business processes accessible through standard service interfaces without bothering about the internal workings of the system. SOA enables software systems to be designed in a way to provide services that are published to a directory and could be invoked over a network through a discoverable interface. With the SOA paradigm, organizations could easily unite customer or product data through data integration across the enterprise as well as application integration such that services or tasks could be invoked across departments within the organization or between business partners. Service Oriented Architecture stems from the idea of service orientation: an idea that allows service to be readily available and on-demand. In other words, SOA is a framework that allows services to be accessed and consumed over a network.

So much has been written about service orientation and there are many misconceptions about SOA. The reason is that SOA is not a technology but a design philosophy/principle not dependent on any platform, programming language and not owned by anyone as a product. A question that comes to mind is; how do we determine if a company is really implementing SOA? The answer is, there are SOA principles such that when followed effectively SOA will be realized. Principles [19] of service orientation are summarized below:

1. **Service Contract**: The idea of Service Oriented Architecture is to be able to find and use services that exist anywhere in a network not minding the program or language used in locating the service. The service is consumed based on its interface description. In implementing SOA using Web Services, services are published to a service registry or registries, when the service is found, it is invoked by the service requestor as long as the terms and conditions stated in the service description are met by the service requestor.

2. **Loose Coupling**: One of the problems of the traditional ways of achieving interoperability in a distributed computing environment was that systems were tightly coupled; this led to the inability of IT systems to respond to change very quickly. The term ‚Loose Coupling' has to do with the extent to which systems/programs are dependent on themselves. To achieve loose coupling, software services have to be developed a model where a web service and its requestor are independent of one another such that any requestor whatsoever can invoke the web service [19]. Once a software program is available as a web service, it can be accessed through any service requestor in a variety of ways.

3. **Service Abstraction**: One of the benefits of SOA is the ability to establish reuse of legacy systems. To enable reuse, the systems' functionality is abstracted on the interface-level and underlying the details is hidden from the surface. With the help of the service layer provided on top of the legacy application, the system is able to receive and respond to SOAP messages that

request for its functionality without minding the internal workings of the web service and the system.

4. **Service Discoverability:** The principle of discoverability embodies the ability of a service to describe its purpose and its whole functionality. This employs the use of the WSDL to describe the service to be as self-discoverable as possible so that it becomes easy for service requestors to locate and consume them.

5. **Service Reusability and Concurrency**: One of the reasons many companies are excited about SOA is its reusability, hence services must be designed such that its internal logic support reuse when exposed to the outside world. Moreover, services are bound to be accessed concurrently by service consumers, hence the need for services to provide excellent and reliable performance. Services are to be designed to respond to messages promptly so that other concurrent consumers will not be hindered.

2.6. Challenges for Adopting Cloud Computing

Now a day choosing cloud computing as a computing paradigm is unquestionable because of the benefits it brings to the ICT sector. Despite its benefits, there are challenges which are related to Lack of resources/expertise, coherent regulatory framework guaranteeing transparency, data protection and respect for data integrity, business, technical and organizational challenges.

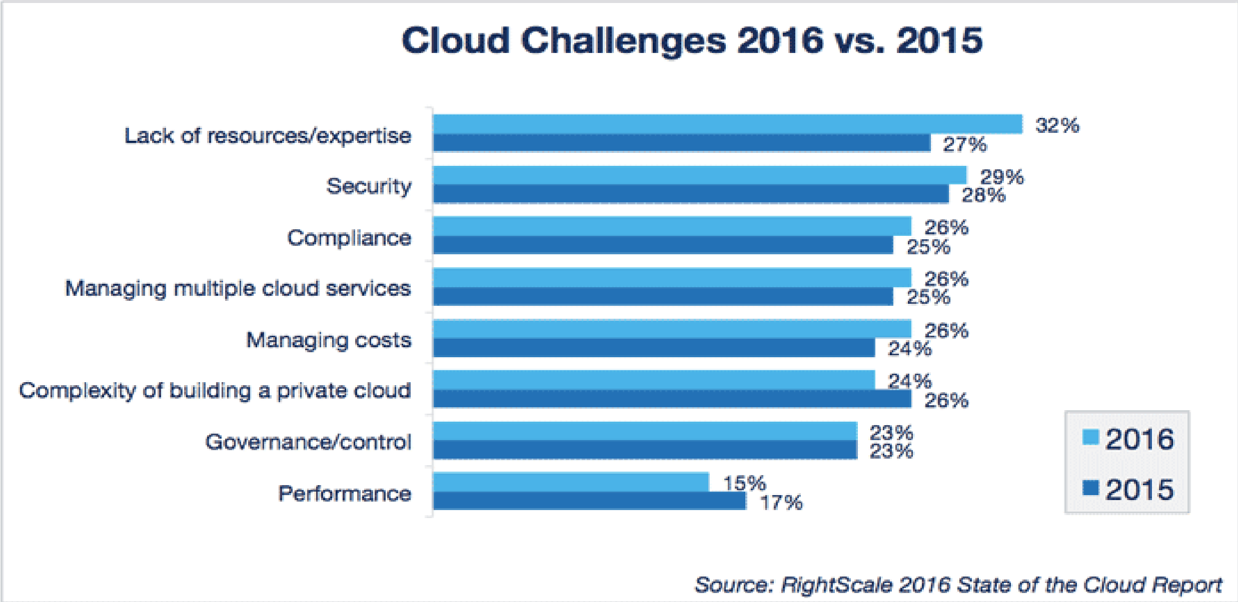

Figure 2.2: Cloud adoption challenges [20]

Lack of resources/Expertise: The Right Scale report on February 2016 shows that since the 2013 State of the Cloud Report, security has been cited as the top challenge in the cloud. Lack of resources/expertise increased from 27 percent last year to 32 percent to supplant security as the largest concern. As more organizations are placing more workloads in the cloud, the need for expertise has grown. Additional training of IT and development staff will be critical to helping address this challenge.

Security: Security is the most challenging barrier to adoption of cloud computing in financial institutions. Many of the security issues involved in protecting clouds from outside threats are similar to those already facing large data centers. Cloud computing security is an evolving sub-domain of computer security, network security, and, more broadly, information security. It refers to a broad set of policies, technologies, and controls deployed to protect data, applications, and the associated infrastructure of cloud computing. Some of the common threats to cloud computing security are: data breaches, data loss, Account/service traffic hijacking, insecure interface and APIs, denial of service, malicious insiders, cloud abuse, insufficient due diligence and shared technology vulnerability.

It is obvious that data is the most precious corporate asset, and companies want to know that their data is safe. Companies feel confident when they store data internally because they have full control over it. There is a general agreement among security professionals and experts that the overall objective of information security is to preserve the availability, integrity, and confidentiality of an organization's information. To protect information and privacy of their customers' cloud providers adopt different security mechanisms like encryption, multi-tenancy, and VLAN.

Whenever companies decided to move their data to the cloud, they should have a clear understanding about who and how to secure their data at a different level, i.e. Security at the network level, security at the host level and security at the application level. Security at the network level means ensuring data confidentiality and integrity of the organization's data in transit to and from the public cloud provider. Application level security is usually the responsibility of both the cloud service provider and the customer. Host level security is protecting attacks to the guest operating system; stealing keys used to access and manage the hosts.

Regulatory and Compliance Restrictions: Besides technological and security issues, there are also regulatory, compliance and legal issues to consider when moving to the cloud. Based on business requirements, a company's computing infrastructure could be a focuson certain compliance regulations. Companies should have a clear list of compliance requirements before considering cloud service providers. If the tenant or cloud customer operates in the United States, Canada or the European Union, they're subject to numerous regulatory requirements. These include Control Objectives for Information and related Technology and Safe Harbor. These laws might relate to where the data is stored or transferred, as well as how well this data is protected from a confidentiality aspect

Performance Bottlenecks: Cloud provisioning is the process of deploying and managing IT resources on cloud infrastructures. Rapid provisioning is a key performance requirement for cloud services, especially when there are a large number of customers requesting resources at the same time. However, it is difficult to determine what factor, or a combination of factors, are the causes of poor provisioning performance because there are no existing tools and methods to trace each status change and execution step in provisioning [21]. Multiple virtual machines (VMs) can share CPUs and main memory surprisingly well in cloud computing, but that network (HTTP protocols and bandwidth issues) and disk input-output sharing are more problematic.

Lock-In: Vendor lock-in is a situation in which a customer using a product or service cannot easily transition to a competitor's product or service. Vendor lock-in is usually the result of proprietary technologies that are incompatible with those of competitors. However, it can also be caused by inefficient processes or contract constraints, among other things. Moreover, these types of services dent high switching costs between competing vendors, making customers reluctant or even incapable of transitioning to different vendors. It's the classic case of a tradeoff between good technology and good business. Unfortunately for customers, bad technology and closed standards sometimes make for a more profitable product. The fear of vendor lock-in is often cited as a major impediment to cloud service adoption.

It is not recommended a company become locked-in with a specific cloud provider, because this dependence may limit control over costs and technical cloud hosting options. It is not uncommon for cloud providers to raise service prices or alter their technology offerings [22].

According to [25], one solution to vendor lock-in is to standardize the APIs in such a way that a SaaS developer could deploy services and data across multiple cloud computing providers so that the failure of a single company would not take all copies of customer data with it. Storage expert Arun Taneja offers the following tips for avoiding cloud vendor lock-in:

- Read the fine print of each provider's policies, and if necessary, ask them directly how they facilitate moving customer data out of their cloud storage repository.
- Ask the provider whether they offer data migration tools or services to facilitate the movement of large amounts of data.
- Choose providers that have pledged to support emerging industry standards, such as the cloud data management interface standard created by the storage networking industry association.

2.7. Benefits of Cloud Computing in the Agriculture Sector

Cloud computing is one of the business solutions that every enterprise uses. Many businesses moving to the cloud because cloud computing increases efficiency, effective and offer many more benefits. The benefits of cloud computing for Agriculture are listed in the following paragraph.

In order to meet the needs of agricultural informatization, the cloud computing service platform should be built up and applied in the agricultural sector [22]. It can not only lower the cost of agriculture but also greatly improve the capability of information service. According to the features of the agricultural sector in Ethiopia, the application of cloud computing will open up vast storage of agriculture, the tracing management of agricultural products quality, the comprehensive data analysis of agriculture management, the intelligent monitor of the agricultural production process, and the service of comprehensive agriculture information.

Cloud computing can provide safe and reliable data storage, powerful computing ability, easy and fast internet service for agricultural information. The use of cloud service can make the vast data collected, stored, disposed of and analyzed [23], which appears in the form of multimedia, such as words, pictures, sounds, and videos. It will break the limits of data storehouse and make it easy to store, process and use agricultural information resources. Cloud storage has the advantages of low cost, safe and reliable data, non-stop service, easy to enlarge the capacity and to manage.

The agricultural production process involves vast and complicated information. It is difficult for farmers to directly use those firsthand data to instruct the agriculture production. Experts in agriculture can make an accurate judgment only by basing on quantitative analysis [24]. Therefore, the production and management of agriculture need the support of intelligent and large-scale computing system. Agricultural information needs real-time collection and analysis based on the dynamic data appearing by the minute interval. The large-scale storage and computing power of cloud computing can effectively organize the distributed agriculture information on the internet and turn it into an organized information system. Thus, information can be managed and controlled. Obviously, cloud computing is important and valuable in data storage, analysis, policymaking and direction of agriculture information. In terms of terminal price and infrastructure, cloud computing is far cheaper than the traditional IT framework. Limited by their less education, farmers cannot make good use of computers and they need an easy-operated and less input system. The man-machine interface of cloud computing can make it possible to use a mobile phoneand sound recognition, which will play an important role in the field of agriculture, making it easier to operate a computer and providing fast scientific direction and references for government policy-making.

2.8. Challenges in ICT adoption by farmers to support Agriculture

There are numerous challenges that have delayed penetration of ICT in Ethiopian agriculture and below are grouping them into three categories: policy environment, rural setting, infrastructure, and capacity problem, and the nature of local communities. This is definitely not the complete list but key barriers.

First is the policy environment. In [25] argues that the national objectives of achieving universal and affordable access to the full range of communications services in most African countries have been undermined either by poor policies constraining market entry and the competitive distribution of available resources; weak organizational arrangements with a death of technical capacity and competencies; and, in some instances, returning taxes on usage. One of the key factors affecting the use of ICT in agriculture is inappropriate ICT policies, especially those targeting rural communities and rural development, language barriers, poor information sharing culture, and the fact that not all people in rural areas have even the low-end ICT such as radio and television. Although there have been various attempts to introduce ICT to small-scale farmers in Ethiopia to provide effective communication and information services. It would also require the optimumcombination and use of ICT with other productive inputs in all aspects of agricultural value chains. There is an urgent need to bring all technological development, available information, market sources, government policies and actions, research work, international efforts, andanother stakeholder to one table and formulate policies for agriculture. Effective design and consistent, transparent implementation of appropriate policies and regulations guiding a country's investment in and provision of ICT infrastructure, tools and services are keys to enabling ICT interventions. In generating a sympatheticsituation for ICT innovation and service provision, activerules and regulations in a number of other key areas are equally important, such as public and private financing of infrastructure, the business environment, support for innovation, and intellectual property. ICT-in-agriculture involvements require a strong, but flexible, regulatory environment; the policy environment is further strengthened by incentives for the private sector to make investments.

Second is the rural situation, structure, and measurement problem. Rural people mostly live sparsely and this would make delivery of infrastructure and public utilities such as electric powerand some devices of modern ICT very difficult to deploy in rural areas. In addition, delivery of ICT services would require electricity which is limited in most places in rural Area. However, this is easily addressed by tapping solar energy since most of our countries have intense sunshine all year round. Authors in [26] argue that since commercial investments including ICT are driven by profit motive, ICT operators may not be willing to cover the rural areas unless there are strong incentives to do so. This is because of the high cost of start-up, operating and programming costs given the capacity of the rural people to pay for the services offered.

The third is the nature of local communities, including their ability to use technology to access information for their work, gender, and social differences. The study conducted by [27] summarizes the main challenges and factors that influence the use of ICT as the high cost of available technologies, inadequate infrastructure, and low ICT skills, poor and expensive connectivity, inappropriate ICT policies, language barriers, low bandwidth, inadequate and/or inappropriate creditfacilities and systems. Other challenges identified are poor involvement of women and other disadvantaged groups, inappropriate local content, weak institutions, and inadequate collaboration and awareness of existing ICT facilities and resources, poor information sharing culture and low awareness of the role of ICT in development at all levels. In fact [25] in their independent studies found that the diffusion of ICT is highly uneven, concentrated in urban areas and leaving some rural areas almost untouched. Access to these technologies is constrained by income as is usage, and as they become more complex, they are increasingly constrained by literacy and education.

2.9. Why the future of agriculture will depend much on ICT?

Knowledge, information and data and the social and physical infrastructures that carry them are widely recognized as key building blocks for more sustainable agriculture, effective agricultural science, and productive partnerships among the global research community. The study by [28] argues that the processes by which knowledge, information, and data are generated and shared are being transformed and reinvented especially enabled by ongoing developments in the area of ICT and that these transformations provide massive opportunities for agricultural research. Catching and successfully harnessing these 'waves' requires strategic investments in capacities, bandwidth and infrastructure, skills, tools and applications, and the adoption of an 'open innovation' mindset that breaks barriers, links data, and knowledge, and guarantees the public accessibility of goods generated and captured through science. Some of the trends and changes in cloud-based Agriculture predictable in the future include [28]:

- Increasingly 'ubiquitous' connectivity along value chains – It is expected that all farmers will increasingly make use of a range of devices and platforms to access and share knowledge: from the web to phones, radio, video, and text messaging.
- Increasingly 'precise' applications and tools – ICT and digital signatures or labels of various types will be used to track products from producer to consumer; to monitor local soil, weather, and market conditions; to tailor data and information services to the demands of a specific audience or individuals. Applications will come in many shapes and sizes, to suit even the most specialized needs.

- Increasingly ‘accessible’ data and information – Vast quantities of public data and information held by institutions and individuals will become visible and re-usable at the click of a device. More intermediary skills and applications will be needed to help harvest, make sense of, and add value to these layers of data and information.
- Increasingly ‘diverse’ set of applications available across digital clouds – The digital ‘identities’ of scientists and their collaborators will give them access to a wide range of online tools and applications, accessible from any location and across different devices, enabling collaboration across boundaries as never before. Local firewalls and server configurations conditions will not restrict global sharing.
- Develop sustainable business and investment models through partnerships - public-private partnerships (PPP) are now considered essential to the long-term viability of most interventions that use ICT in agriculture. The public sector in Ethiopia particularly may need guidance in providing technological services; lacks of human and financial resources, as well as the overwhelming needs of the farming population, weaken its ability to provide widespread services of acceptable quality [29].

2.10. Related Work

The study conducted by [30] proposed architecture of a farm management system using features of the internet which concentrated on the technique of farming and devices to exchange information among stakeholders. Further, this study describes the method for better management of only some of the tasks of farmers. Ranya et al. [31] propose ALSE (Agriculture Land Suitability Evaluator) to study several types of land, to find suitable land for different kinds of crops by analyzing geo-environmental issues. ALSE used GIS (Global Information System) abilities to estimate land using local environmental conditions through the digital map and based on this information decision can be made. Raimo et al. [32] proposed FMIS (Farm Management Information System) used to find the precision agriculture requirements for information systems through a web-based approach. The author recognized the management of GIS data is a key requirement of precision agriculture. Similarly, the study conducted by Sorensen et al. [33] on the FMIS to examine dynamic requirements of farmers to improve decision processes and their corresponding functionalities. Further, they described that identification of the process used for the initial analysis of user needs is mandatory for the actual design of FMIS.

Sorensen et al. [34] recognized several functional requirements of FMIS and information model is presented based on these requirements to refine decision processes. They accepted that intricacy of FMIS is increasing with an increase in functional requirements and create that there is a need for an autonomic system to reduce complexity. The study conducted by [35] proposed WASS (Web-used Agricultural Support System) and recognized functionalities (information, collaborative work, and decision support) and features of WASS. Based on features, authors divided WASS into three subsystems: production, research-education, and management.

Reddy at al. [36] proposed a GIS-basedDSS (Decision Support System) of framework in which spatial DSS has been designed for watershed management and management of crop productivity regional and farm level. GIS is used to collect and analyze the graphical images for the creation of new rules and decisions for the effective management of data. Shitala et al. [37] presented a mobile computing-based framework for agriculturists called AgroMobile for cultivation, marketing, and analysis of crop images. Further, AgroMobile is used to detect the disease through image processing and also discussed how the dynamic needs of the useraffect the performance of the system. Seokkyun et al. [38] proposed cloud-based Disease Forecasting and Livestock Monitoring System (DFLMS) in which sensor networks have been used to collect information and manage virtually. DFLMS provides an effective interface for the user, but due to a temporary storage mechanism used, it is unable to store and retrieve data in databases for future use.

Renaud et al. [39] presented cloud-based weather forecasting system to collect and analyze the weather data replication and ensures load balancing for the management of resources. The study conducted by Peter et al. [40], has proposed as a study which is conducted at the majority of farmers in Kenya who are not able to sell their produce at a market price due to lack of sufficient information available. Also, agricultural productivity is being lessened due to the lack of information and resistance developed by agricultural universities. For such farmers to produce and sell their products at market-based competitive prices, information communication technologies (ICT) tools have been availed to them. This is because the growth of agriculture is dependent on how fast and appropriate information is provided to the end users.

The proposed cloud-based agricultural framework compared with existing agricultural applications as described in Table**2.2** below. From existing systems which have been highlighted and analyzed, it is clear to find out that all these systems are good but none of them offer the combination of the services as a single point of information access in order to help the user to find what are looking for in one place. It is necessary to enhance these systems and avoid their limitation in the proposed framework. It is important to have a much more interactive, easy to use and user-friendly interface to be created that will focus on fulfilling system requirements and features that will be added and enhanced to the current application.

Agriculture System	Application Type	Feature	Limitation	Method
ALSE	Web-based	find the appropriate land for different types of crops	Limited scalability	Web-based
WASS	Web-based	Productivity	Limited scalability	Not known
AgroMobile	Cloud based	Detect crop diseases	Data accuracy	Image processing techniques
FMIS	web-based	finding precision agriculture	Data accuracy and limited scalability	web-based
DFLMS	cloud-based	Crop and livestock	temporary storage mechanism used	Analyzing sensor networks
Proposed cloud based framework	Cloud-based	Integrating agricultural services	Security issues	Service-oriented Architecture

Table 2.2: Comparison of the existing system with the proposed system

CHAPTER THREE

3. METHODOLOGY

In order to achieve the general and specific objectives of the study and to answer the research questions, different data gathering and analysis strategies have been used. This chapter presents the methodology used in this study. It considers the use of quantitative methodology to investigate the processes and influences involved in the sector. Then the relevance of the current Ministry of agriculture is examined and the research design, process model used for prototype development, data source, sampling method, and instruments used for data collection, a method of data analysis and prototype development is presented under this chapter.

3.1. Research design

The intent of this research is developing a solution to the problem followed by a detailed analysis of the existing system environment. Hence the research type is constructive research. Constructive research method implies building of an artifact (practical, theoretical or both) that solves a domain specific problem in order to create knowledge about how the problem can be solved (or understood, explained or modeled) in principle. To give a solution to the problem, the existing system was analyzed by using an interview question which helps to study the system.

A Quantitative approach was used in this study to conduct the subjective assessment of attitudes, behaviors, and opinions of target data sources (respondents). This approach was selected because this study aims to consider the existing IT infrastructure, understand what is happening, and find an alternative solution from an operational point of view.

3.2. Process model

In this research we follow the method of Problem identification, Define the objectives for a solution, Design and prototype development, and Evaluation.

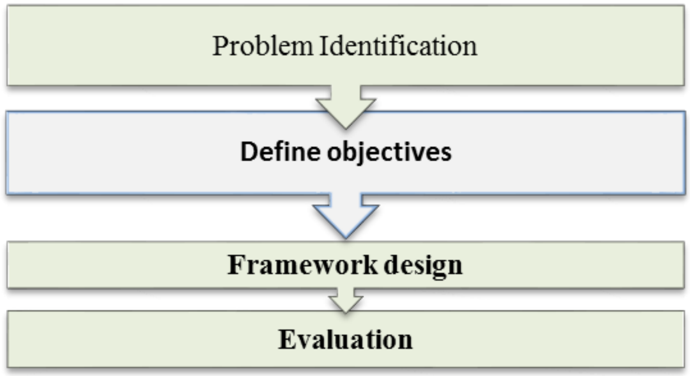

Figure 3.1: Research process

3.2.1. Problem identification and motivation

This stage includes defining the knowledge of the state of the problem and the importance of its solution. The study began by defining the specific research problem and justifies the value of a solution by conducting interview and rigorous analysis of the literature on the importance of cloud computing in the agricultural sector. Since based on the problem definition the author of the study atomizes the problem conceptually to capture its complexity for developing the proposed cloud-based framework that can effectively provide a solution. The value of the solution also motivating the author of the study and the audience of the research to pursue the solution and to accept the results and to understand the reasoning associated with the researcher's understanding of the problem.

3.2.2. Define the objectives for a solution

This stage aims to identify or drive the requirements for developing the proposed cloud computing framework from knowledge of the state of problems and current solutions. The author of this study infers the objectives of a solution from the problem definition and knowledge of what is possible and feasible to align with the agricultural requirements. The qualitative objectives are used, which described how a proposed framework is expected to support solutions to problems. The author of this study used the conceptual framework to inferred objectives rationally from the problem specification. In order to develop the study conceptual framework, the study has started with the literature review to gather relevant requirements and aspects of existing Cloud frameworks.

3.2.3. Framework Design

This phase includes determining the framework's desired functionality and its architecture and then creating the actual artifact. The knowledge of theory that can be brought to bear in a solution is required to move from the objective of a solution to the design and development of the proposed framework. Based on the required knowledge of a solution identified in phase one and two mentions above and in addition to the literature review, and an expert interview analysis proposed framework was developed by accomplishing the following process: particular processes are selected, the type of deployment model is decided, strategies for storing data, the cloud vendors selected. Finally, the proposed framework has been designed.

3.2.4. Evaluation

This phase aims to evaluate and measure how well the framework supports a solution to the problem by evaluating prototyping using questioner that collects feedback from respondents.

3.3. Data Source

Both primary and secondary data source was used during data collection. Quantitative data were collected from primary sources; Agricultural experts selected from the ministry of agriculture. We have also used Secondary data source like previous researchers work on this area in Ethiopia and other countries, annual reports of Ministry of Agriculture (MOA), World Bank reports (WB), publications on cloud computing paradigm and books, journal articles, and the like for especially to deal with the solution domain.

3.4. Data Collection Techniques

In the previous section, it’s mentioned that different data sources have been used to achieve the objective of the research. In this section, we have explained the way how and where to gather this information and why we choose those techniques.

Semi-structured interview method was selected for this study and ICT; marketing experts from the Ethiopianministry of agriculture were interviewed. Semi-structured interviews give the researcher flexibility to establish their own style of conversation depending on the direction of the interview. To gather information about the current system in agriculture industries interview questions were organized in the way that enables to get information related to customer satisfaction, the reaction of the ICT expert about the existing system, availability of integrated system and reaction about the proposed solution. Interviews were conducted between May 15 and May 30, 2018, and responses were obtained from all selected informants. The objectives and concepts of the study were briefly explained for interviewees. Each informant was interviewed individually by the researcher.

3.5. Sampling method and Techniques

To study the current situation in agriculture sector we have used a mixed sampling technique such as purposive sampling and random sampling. The random selection method is applied to choose respondents from the sector experts; the purposes were to identify the willingness of the agriculture sector for integrated ICT service delivery strategy. The best suitable respondents, ICT experts, and marketing expert were purposively selected from MOA in order to understand sectors activities or phenomenon because they understood the technological environment better than the other. Once the target population was defined, the next task performed was taking representative samples. The researcher used judgment sampling techniques of non-probability sampling methods. Judgment sampling technique was applied to get quantitative data from 14 respondents; 10 IT and 4 marketing experts from the Ministry of Agriculture.

3.6. Data Analysis Techniques

This research aimed to answer three research questions the first two questions enable to understand the problem domain and the last one for the solution stack. To answer these questions using different data gathering tools like an interview, observation and literature review. These data were organized, analyzed and summarized for a better understanding of the current ICT capability, structure, and usage.

As mentioned in the previous section purposive sampling technique was used to understand the willingness of the agricultural sector for an integrated service delivery model and providing sufficient ICT service to their customers. The result obtained from the interview has been compared and contrasted with the relevant literature review findings. The analysis made based on the finding of the literature and the data collected from the interview for presenting the requirements for constructing the framework intended in this study.

The literatureon the concepts of cloud computing including and related studies were reviewed. Accordingly, interview and review of the relevant literature are employed to develop the knowledge bases required for developing the proposed cloud computing framework.

3.7. Development of the Prototype

To implement the prototype of the proposed framework we have used different technologies and architectural models listed below.

3.7.1. Aneka

Aneka is a platform for deploying Clouds developing applications on top of it. It provides a runtime environment and a set of APIs that allow developers to build .NET applications that leverage their computation on either public or private clouds. One of the key features of Aneka is the ability to support multiple programming models that are ways of expressing the execution logic of applications by using specific abstractions. This is accomplished by creating a customizable and extensible service-oriented runtime environment represented by a collection of software containers connected together. By leveraging on these architecture advanced services including resource reservation, persistence, storage management, security, and performance monitoring have been implemented. On top of this infrastructure, different programming models can be plugged to provide support for different scenarios as demonstrated by the engineering, life science, and industry applications

3.7.2. ASP.NET

To implement the prototype, the component of the visual studio called ASP.Net (Active Server Pages) platform which is built on the top of the visual studio standard edition have been used. ASP.Net is a web development platform, which provides a programming model, a comprehensive software infrastructure and various services required to build up a robust web application for PC, as well as mobile devices. ASP.Net is a part of Microsoft.Net platform. ASP.Net applications could be written in either of the following languages such as C#, Visual Basic.Net, JScript, J# and etc. The key development tool for building ASP.Net applications and front ends is Visual Studio. Visual Studio is an integrated development environment for writing, compiling and debugging the code. It provides a complete set of development tools for building ASP.Net web applications, web services, desktop applications, and mobile applications.

3.8. Issues of Reliability and Validity

Interview questions were organized in the way helps to answer the research question and respondents who have better domain knowledge were chosen for an interview. The result was organized in a group and compared with other researchers result. Readily available literaturewas carefully selected from the authenticated sources. The Scientific research method was applied to the interpretation and explanation of findings. Finally, the proposed framework has evaluated by developing the prototype and the reaction of ICT experts of the MOA to test its' validity and acceptability.

CHAPTER FOUR

4. CLOUD-BASED AGRICULTURAL FRAMEWORK

4.1. Backgrounds of the Framework

Existing Agriculture systems are not capable of satisfying the needs of today's generation due to omitted of essential requirements like processing speed, lesser data storage space, reliability, availability, scalability etc. and even the information in computer-based agricultural systems are not used efficiently. To resolve the problem of existing computer-based agriculture systems, there is a need to develop a Cloud-Based agricultural framework (CBA) which delivers agricultural Services at the platform as a service level (PaaS). In this section, the framework of Cloud-Based agricultural System for agricultural service manages various types of agricultural related data based on different functionalities. The framework of CBA is shown in Figure 4.1 below. The main functionalities of this proposed framework are: to collect information from various users, to analyze the information and create various classes based on the information required, store the information in cloud repository and response the user query based on information stored in the repository.

4.2. Proposed Cloud-Based Agriculture Framework

In figure 4.1, a framework to realize the needs of the farmers and all stakeholders in agriculture has been defined. Specifically, the framework attempts to ensure that all the stakeholders have their desires and goals met while promoting agricultural productivity. The framework is developed using the following building block: agricultural stakeholder, data center, big data, machine learning algorithms, and information retrieval modules. The framework has three layers, that is, the management layer, data layer, and the access layer.

4.2.1. Management Layer

This layer is the first layer of the framework, its main objective is to coordinate and integrate the roles of each stakeholder towards increasing their contribution to agricultural productivity. Therefore, this layer is crucial in the framework as it determines the sustainability and workability of the framework. It is the basis of ensuring that farmers have a single access point for agricultural information.

4.2.2. Data Layer

This layer's role is to develop and maintain a data center that collects process and stores all the data. The desire is to meet the information needs offarmers that have been shown to meet a specific standard such as being timely, accurate, relevant and consumable. The goal of this layer is therefore to provide a single information access point where all the stakeholders can host their information and the farmer can access them from this point. Given that the stakeholders had formed at first layer, it is to their advantage that they share their resources with the farmer using a single information center. The other function of this layer is to provide secure data storage and to authenticate access, provide a way to integrate heterogeneous data from various stakeholders and combination from different stakeholders to providecomplete information needs of farmers.

4.2.3. Information Access Layer

This is the uppermost layer of the framework and is used by the farmers to meet their information needs. Key functions of this layer are its ability to empower farmers to retrieve information from the data center that host information from all stakeholders within giving farmers a single information access point. The information retrieval techniques are customized to the farmers' needs based on their culture, gender, literacy level, digital device, urgency just to mention a few. For instance, farmers can automatically call the stand by agents to get specific and relevant information on time as required. Besides, language translation, speech synthesis, automated SMS and calls and dedicated websites for agriculture enables farmers to access information all over the place.

Urgent information or any information meeting the farmers' standing queries are automatically pushed to the farmers to their inboxes using SMS or calls. Also, farmers can pull any relevant information they need from the framework. The framework is well aware that farmers need to communicate and share information among themselves and to learn from others within the region and around outside the region.

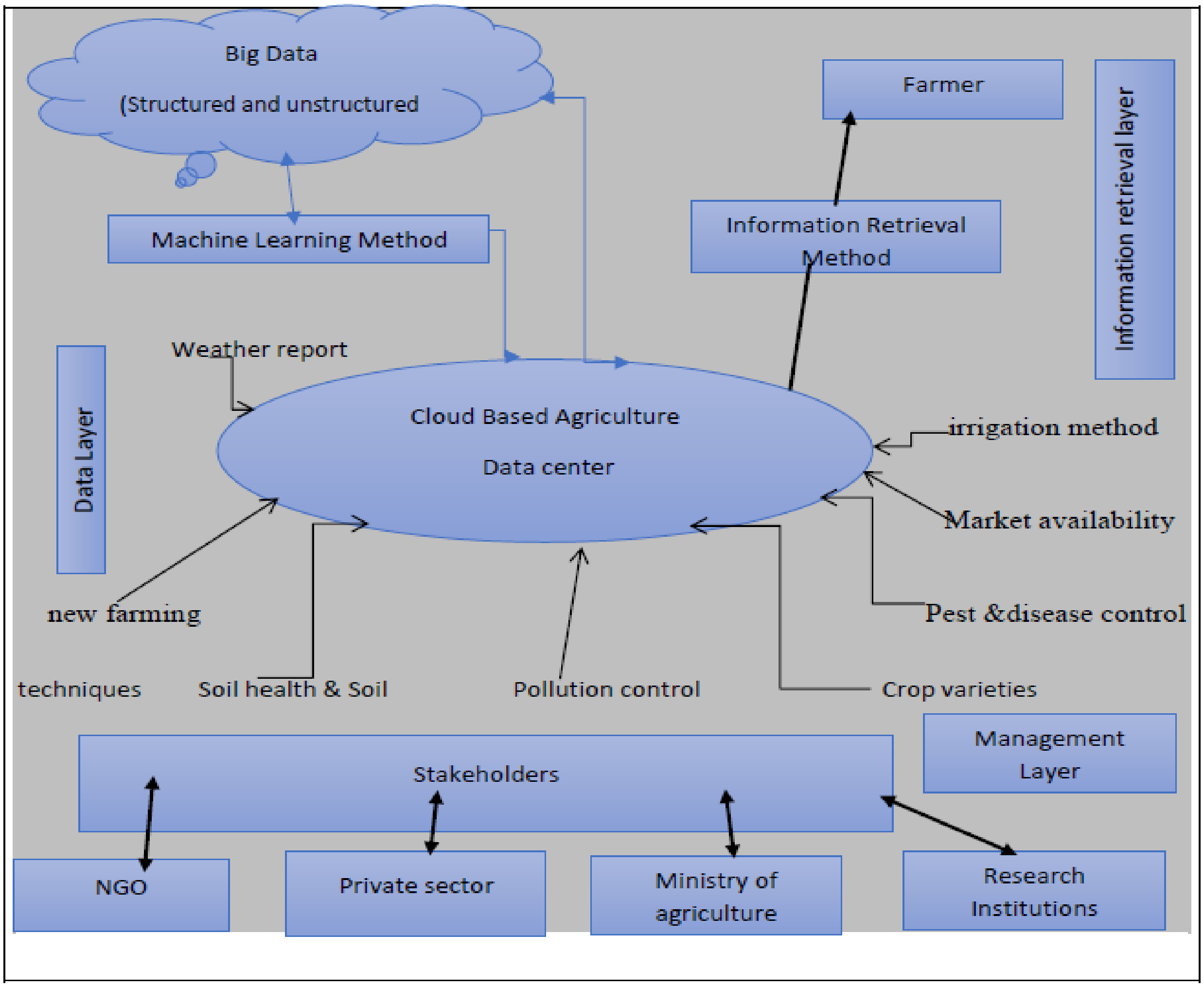

Figure 4.1: Proposed cloud-base agricultural framework

4.3. Modules of the proposed cloud-Based Agriculture framework

4.3.1. Cloud-Based Agriculture data center

This is the data host that collects, structure, process, and stores all the data collected from the various sources including the agricultural stakeholders, internet and etc. The data can be seen as a traditional database that stores data and supports relational querying and information retrieval both manual and automated. The resource such as distributed computing techniques like a grid, cluster computing can be used to support this resource. For sake of clarity, this resource needs to be managed by the agricultural sector but openly accessible to authenticated public users for research and general use. There is massive information available in the sector that is being generated daily from all over the country that can only make farmers more informed. This gives the farmers much more than they can gather on their own from past experience or friends and extension services. However, there is a need to extract only what is relevant to the massive data available. We, therefore, consider a machine learning system to determine only what is relevant and feed the data center.

4.3.2. Machine learning module

Machine learning algorithms are proposed to enable the framework to extract what farmer relevant information to develop the agricultural data center. The final goal is to make use of the massive data available, labeled or unlabeled, to learn a concept and update the data center with the concept. There are a lot of machine learning tools existing ranging from controlled to unmanaged learning and even semi-supervised learning. The key idea is to cluster or classify concepts and use the learned classification to make recommendations for current observation and even to predictions probable concepts based on the current observation. The task is done in this module can also be described as data mining.

4.3.3. Information retrieval module

Now that the agricultural data center has been developed and the next task is to make this data center able to support the farmers' informational needs. To achieve this, the framework has proposed an information retrieval module that is intended to crawl and search all the concepts in the data center to respond to the farmers' queries. Farmers can decide to build an information query and submit it to the information retrieval module. Another option is that the farmers send their queries to the module when there is a need. Information retrieval moduleneeds to automatically send information to the farmers without farmer's involvement particularly when there is an alert learned in the data center. This is called push information.

However, when the request for information is generated by the farmers themselves then the information retrieved by the module response is referred to the module as a pull request. Nevertheless, there is a need to have the information availed to the farmers in a format and language that they can consume them. Call center agents who are able to speak the farmer's native language may be needed in cases where the farmers cannot communicate in official languages like English or even that the farmers are not literate and therefore cannot read text short messages or information displayed on webpages. Another option is to build a system a language translator plugin into the website that can change the website content to the language the farmers can access. Another option is to build a speech synthesis system that is able to convert text to audio and then translate it into the language of interest to the farmers. In this research, we can only consider call agents, text language translation tools, short messages text, and video tutorials.

CHAPTER FIVE

5. DATA ANALYSIS AND PROTOTYPE DEVELOPMENT

In this chapter, the study focuses on the identification of service and deployment models that are best for agriculture in the cloud. Also presents the results of the interview described in chapter three. The data collection method utilized was the semi-structured interview that provided both control and direction through a list of the question under the interview. Respondents were ICT managers` and senior staff who have an authority to decide which direction agriculture takes with regard to adopting new IT infrastructure or not and integrate the services. Interviewees were selected from the ministry of agriculture ICT department using purposive sampling. Ten interviewees from the ICT department and four interviewees from the marketing department were interviewed. Accordingly, results are discussed in this chapter by grouping the issues and comparing the interview findings from relevant literature findings

5.1. Cloud services selection

It is blameless for organizations to wisely considering their IT portfolios and developing a roadmap for deployment and migration to cloud computing. These roadmaps prioritize services that have high anticipated value and high readiness to maximize benefits received and minimizes delivery risk. Outlining exactly which cloud services an organization expects to provide or consume is a fundamental initiation phase activity in developing an agency roadmap. The cloud-based services were selected and identified by considering the needs of their uses in the cloud environment for agriculture system. The following sections discuss the three types of cloud services among which platform as a service offered for this study due to its important characteristics.

5.1.1. Software as a Service (SaaS)

SaaS enables users to access applications running on a Cloud infrastructure from various end-user devices (generally through a web browser). The user does not manage or control the underlying Cloud Infrastructure or individual application capabilities other than limited user-specific application settings. In SaaS users can access agricultural information system from the cloud.

5.1.2. Platform as a Service (PaaS)

With Platform as a Service, the cloud provider hosts applications developed by the user, or on behalf of the user, using the cloud provider's operating system. In other words, the service provider offers a software platform and protocol stack on which a customer's application can run. For example, an agricultural application could be managed in the cloud utilizing a SQL or Oracle database instance offered by the PaaS provider. In PaaS service model user have full control over application and data so that the application manager or administrator can modify application accordingly when user requirements changed. In PaaS, service model user can develop an application using different Solution Stacks such as Java, PHP, ASP.NET, and Storage such as databases and file Storage.

5.1.3. Infrastructure as a Service (IaaS)

In this service model, the provider owns the equipment and is responsible for housing, running, and maintaining it, therefore, the cloud user contracts out the equipment used to support operations, including storage, hardware, servers, and networking components. The user typically pays on a per-user basis. The benefits of IaaS include rapid provisioning, ability to scale and pay only for what you use.

5.2. Selecting a cloud service provider

Selecting a proper cloud provider is the most significant portion of the implementation plan. Different providers may suggestion different service models, pricing schemes, audit procedures, and privacy and security policies. Agricultural providers have to compare different offerings and evaluate the provider's status and performance before it signs a contract. The following sections discuss the different types of cloud services providers by emphasizing properties that are likely to affect the decision to move the application to the cloud. For example, describe supported languages and frameworks, runtime environment restrictions, the platform provided services and features, and pricing models. Accordingly, Microsoft Windows Azure offered for this study due to the important characteristics that it provides possibilities to develop applications in different programming languages and architecture and enable deployment of these applications on operating systems of organization choice. Windows Azure provides both platform-as-a-service (*PaaS*) and infrastructure-as-a-service (*IaaS*) models and supports many different programming 'languages (C#, C++, Java, JavaScript, Python, ...), tools (Visual Studio, Git, Eclipse, Command

Line...) and frameworks (.NET, Node.js, ...), as well as different operating systems (Windows Server, Ubuntu, Open Logic, SUSE, ...) for virtual machines. There are several motives to choose Windows Azureinstead of a classical web hosting. One motive is definitely the covering distribution of the data centers. The CDN nodes are currently located in 24 countries. Most of the providers support different flavors of both Windows and Linux based environments and almost all of the providers (except Google App Engine) offer deployment options for both 32 and 64-bit architectures. It can be seen that Java, Python, and Ruby have been the dominant languages for development of applications and supported by most of the platforms as discussed in Table 5.1 below.

Characteristic	Public Cloud	Private Cloud	Hybrid cloud
Scalability	Very high	Limited	Very, high burstable
Security	Low; depend on encryption techniques used by service providers	High	Moderate
Performance	Low to medium	Very Good	Good
Reliability	Medium, it depends on the service provider availability and connection to the internet	High, as many of the equipment is within the organization	Medium to high, as the replicated content is kept within enterprises
Cost of use	Pay-as-you-use	The high cost of the initial set up	Pay-as-you-use
Data & Application Integration	Easy	Easy	Difficult due to change in cloud platforms
System management	Easier as compared to hybrid cloud	Easier as compared to hybrid cloud	Difficult as compared to public and private cloud
Portability	Easy	Easy	Difficult

Tooling and Skills	Easy	Moderate	Difficult, as it's relatively a new idea
Data Security Solutions	Better encryption techniques, authentication of the user by the provider	Encryption of data on private servers	Encryption of personal data, Sensitive data should not be stored in public cloud
Accountability Solutions	Moderate chances of privacy violation	Fewer chances of privacy violation	Audit needed for each step, Data loss, leakage or privacy violation may be dangerous
Data Handling	All the data is on a public platform	All the data is on a private platform	Confidential data is stored on private servers to respect country-specific laws
Workload	Normal workload with short-term spikes in demand	Mission-critical workload with security concerns or management demands	Highly dynamic or changeable
Capital expense	Low	High	Reduced, as the increase in demand is outsourced to a public cloud
Network Requirements	Works on the internet	Works on the organization's intranet	Needs to move from intranet to internet

Table 5.1: Comparison of features provided by major PaaS cloud computing providers [**41]**

5.3. Selecting a deployment model

Clouds are generally deployed using Public, Private or Hybrid models depending upon the requirements of the user. In this section, the cloud computing architecture has been assessed, focusing on the various features of the Public, Private and Hybrid cloud models relevant to most individuals and organizations and how they support or hinder the operation of various cloud computing models. There are many parameters which area concern when we compare the different types of cloud deployment models. Generally, according to [42] for small organizations that seek cost savings and test their software products before they are out in the market, using public clouds is a good option. Private clouds are better suited for organizations that handle sensitive data and are apprehensive about its confidentiality. For organizations which want to gain the benefits of both security as well as cost-effectiveness, hybrid clouds are appropriate. Depending on the organization’s priorities and needs, a particular cloud infrastructure can be selected. The comparison has been shown in Table 5.2, based on some parameters which are relevant to most of the SMEs and large organizations as well as individual users. The hybrid cloud model is a pragmatic solution for most of the issues of the enterprises and individuals. Accordingly, the Hybrid cloud model offered for this study due to its important characteristics as discussed in Table 5.2.below.

Characteristic	Public Cloud	Private Cloud	Hybrid cloud
Scalability	Very high	Limited	Very, high burstable
Security	Low; depend on encryption techniques used by service providers	High	Moderate
Performance	Low to medium	Very Good	Good
Reliability	Medium, it depends on the service provider availability and connection to the internet	High, as many of the equipment is within the organization	Medium to high, as the replicated content is kept within enterprises
Cost of use	Pay-as-you-use	The high cost of the initial set up	Pay-as-you-use
Data & Application Integration	Easy	Easy	Difficult due to change in cloud platforms
System management	Easier as compared to hybrid cloud	Easier as compared to hybrid cloud	Difficult as compared to public and private cloud
Portability	Easy	Easy	Difficult
Tooling and Skills	Easy	Moderate	Difficult, as it's relatively a new idea

Data Security Solutions	Better encryption techniques, authentication of the user by the provider	Encryption of data on private servers	Encryption of personal data, Sensitive data should not be stored in public cloud
Accountability Solutions	Moderate chances of privacy violation	Fewer chances of privacy violation	Audit needed for each step, Data loss, leakage or privacy violation may be dangerous
Data Handling	All the data is on a public platform	All the data is on a private platform	Confidential data is stored on private servers to respect country-specific laws
Capital expense	Low	High	Reduced, as the increase in demand is outsourced to a public cloud
Network Requirements	Works on the internet	Works on the organization's intranet	Needs to move from intranet to internet

Table 5.2**:** Comparison of public, private and hybrid cloud **[**42]

5.4. Select the framework for simulate cloud computing

There are different frameworks for simulating cloud computing among which Aneka was offered for this study due to its important characteristics as discussed in Table 5.3 below. One of the key features of Aneka is its capability to support multiple programming models that are ways of communicating the execution logic of applications by using specific abstractions. This is skillful by creating a customizable and extensible service-oriented runtime environment represented by a collection of software containers connected together.

Factors	Open Stack	Open Nebula	Aneka
Cloud Type	Private and public cloud	Private, public and hybrid cloud	Private and public cloud
Supported OS	Most Linux distribution	Most Linux distribution	Windows, Linux, maOSX
Programming language	Python	Java and Ruby	$C^{\#}$, C^{++}, VB
Compatibility with public cloud	Amazon EC2,S3	Amazon EC2	Amazon EC2, window Azure
Commercial model	Free	Free	Free
Used by	Large commercial enterprises	Research Institute, university and Public institution	Engineering, health, university and public institutions
Main purpose	Build private and public cloud	Provide cloud computing services and resource management	Building private and public cloud
User access interface	Command line	Command line, web APIs	Web APIs, custom GUIs

Table 5.3:Comparison of open-source cloud management platforms [43]

5.5. Selection of Integration Approaches

Service Oriented Integration is a more application-agnostic approach for integration. It is a functional integration technique which leverages exposed business functionality as services. These services are basically published and accessed in a standard way. SOA promotes assembly, orchestration, and choreography based on service, made possible by a Service-based integration. Integration approaches used inside the enterprise have come a long way from the point-to-point customized integration approach to a more disparate Service Oriented Integration. An initial approach, with point-to-point integration, can be termed more accurately an application-to-application integration where each application owner may get involved in sorting out the difference in platform, data semantics, and communication protocols. Some design document is prepared for this integration and for extra lines of code based on the design. This process gives us, first, point-to-point integration. It requires a host for the application and the communication protocol and port number details need to be coded inside the program or read from outside config files. This approach becomes very cumbersome as the number of integration points increase.

Due to large number of integrations needs for an enterprise, a standard product approach is adopted. It basically uses EAI software and a myriad of adapters for legacy and ERP applications like SAP, Baan, Siebel, etc. It solves the point-to-point connection problem by providing central access to each integration application. It provides messaging, reliability, choice of transport and transformation. This approach is flawed by the need for skill resources, an inherent complexity, and the need for centralized control. The Service Oriented approach, on the other hand, proposes a standard way of integration based on services. It could be implemented via different technologies or patterns. In this approach, the designer is basically concerned with functionality and granularity, rather than plumbing issues between the applications. The underlying integration infrastructure should take care of interaction between the services. It provides a more uniform approach to all integration needs like data integration, and so on. Service-oriented integration is selected for this study due to its advantage as discussed in Table 5.4below.

Integration Approach	Advantage	Disadvantage
Point to Point	Simple to implement Short time in market Can use existing tools	Infrastructures concerns need to be handled. May not align properly with business goal. Doesn’t scale. Tight coupling
EAI(Enterprises architecture integration)	Asynchronous model. Rule-based transaction. Avoid N to N connection with Hub and spoke model. Offers much powerful functionality.	High TCO. Use of proprietary protocol. More inclined toward data level integration rather than process. API based integration it basically gives shade of application-level integration rather than abstract functional integration and difficult to manage. It depends on hub and spoke which can result in single point of failure.
SOA(service oriented architecture integration)	Application agnostic integration approach. Standard-based and Loosely coupled Reusable and independent services are used for integration. Multiple model are supported More scalable integration approach as standard message routing and transport is provided by BUS.	Maturity concept More control required over services as it not end up within web services wrapper around existing services. Lot of scope improvement for service level integration infrastructures.

Table 5.4: Comparison of integration approaches

5.6. Presentation of the Interview Result

In this section, the data collected from the sample sector were presented and accordingly the appropriate interpretations were made

Legal and Regulatory Framework

Is there any specific legal and regulatory framework to adopt and implement cloud computing in the sector?	Number of "Yes "	**Number of "No"**
	0	10

Table 5.5: Legal and regulatory framework

All respondents were agreed that there are no specific legal frameworks in Ethiopia agricultural sector to adopt and implement cloud computing. Likewise, respondents were agreed that the differences in agricultural regulation in a different country will have an impact on the adoption of new technological innovation such as cloud computing. Similarly, an interview conducted with one of the sectors' supervision manager at EMOA also provesthat Ethiopia does not have a special rule on the use of cloud computing or it is not yet has included in the regulation.

Limitations of ICT Investment and Usage

All Respondents agreed that high investment cost on IT infrastructures, inefficient use of IT resources, lack of collaboration among national meteorology, marketing, and others to share IT resources, internet bandwidth inconsistency, the changing computing needs which bear compatibility problems and other related factors were the key challenges in the current ICT usages of the Ethiopian agriculture sector. Lack of up-to-date plan for ICT service delivery strategy also considered as a limitation for sectors` to fully harvest the opportunities presented by the latest technology. The result shows that in regard to the existing cost incurred on ICT infrastructure to support the agriculture services, many respondents were not agreed about its efficiency. The suggestions from all respondents on cloud indicated that 'compared with the existing IT system to support agricultural services, using cloud computing in the agriculture sector is efficient to perform agriculture activities at lower costs. Respondents agreed on the insufficiency of the current ICT infrastructure investment and usage suggested that sectors needed to improve the agricultural services by employing the state-of-the-art technology being used anywhere in the world. They also suggested that continual improvement and advancement of technology would assist sectors` for harvesting the actual and expected benefits from ICT.

Sufficiency of technology to achieve sectors mission and vision

Do you think that the current ICT owned by your sectors are sufficient to achieve EMOA mission and vision?	**Number of "Yes"**	**Number of "No"**
	0	10

Table 5.6: Current information technology

The question asked to get the reaction of the respondent whether their ICT is sufficient or not. As shown in table 5.6 above the entire respondent agreed on the insufficiency of their access ICT to meet their sector mission and vision in satisfying their customers. All the respondents say "NO".

Market Accessibility for Agriculture product

Do you think that the market access for the agricultural product through the country is equal?	**Number of "Yes"**	**Number of "No"**
	0	**14**

Table 5.7: Market accessibility

The question asked about the equality of market accessibility through the country for the agriculturalgoods and products has been asked all of them say "NO". It was true there is no uniform market through the country which means that the accessibility of the market is local rather than global (not equal) or big difference is there from market to market.

Availability of integrated service delivery

Number of "Yes"	**0**

Number of “no”	14

Table 5.8: Availability of integrated system

The question asked about the availability of an integrated service of that needed for the Agriculture sector together with meteorology, marketing, and others has been asked all of them say “NO”. It was true there is no integrated system in the agricultural sector currently.

5.7. Overview of the Prototype

In the previouschapter, the design of the proposed framework which contain three different layers and which is based on hybrid cloud computing deployment model and PaaS service delivery models have been presented. In this section, we have discussed how the proposed framework can be implemented and become usable to the agricultural sector. We put here, the highest-level view of the system which looks like and how it works if it will be implemented and the programming tools to implement the framework.

5.7.1. Development Environment

To implement the prototype, the component of a visual studio called ASP.Net (Active Server Pages) platform which is built on the top of visual studio standard edition have been used. ASP.Net is a web development platform, which provides a programming model, a comprehensive software infrastructure and various services required to build up a robust web application for PC, as well as mobile devices. ASP.Net is a part of Microsoft.Net platform. ASP.Net applications could be written in either of the following languages such as C#, Visual Basic.Net, JScript, J# and etc. The key development tool for building ASP.Net applications and front ends is Visual Studio. Visual Studio is an integrated development environment for writing, compiling and debugging the code. It provides a complete set of development tools for building ASP.Net web applications, web services, desktop applications, and mobile applications.

The asp.net framework helps in storing the information regarding the state of the application, which consists of Page state and Session state. The page state is the state of the client that content of various input fields in the web form. The session state is the collective obtained from various pages the user visited and worked with, i.e., the overall session state.

5.7.2. Prototype Modeling

A model is an abstraction describing a system or a subset of a system. Under this topic, we have used different kinds of UML (Unified Modeling Language) diagrams to model the functionality and Sequence of activities of the system. The functionality of the system has described by using use case diagrams which describes the functionality of the system from the user's point of view and Sequence of activities of the system by using sequence diagrams which describe the sequence of messages exchanged among a set of objects.

5.7.3. Use Case Diagram

Use cases focus on the behavior of the system from an external point of view and describe a function provided by the system that yields a visible result for an actor.

Actors and their related use case identification

. We can identify the following use cases and related to each actor:-

- **Actor name**: <u>admin</u>

Related use cases:

- ✓ Login
- ✓ Diagnosis of agricultural status
- ✓ Update agricultural status
- ✓ Integrate service related to agriculture

- **Actor name**: <u>Agricultural Expert</u>

Related use cases:

- ✓ Login
- ✓ Diagnosis of agricultural status
- ✓ Update agricultural status
- ✓ Answer query

- **Actor name**: <u>Farmer</u>

  Related use cases:

  - ✓ Ask query
  - ✓ Get query answer

- **Actor name**: <u>NGO</u>

Related use cases:

- ✓ login
- ✓ analysisoftheagricultural status
- ✓ update agricultural status

Actor name: Research Institute

- ✓ login
- ✓ analysis of agriculture
- ✓ update agricultural status

Use case diagram for the proposed framework prototype

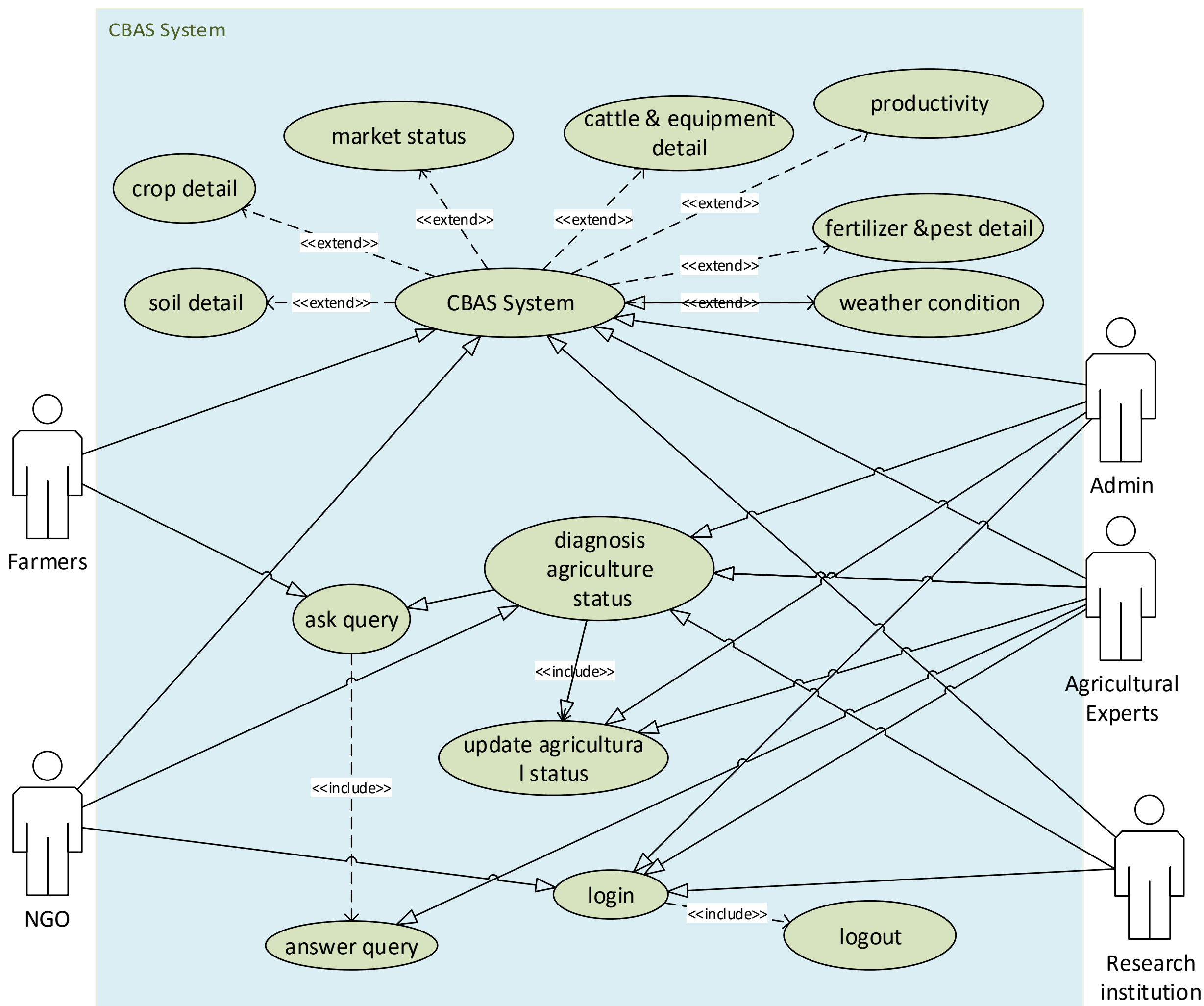

FIGURE 5.1: USE CASE DIAGRAM

5.7.4. Sequence diagram

A sequence diagram is a dynamic model of use cases, showing the interaction among classes during a specified time period. Sequence diagram was used to formalize the behavior of the system and to visualize the communication among objects. This diagram describes the flow of messages, events, and actions between objects and shows time sequences that are not easily depicted in other diagrams.

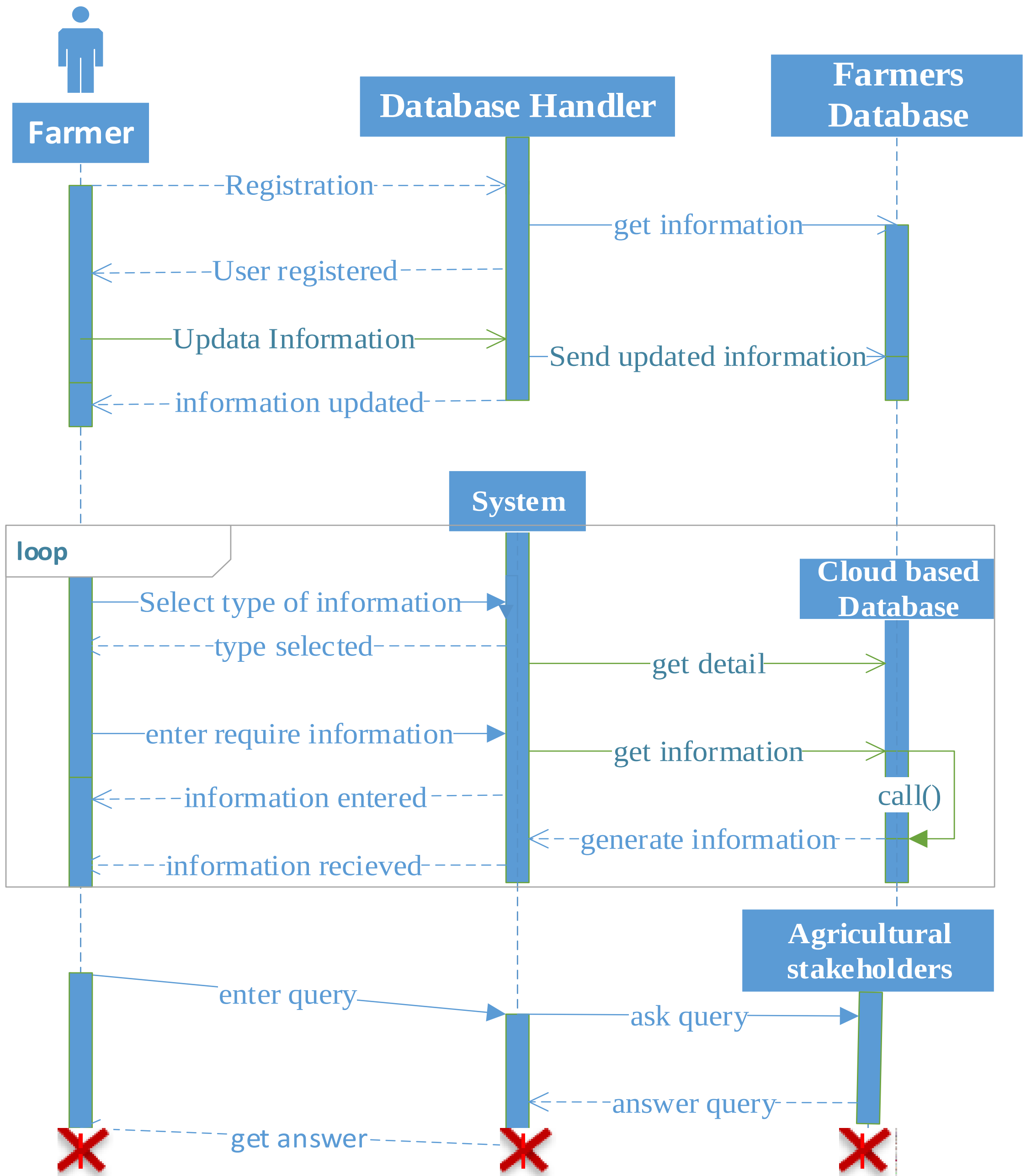

Figure 5.2: Sequence diagram

5.7.5. Screen snapshot of the prototype

In this section, some of the sample application interfaces snapshots have been included.

Home Page

Homepage enables the user mainly farming community can access the agricultural information, ask a question and get the response through this page.

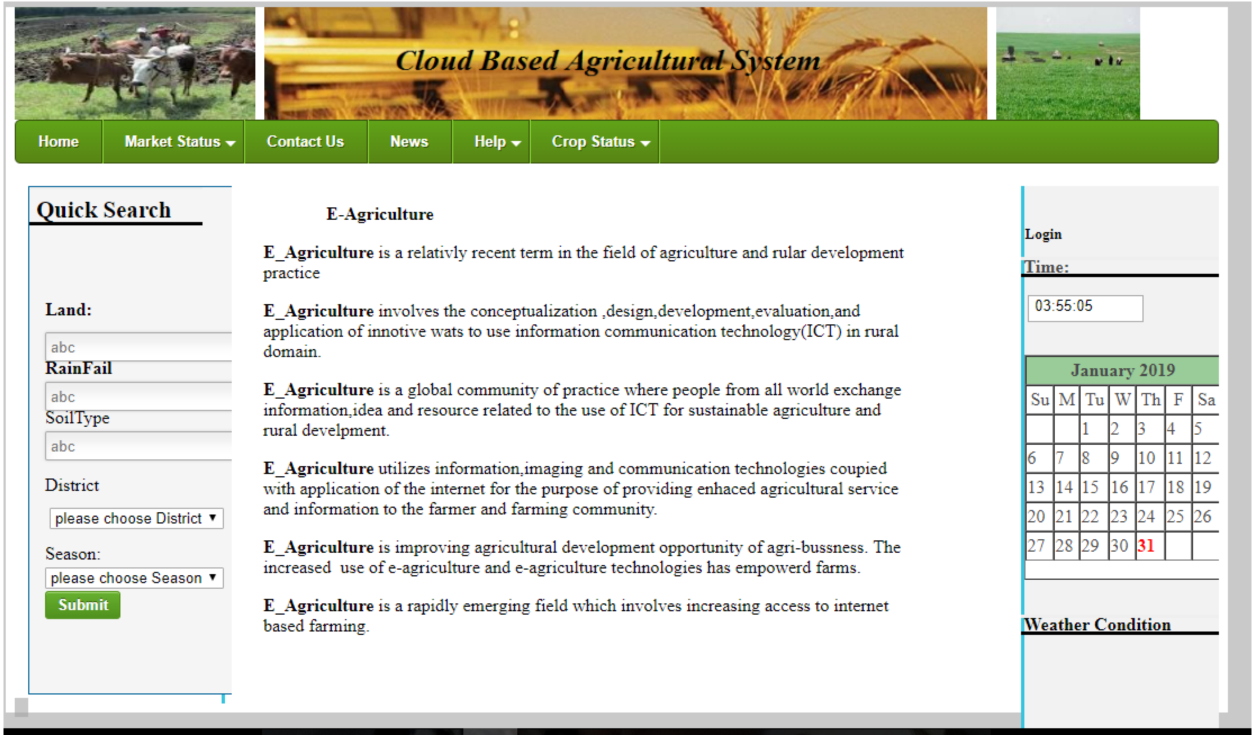

Figure 5.3: Home page

Crop Searching Page

Crop Searching page enables the user to know the status of crop and how the crop is cultivated based on temperature, rainfall, soil Types and so on. The page gives hit to users on how to cultivate the crop.

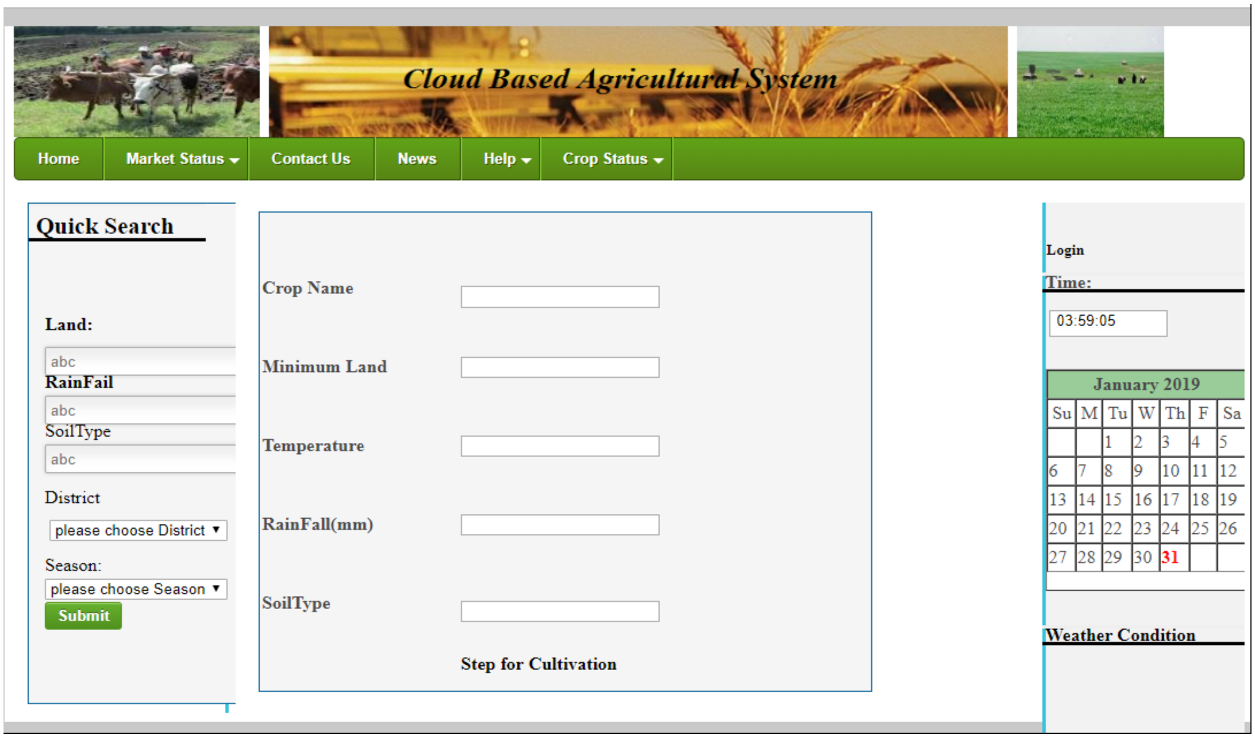

Figure 5.4:Crop searching page

5.8. System Evaluation

To clearly define the problem in Ethiopian agriculture industry we have followed the scientific research method and we have prepared the interview question which enables to understand the agricultural environment. The interview includes thebest respondent of IT workers having a clear idea about the current working process. The result obtained from the study shows that no single agricultural services in Ethiopia can afford enough access channels to serve their farming community.

As a solution to the problem, we have proposed a cloud-based framework which integrates different agricultural services together to support the farming community and merging separate data centers which are the causes of performance degradation. The framework also enables the agriculture sector to use agricultural channel owned by one agricultural organization can be used by another agricultural organization, this integrity of services solves the economic limitation of the agricultural sector to give enough access channel to the farming community. As we have observed in current agricultural sectors has no integrated system which gives agricultural service together. Hence, this proposed framework enables them to share agricultural system software and other management system software accordingly they save unnecessary cost of purchasing and maintain the software purchased from abroad and this also has a value in countries economy. The framework is also valid from the customer's point of view because it enables them to access information on any device which enables to agricultural service atanytime. The validity of the framework is also checked by developing the prototype and take interview from the information Technology experts existed in a ministry of agriculture.

The reflection from the agricultural sector expert’s shows that the framework and the prototype solve the current agricultural sector problem but they still doubt in security issue is there. In this research we have achieved the initial goal hence it is valid in achieving the goal of the research.

CHAPTER SIX

6. CONCLUSION AND FUTURE WORKS

6.1. Conclusion

This research has been begun with the intent to seek a solution to the problem that we have observed from the environment. The problem that initiates to do this research is the unavailability of sufficient agriculture access channel in the agriculture sector. We have inspired by this problem and followed a scientific research method by asking three research question which enables to understand how the current agricultural sectors are operating and what other problems are there, and also what techniques and technologies are there to solve the existing problem.

Interview questions are designed in a way that enables to capture the real economic and potential capability of the agriculture to afford enough infrastructures for their customer and to seek other problems in the agriculture sector. After formulating the problem in the agriculturesector, we have reviewed a number of journals and books to give a solution to the existing problem.

The result obtained from the study shows that no single systems in Ethiopia agriculture that can afford enough access channel to serve the farming community. Due to this insufficiency, there are some attempts to integrate the agricultural service owned by a differentstakeholderlike national meteorology agency, agricultural marketing, agricultural research, and others. Inthese organizations, we can observe that unnecessary duplication of efforts and there is no integrated service that delivered for the farmer. Even if challenges to integrating the agricultural services we could observe that there are also individual runs among the organizations that give services to the agriculture industry.

In this thesis, we have proposed cloud-based framework for integrating services related to Agriculture together which uses a hybrid cloud deployment model to make access channels owned by all stakeholder under the Ethiopian agricultural sector that gives services for the farming community and which shows how to use a single instance of software is shared by all organized under the sector. We have basically considering the integration of agricultural services which is using shared information and the semantic integrity which is based on the meaning of the shared information.

The aim of this thesis was to allow the farmers with right and accessible information to make decisions anytime-anywhere withrespect to increasing their agricultural productivity. Farmers' information want is accurate and specific with the following characteristics; accuracy, relevant, timely and consumable. The information provided to the farmer needs to be "just-in-time" to help farmers' decision making, for example, information on credit evaluations or locating a remote specialist for disease and treatment has to be accurate and timely. Besides, issues of literacy, use of local language, digital device, culture, and gender must be considered while packaging the information to the farmers in affection to their contexts. Otherwise, the information may just be inconsumable bearing in mind that these are smallholder farmers who are mostly based in the rural setup.

A single point information access framework for cloud base Agriculture was developed to encourageprogressive use of ICT to bridge the distance between the farmers and the stakeholders, and to bring transparency in an agricultural market by unpromising middlemen in the market value chain. A framework is, therefore, a combination tool for farmers to impact the collective reduced at both the supply and at the market ends. The key contribution of the framework is that it bridges the gap between the information need of the farmer and integrate the agricultural services.

In addition, there is a need to have ICT specialists biased to agriculture (agricultural informaticians), who are able to interpret ICT solutions for agriculture based on agricultural needs and not technical needs. Most ICT specialists develop applications for agriculture with disposition to technological needs and less consideration to the farmers' needs. Also, there is a need to integrate all ICT-in-agriculture tools motivated by widespread ICT equipment within farmers' reach (such as mobile phones, the World Wide Web, smart devices - sensors among others).

6.2. Future Works

In this thesis the problem raised and the question asked has been answered and the framework which enables to achieve integrity been designed. We forward some research ideas as future work to make the framework more reliable.

- ✓ Since cloud computing needs a fast and secure network connection; hence workability of the framework on current Ethiopian internet connection should be tested.

- ✓ Since security issueshybridcloud deployment model, a comparative study between private, community cloud and a public cloud is required by deploying both frameworks in a testbed environment.

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Appendix

Interview Questions

1. What is the current state of Agricultural service or different kinds of service that exists now?
2. What are the different technological challenges in agriculture sectors?
3. What are the current challenges in the agricultural sectors to use cloud computing technology or new technology?
4. How is the agricultural sector going to be for the next five years?
5. How Agricultural services are a plan to integrate to provide centralized information in the sector?
6. What kinds of technical work or framework that can help you to improve the quality of the agricultural sector?
7. Is there any Availability of integrated system that integrates all agricultural information services to give full informationto users? What is that?
8. Does the ministry of agriculture have an ICT policy based on country ICT policy and legal framework for new technology adoption? Do you know them?
9. Is there any specific legal and regulatory framework to adopt and implement cloud computing in the sector?
10. Do you think that the current ICT owned by your sectors are sufficient to achieve EMOA mission and vision?
11. Do you think that the market access for the agricultural product through the country is equal?
12. Could you mention the limitations of the current ICT delivery strategies in your sector?
13. What is your suggestion in formulating a new paradigm for providing ICT services and supports in the ministry of agriculture? And if possible, suggest your own solution from the current technology trends?

A. Home Page

```
<%@PageLanguage="C#"AutoEventWireup="true"CodeFile="Home.aspx.cs"Inherits="Home"
%>

<!DOCTYPEhtmlPUBLIC"-//W3C//DTD XHTML 1.0
Transitional//EN""http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<htmlxmlns="http://www.w3.org/1999/xhtml">
<head>
<title>Cloud based Agriculture Information</title>
<metahttp-equiv="Content-Type"content="text/html; charset=iso-8859-1"/>
<metahttp-equiv="Content-Style-Type"content="text/css"/>
<scriptsrc="css/ac_activex.js"type="text/javascript"></script>
<linkhref="css/template_css.css"rel="stylesheet"type="text/css"/>
<linkhref="css/css.css"rel="stylesheet"type="text/css"/>
<linkrel="stylesheet"media="screen"type="text/css"href="css/formstyles.css"/>
</head>
<bodyid="bd"class="auto fs3">
<divid="ja-wrapper">
<divid="ja-wrapper-inner">
<! -- BEGIN: HEADER -->
<divid="ja-headerwrap">
	<divid="ja-header"class="clearfix">
		<h1>
<imgsrc="image/dd.jpg"width="20%"height="100"alt="Farmer Guide"align="top"/>
<imgsrc="image/ff.jpg"width="60%"height="100"alt="Farmer Guide"align="top"/>
<imgsrc="image/fm.jpg"width="15%"height="100"alt="Farmer Guide"align="top"/>
		</h1>
	</div>
</div>
<!-- END: HEADER -->
```

```
<!-- BEGIN: MAIN NAVIGATION -->
<divid='cssmenu'>
<ul>
<liclass='active'><ahref='Home21.aspx'target="iframe1"><span>Home</span></a></li>
<liclass='has-sub'><ahref='market.aspx'target="iframe1"><span>Market Status</span></a>
          <ul><ul>
<liclass='last'><ahref='Contact_us.aspx'target="iframe1"><span>Contact Us</span></a></li>
<liclass='last'><ahref='news.aspx'target="iframe1"><span>News</span></a></li>
<liclass='has-sub'><ahref='Help.aspx'target="iframe1"><span>Help</span></a>
</li>
<liclass='has-sub'><ahref='CropStatus.aspx'target="iframe1"><span>Crop
Status</span></a></li>
</ul></div>
<divid="ja-containerwrap">
<divid="ja-container"class="clearfix">
                    <!-- BEGIN: CONTENT -->
                    <divid="ja-mainbody">
                    <divid="ja-contentwrap">
                              <divid="ja-content">
<iframename="iframe1"width="600"height="450"src="Home21.aspx"scrolling="auto"framebor
der="0"></iframe>                                                    </div> </div>
<!-- BEGIN: RIGHT COLUMN -->
                    <divid="ja-rightcol">
                    <divid="ja-rightcol-inner">
                    <divclass="module">
<ahref="Login.aspx"target="iframe1"><h5><fontstylesize='5'>Login</font></h5></a>
          <h3>Time:</h3>
<scriptsrc="css/time.js"language="javascript"type="text/javascript"></script>
<bodyonload="yourClock()", onunload="stopClock(); return true">
<formname="the_clock">
<tablewidth="100%"border="0"cellpadding="0"cellspacing="0">
```

```
<tralign="left"><td><aclass="mainlevel">  
<inputtype="text"name="the_time"size="10"style="padding-
bottom:5px;"align="top"></a></td></tr>
        <tralign="left"><td><br/></td></tr>
        </table></form>
        <scriptsrc="css/calander.js"language="javascript"type="text/javascript"></script>
        <h3>Weather Condition</h3>
        <embedsrc=""width='200'height='140'autostart="False"loop="False"></embed>
              </div>
</div>
</div>
</div>
                <!-- END: RIGHT COLUMN -->
</div>
                <!-- END: CONTENT -->
                <!-- BEGIN: LEFT COLUMN -->
<divid="ja-leftcol"><divclass="moduletable">
<fieldsetid="fieldset1">
<divclass="moduletable"><h3>Quick Search</h3>
        <formaction="search.asp"method="post"name="contact_form"class="contact_form">
        <table>
<tr><th>Land:<br/>
 <br/>
<inputtype="text"name="LL"placeholder="abc"id="Text1"required/>
<spanid="Span1"class="error"></span></th></tr>
<tr><th>
<inputtype="text"name="rfaill"placeholder="abc"required/>
<spanid="Span2"class="error"></span></th></tr>
                        <tr><td>
SoilType
inputtype="text"name="soil"placeholder="abc"required/><br/>
```

```
<br/>
 <spanid="Span3"class="error"></span></td></tr>

<tr><td>District<br/>
 <selectrequiredname="District"id="Select1"required>
<optionvalue="">please choose District</option>
<optionvalue="Oromia">Oromia</option>
<optionvalue="Amhara">Amhara</option>
<optionvalue="Tigray">Tigray </option
<optionvalue="Gambela">Gambela</option>
<optionvalue="BenishanGuz">Benishan</option>
<optionvalue="Afar">Afar </option
<spanid="Span4"class="error"></span></select></td></tr>
<tr><td>
                    Season:
<selectrequiredname="season"id="ss"required>
<optionvalue="">please choose Season</option>
<optionvalue="September">September</option>
<optionvalue="October">October</option>
<optionvalue="November">November </option>
<optionvalue="December">December</option>
<optionvalue="Jun">June</option>
<optionvalue="July">July </option>
</select></td>
          <tr><td><buttonclass="submit"type="submit">Submit</button></td></tr>
          </table></form>
</fieldset></div>
<!-- END: LEFT COLUMN -->
</div></div>
<!-- BEGIN: FOOTER -->
<divid="ja-footerwrap">
```

```
<divid="ja-footer">

            <tablewidth="100%"align="center"border="0"cellspacing="0">
<tr><tdwidth="80%"color="green">Copyright &copy;2018 ASTU. </td></tr>
</table>
      <divid="ja-cert"></div>
</div>
</div>
<!-- END: FOOTER -->
</div>
</body>
</html>
```

B. **The login View form**

```
<%@PageLanguage="C#"AutoEventWireup="true"CodeFile="login.aspx.cs"Inherits="login"%
>

<!DOCTYPEhtmlPUBLIC"-//W3C//DTD XHTML 1.0
Transitional//EN""http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<htmlxmlns="http://www.w3.org/1999/xhtml">
<headrunat="server">
<title></title>
<metahttp-equiv="Content-Type"content="text/html; charset=iso-8859-1"/>
<metahttp-equiv="Content-Style-Type"content="text/css"/>
<scriptsrc="css/ac_activex.js"type="text/javascript"></script>
<linkhref="css/template_css.css"rel="stylesheet"type="text/css"/>
<linkhref="css/css.css"rel="stylesheet"type="text/css"/>
<linkrel="stylesheet"media="screen"type="text/css"href="css/formstyles.css"/>

</head>
<bodystyle="width: 682px">

<fieldsetstyle="width: 550px"id="fieldset1"style=height:300px"">
<formid="form1"runat="server">
<tableclass="style1">
<divclass="style5">
<strong>Well Come ToAgro Information</strong></div>
<tr>
<tdclass="style12">
<strong><span>Your Name</span>
```

```
</strong></td>

<td><strong><asp:TextBoxID="TextBox1"runat="server"
Width="174px"></asp:TextBox></strong></td>
</tr>
<tr>
<tdclass="style7"><strong>Password</strong></td>

<td><asp:TextBoxID="TextBox2"runat="server"TextMode="Password"Width="170px"></asp:
TextBox></td>
</tr>
<tr>
<tdclass="style10">
<asp:ButtonID="Button1"class="submit"runat="server"onclick="Button1_Click"Text="LogIn"s
tyle="font-weight: 700"/></td>
</tr>
<tr><td><strong><spanclass="style9">Remember</span></strong>?</td>

<td><inputtype="checkbox"name="remember"value="yes"class="submit"align="left"/>
</td></tr>

<tr><tdclass="style3"><strong><spanclass="style6">
<spanclass="style4">Create New Account
Here</span></span><spanclass="style9"></strong></td>
<tdclass="style2<ahref='Createaccount.aspx'target="iframe1"><spanclass="style4">Create
Account</span></a><span
</td></tr>
</table>
</form>

</fieldset>
</body>
</html>
```

D.The login controller

```
using System;
usingSystem.Collections.Generic;
usingSystem.Linq;
usingSystem.Web;
usingSystem.Web.UI;
usingSystem.Data;
```

```
usingSystem.Web.UI.WebControls;
usingSystem.Data.SqlClient;
publicpartialclasslogin :System.Web.UI.Page
{
protectedvoid Button1_Click(object sender, System.EventArgs e)
    {

SqlConnection con = newSqlConnection(@"Data
Source=.\SQLEXPRESS;AttachDbFilename=|DataDirectory|\ASTU.mdf;Integrated
Security=True;User Instance=True");
SqlCommandcmd = newSqlCommand("select * from account where UserName=@username
and Password=@word", con);
cmd.Parameters.AddWithValue("@username", TextBox1.Text);
cmd.Parameters.AddWithValue("@word", TextBox2.Text);
SqlDataAdaptersda = newSqlDataAdapter(cmd);

DataTable dt = newDataTable();
sda.Fill(dt);
con.Open();
inti = cmd.ExecuteNonQuery();
con.Close();
if (dt.Rows.Count> 0)
        {
            Session["UserName"] = TextBox1.Text;
Response.Redirect("Admin/Admin.aspx");
//Session.RemoveAll();
        }

else
        {
Response.Redirect("Home.aspx");        }    }}
```