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Evaluating Community Forest Management Based on Ostrom Designing Principles and Using Gis & Remote Sensing Techniques: Case Of Bucha Community Forest Management in Adaba-Dodola Forest Priority Area District. Oromia Region, Ethiopia

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BAHIR DAR UNIVERSITY
INSTITUTE OF LAND ADMINISTRATION
DEPARTMENT OF LAND ADMINISTRATION AND MANAGEMENT
SPECIALIZATION: LAND INFORMATION SYSTEM

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OSTROM DESIGNING PRINCIPLES AND USING GIS & REMOTE
SENSING TECHNIQUES: CASE OF BUCHA COMMUNITY FOREST
MANAGEMENT IN ADABA-DODOLA FOREST PRIORITY AREA
DISTRICT, OROMIA REGION, ETHIOPIA**



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A Thesis Submitted to Institute of Land Administration, in Partial Fulfilment of the Requirements for the Degree of Master of Science in Land Administration and Management Specialization in Land Information System

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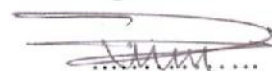
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Acronyms

BDU- Bahirdar University

BOFED- Bureau of Finance and Economic Development

CFM- Community Forest Management

CPR's- Common Pool Resources

DEM- Digital Elevation Model

ERDAS- Earth Resources Data Analysis System

ETM- Enhanced Thematic Mapper

FBAA- Forest Block Allocation Agreement

FPA- Forest Priority Area

GCP- Ground Control Point

GIS- Geographic Information System

GPS- Global Positioning System

GTZ- German Society for Technical Cooperation

JICA- Japan International Cooperation Agency

NASA- National Aeronautics and Space Administration

NGO- Non Governmental Organization

OLI - Operating Land Imager

ONRS- Oromia National Regional State

PFM- Participatory Forest Management

RLNRAA- Rural Land & Natural Resource Administration System

SNNPR- Southern Nation Nationalities and Peoples Region

SRTM- Shuttle Radar Topography Mission

TM- Thematic Mapper

TIRS- Thermal Infrared Sensor

UNEP- United Nation Environmental Protection

USA- United States of America

USGS- United States Geological Survey

UTM- Universal Transversal Mercator

WAJIB- Waldaya Jiraattota Bosonaa (Oromifa), Forest Dwellers Association

WGS- World Geodetic Reference System

Abstract

The aim of this study was to evaluate community forest management based on the designing principles of Ostrom and detecting land use/land cover of the area over the last 24 years (between 1990 – 2014) using GIS & Remote sensing techniques in Bucha community forest that covers the total area of 18619.252 hectares.

Tragedy of the commons model suggested that all commons will suffer over exploitation and degradation. However, the tragedy is not due to inherent flaws in the common property rights management regimes, but because of institutional failure to control access to resources, and to make and enforce internal decisions for collective use. The question of how to deal with the problem of commons is, therefore, primarily an issue of the existence of robust institutions. The prevailing decline of the community forest in Bucha Raya kebele requires robustness of the institution. This thesis attempts to address this problem specifically in relation to the institutional efficiency of WAJIB that govern the community forest.

The study was conducted in the kebele located in the highlands of Bale based on qualitative and quantitative data forms. Data were collected through various forms of interview (structured interviews, non-structured interviews, key informant interviews, in-depth interviews and group discussion interviews), direct field observation, document review and digital data of the satellite image over the periods of 1990 – 2014. The data gathered by these instruments were cross-checked to provide a triangulation of methods and to strengthen the validity and reliability of the data.

Although the study was conducted to evaluate the potential of WAJIB institution in the management of the community forest based on the design principles of Ostrom, GIS and Remote sensing techniques were used to cross-check the forest cover changes and rate of deforestation before and after the establishment of this institution by using Landsat images of the year 1990, 2005 & 2014. The major land use/land cover types in the study area are: forest, bush land, grass land, farm land & settlement and degraded land. The result of change detection analysis revealed that the area has remarkable land-use/land cover change. Specifically, the forest cover declined from 3101.49 ha in 1990 to 2179.72 ha in the year 2014 in the study area. A significant forest cover reduction by 6.47% has been realized in the year 2014

when compared with the 1990 forest cover condition with a deforestation rate of 200.8 ha per annum. The empirical findings reveal that the forest cover was declined after the establishment of WAJIB institution in the area. Findings of the application of design principle indicate that the boundary of the forest is not clearly defined and only legitimate users were not using the forest free-riders too were using the forest. Other designing principles are also not fully met by the Bucha community forest. The problem of forest cover change in the area was linked to population pressure, agricultural land & settlement expansion, fuel wood & charcoal production, collection of wood for construction & timber and sources of income generation. This situation implies that the existing local institution of WAJIB in the study area is not sufficiently robust to manage the community forest. Based on these gaps, immediate recommendations are provided for the improvement of Bucha community forest from the perspective of designing principles of Ostrom.

Key Words: Bucha Community Forest, CPR's, Design Principles, Forest cover change, GIS & Remote Sensing and WAJIB

1. CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Millions of people in developing countries depend on forest for their livelihoods. The World Bank (2000) identifies that one out of four of the world's poor depend, directly or indirectly on forests for their livelihood. The resources that the poor households depend on include: (1) subsistence goods such as fuel wood, medicines, wood for building, fodder, honey, edible leaves, roots and fruits; (2) goods for sale for example all of the above subsistence goods, plus arts and crafts, timber and other wood products; (3) income from employment, both in the formal and the informal sectors and; (4) indirect benefits such as land for other uses, social and spiritual values, environmental services (Felix, 2012). Based on UNEP of 2004 even though there are over 100,000 protected areas around the world including about 10% of the forested areas of the world, many calls for still further efforts would be required to create and maintain protected areas as the only way to protect biodiversity (Soraya, 2013).

The controversial issue of anthropogenic global warming has recently sparked a renewed interest in forest conservation, including research addressing carbon sequestration programs. Concurrent with the interest in forest conservation is the attention that the development community is giving to decentralized and participatory processes that embrace local human resources. Empowering local people for the forest conservation & management is a new paradigm that started in 1970's in the world in order to create interdependence between forests & rural peoples. As traditional forest management policies became increasingly powerless to stem deforestation, different agencies and donors began trying more "holistic" approaches to forest management that included collaboration with local communities to be at the forefront of their own development, in the context of forest conservation and management, has become a paradigm for sustainable socio-economic and environmental development. Institutions are important to mitigate the deleterious effects caused by the over-exploitation of CPRs such as public forests in rural areas where a lack of cooperation, cohesiveness, and coordination frequently hampers economic progress (Frederick, 2007).

Government-controlled forest conservation initiatives began in Ethiopia in the mid-1970s. These initiatives have resulted in the establishment of different types of protected areas such as State-owned Forest Priority Areas (FPAs), National Parks, Game Reserves, Sanctuaries and

Controlled Hunting Areas. By definition, all FPAs are state owned, settlement inside the FPA is prohibited, and only the government may harvest the forest products (Sewbesew, 2010). SOS Sahel and FARM-Africa are the NGOs that pioneered the current participatory natural resource and forest management initiatives in Ethiopia. Initiatives were also supported by other development agencies and NGOs including German Society for Technical Cooperation (GTZ) and Japan International Cooperation Agency (JICA). Participatory forest management (PFM) was used as an umbrella term to refer to the various systems that have been developed in different countries including community forest management, collaborative forest management, and joint forest management (Yemiru, 2009).

Adaba-Dodola FPA District is one of the 58 Forest Priority Area's in the country that have been under the management of the forest administration and working on the conservation, rehabilitation and management of the degraded areas, woodlands and high forest (Sewbesew, 2009). The historical background of Adaba-Dodola Forest priority area has shown that the forest resources have been dwindled from 140,000 ha in 1982 to 53,000 ha in 1990s. Bucha community forest is found in Adaba woreda and administered under this FPA district. WAJIB is the newly invented forest conservation approach & initiatives to curb the drastic deforestation in the study area. WAJIB in local language stands for "Waldaya Jiraattota Bosonaa", which means Forest Dwellers' Association. The main principle of WAJIB is; granting exclusive user and legitimate rights to participatory decision making and management. Its implementation has commenced since 2003/4 (Bedada, 2010).

Elinor Ostrom was shaped perspective of the world in an era impacted by economic depression and global war, resulting in a life-long, deep awareness of the limited nature of the earth's natural resources as well as the capacity of communities to come together in times of difficulty, to cooperate and provide a helping hand to those in need. Ostrom believed in the power of the local peoples. Yet her impact and influence was global. Ostrom's analysis of long term local institutions for managing the commons was done with a view to identifying the conditions that shaped how "a community of citizens can organize themselves to solve the problems of institutional supply, commitment and monitoring. Elinor spoke of her work and the 8 "designing principles" of collective action for commons management discussed in her 1990

book, *Governing the Commons* – the work that was instrumental in earning her the 2009 Nobel Prize in Economic Sciences (Alayne Delaney *et al.*, 2014).

The evolution of institutions for collective action to govern the commons by Elinor Ostrom (Ostrom, 1990), answered the dilemma of managing CPR's for a long time. Even though the formulation of principles associated with successive collective action in CPR governance is a challenging endeavor, the model of Ostrom relied on norm adopting individuals who pursue contingent strategies in complex and uncertain environments (Michael *et al.*, 2010).

There is a gap of managing collective action towards sustainable use of forest resources in the study area. The study has contributed in filling knowledge gap of community forest management by local institution from the perspective of designing principles of Ostrom for managing common pool resources by effective local institutions. Bucha community forest management is evaluated using design principles that Ostrom identified as key institutions common to successful, long enduring common-pool resource management regimes. Taken as a group, all of the design principles are found to exist in the state legislative orders and at the community level (to varying degrees). However, implementation of management of the community forest under the institution of WAJIB is often incomplete or otherwise deficient and hence, recommendations drawn from this study are directly applicable to the Bucha community forest management. Besides this, GIS and Remote sensing techniques has been used for land use land cover change detection in order to compare trends of forest coverage pre & post establishment of WAJIB in the area. The integration of applications of the designing principles with land use land cover change detection in the study area has been used as a base line for identifying the causes and impacts of forest cover change.

1.2 Statement of the problem

Forest resource face problems of congestion or overuse, because they are subtractable, unless harvesting or use limits are devised and enforced. Since, forest is a scarce resource its use by multiple individuals with continuation without limitation on its use or withdrawal rate results the tragedy of the commons. Community Forest is amongst other types of CPR's that is difficult (costly) to exclude individuals from using them through physical barriers or legal instruments and the utilization of the resource by one user, decreases the availability of the resource for other users (Ostrom, 1990). According to Sewbesew (2009), economic dependency of rural people on

the forest to satisfy their basic needs such as food, water, housing and social services is the root problem that makes the forest to be converted in to settlement and agriculture that leads to deforestation. Devolution of forest management authority to local communities provides a good opportunity for improving the living standards of the poor who are involved in co-management of forests, as well as enhancing the management of forest resources (Felix, 2012).

Even though the notion of “community” in community-based natural resources management has been the key issue, practically still it is the most criticized aspect of most participatory approaches. In most cases a unified, homogeneous and organic community with locally evolved rules and norms for equitable and sustainable management of resources is not visualized. Participatory forest management approaches in Ethiopia are basically modeled on providing incentives to local communities in terms of use rights or benefits. Local communities (user groups) will in return take collective responsibilities for the sustainable management of the resource by signing contracts with the government. In this regard, PFM approach was influenced by the continuous degradation of natural resources where efforts has to be made by overlooking local traditional uses and giving priority to conservation over the participation of local groups that makes the approach of participation weak in implementation with respect to achieving the overall objectives. However, the participatory agenda designed in planning was attempted to reverse a presumed “open access” situation. In Ethiopia the complexity of the poverty-environment relationship accelerated the degradation of forest resources (Yemiru, 2009).

From Hardin’s tragedy of the commons, individuals appropriating the commons are trapped in a common’s dilemma where individual rational behavior can cause long-range harm to the environment. Therefore, tragedy of the commons is not due to inherent flaws in the common property rights management regimes, but because of institutional failure. The question of how to deal with the problem of commons is, therefore, primarily an issue of the existence of effective institutions. Then the important and interesting task is to figure out how local resources in a particular community were and still are governed by what is referred to as “institutions”, regular devices that define who is allowed to use what kind of resources at what time and under what circumstances (Adam, 2006).

Even though, Bucha community forest is one of the remnant high forest area in the country it has declined every year since local communities use it as farm land & settlement, pasture and

source of wood for fuel & construction materials and for income generation activities. Thus, rapid population growth, agricultural land & settlement expansion, commercial logging and charcoal production contributed a lot for the change of forest cover in the area. Another key issue for the decline of community forest was the challenge of free-riding of non-members by exploiting unlimited amount from the forest resource that is commonly used by the member groups of the community. The decline of the forest cover resulted land degradation and shrinking of the biodiversity. The prevailing severe and unabated degradation of the forest calls the question of the efficacy of the institutional arrangements for the governance of these resources. So the research problem of this study is concerned with how efficient/robust the local institutions of WAJIB management regimes in governing Bucha community forest. Challenge of the community forest is related to institutional efficiency of WAJIB from the perspective of the designing principles of Ostrom. Thus, community forest member's demand for farm land, fuel wood, timber, fodder and other environmental services requires institutional paradigm shift.

1.3 Objectives

1.3.1 General objective

The purpose of this study is to critically examine the potentials of management approach of WAJIB institution from the perspective of designing principles of Ostrom with the support of change detection of land use/land cover in the study area over the period of 1990 to 2014 and to point out implications for a well-designed co management regime that ensure sustainable management of the community forest based on the designing principles of Ostrom.

1.3.2 Specific objectives

- To evaluate institutional efficiency of PFM approaches of WAJIB in governing the community forest based on the Ostrom designing principles
- To assess patterns of forest cover change over the stated period
- To identify driving forces and impact of forest cover change in the study area
- To quantify rate of deforestation before & after establishment of the WAJIB institution
- Recommending sustainable forest management for Bucha CFM based on the Ostrom designing principles

1.4 Research questions

- ✓ What was the institutional efficiency of WAJIB approach looks like in governing the community forest from the perspective of Ostrom designing principles?
- ✓ What was the area of natural forest land cover during the different period?
- ✓ What are the major causes and consequences of forest cover change?
- ✓ What was the rate of deforestation pre & post establishment of the institution of WAJIB?
- ✓ What are the solutions required for the sustainability of Bucha CFM based on the designing principles of Ostrom?

1.5 Significance of the study

Apart from academic purposes, it is hoped that theoretical discourses and the empirical analysis contained in this research paper has great significance to community forest management of the study area by improving institutional efficiency. This study attempted to contribute to the management option of the forest at grass root level by the local community based on the designing principles of Ostrom to manage common pool resources. This study incorporated the dynamics of land use and land cover change of the study area in 1990, 2005 and 2014 in order to understand the trends of forest resources to put the right mechanisms of managing the forest by the local community that helps to reduce conflicting land use changes between the communities. This study was therefore conducted to evaluate the management practices of WAJIB approach in the study area from the perspective of designing principles to govern the commons with the support of change detection of land use/land cover in order to provide appropriate design of community forest management for the institution that manages Bucha community forest.

1.6 Definition of terms or concepts

Land cover: refers to the vegetation (natural and planted), water, bare rock, sand and similar surface and also man-made construction occur on the earth's surface (Habtamu, 2011).

Land use: refers to a series of operations on land, carried out by humans, with the intention to obtain products and/or benefit through using land resources including soil resources and vegetation resources which is part of land cover (Habtamu, 2011).

Remote Sensing: is the science and art of obtaining information about an object, area, or phenomenon through electromagnetic radiation sensor to record images of the environment which can be interpreted to yield useful information (Nestanet, 2007).

Geographic Information System (GIS): is a specific information system applied to geographic data and is mainly referred to as a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modelling and display of spatially-referenced data for solving complex planning and management problems (Meseret, 2009).

CPR's: are defined as types of natural resource stock (e.g., a forest or a fishery) from which individual units (e.g., trees or fish) are extracted and hence, resource units are rival goods, which means that use is mutually exclusive i.e., use by one individual precludes use by another because they are used by multiple users (Frederick, 2007).

Public goods: Sometimes called "free goods," where access to the good is not easily restricted and using of the good didn't subtract it's availability to others such as air and water, or public information systems, such as emergency radio broadcasts (Ostrom, 1990).

Design principles: are principles that are introduced by Ostrom that can be used to help the design of institutions for stable local common pool resources management (Felix, 2012).

WAJIB: (an abbreviation meaning Forest Dwellers' Association in Afaan Oromoo): is a Collective officially recognized and whose statutory rights and duties are defined in their Forest Block Allocation Agreement concluded with the District Rural Land & Natural Resources Administration Authority (Bedada, 2010).

1.7 Scope and delimitation of the study

This study investigated governance of Bucha community forest by a local community under the institution of WAJIB from the perspective of globally accepted designing principles of Ostrom to manage common pool resources. The land use land cover change detection of the forest was examined in order to identify the rate of deforestation and assess the possible driving factors of land use and land cover change using remote sensing and GIS techniques. This study was conducted based on the data obtained from satellite imagery, biophysical & socio-economic survey of the study area and different literatures that are supplementary to the topic of the study. After the data obtained from satellite imagery and respondents were further analyzed the study recommended possible management practices of the community forest based on the designing principles of managing common pool resources.

1.8 Limitation of the study

As far as evaluating the management practices of community forest and an assessment of land use/land cover change detection in the study area is concerned the following threats hindered the investigation so far:

- ❖ Spatial resolution of Landsat images for the study area used for extracting land use land cover change matrix may cause the spectral characteristics of the features may not visible for the supervised classification.
- ❖ Budget deficit is also a major threat for the investigation since, the study requires technical instruments like Handheld GPS 72 & Digital camera from the market that are mandatory to accomplish the study.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Common pool resource management and forests

In Economics Common-pool resource (CPR) alternatively termed as common property resource and it is a particular type of good consisting of a natural or human-made resource system, the size or characteristics of which makes it costly, but not impossible, to exclude potential beneficiaries from obtaining benefits from its use. Unlike pure public goods, CPR's face problems of congestion or overuse, because they are subtractable. A CPR typically consists of a core resource, which defines the stock variable, while providing a limited quantity of extractable fringe units, which defines the flow variable. While the core resource is to be protected or entertained in order to allow for its continuous exploitation, the fringe units can be harvested or consumed. Examples of CPR's include irrigation systems, fishing grounds, pastures, forests, water and the atmosphere. Their core resource being vulnerable, common-pool resources are generally subject to the problems of congestion, overuse, pollution, and potential destruction unless harvesting or use limits are devised and enforced. The use of many common-pool resources, if managed carefully, can be extended because the resource system forms a positive feedback loop, where the stock variable continually regenerates the fringe variable as long as the stock variable is not compromised, providing an optimum amount of consumption (Ostrom,1990).

In addition to the CPR's there are also other types of goods and these are; Private Goods: An economic good, or a tangible item that can be purchased and traded within a market. Private goods are excludable. They are also rival, or subtractable because individuals have exclusive rights to use their resources and other members of the community can be excluded from using these resources without the consent of those who hold the rights. Accesses to private goods are controlled by the familiar institutions of private property. Club Goods: Goods that are excludable but non-rival, or non-subtractable. This means that while certain people can be excluded from the consumption of a good, one person's consumption of it does not diminish another person's. Access to club goods is limited by the levying of tolls or the existence of membership restrictions (Ibid).

Ostrom indicated five property rights that are most relevant for the use of common property resources: rights to access, withdrawal, management, exclusion, and alienation. Common

property resource denotes a common pool resource that is accessed and controlled by a group of users recognized as owners. CPR's may be owned by different types of owners: national or regional government, communal groups, private individuals, or corporations. When they are owned by no one, they are used as open access resources. Besides, there are instances of both successful and unsuccessful efforts to govern and manage common pool resources by these different types of owners. Hence, it should not be construed that there is an automatic association of common pool resources with common property regimes. As a result, Ostrom recommended the term "common pool resources" instead of "common property" in referring to the physical resource to emphasize that "property" (social institution) is distinct from "resource" because resource includes physical and biological world. CPR's share two attributes of importance for economic activities: i) developing institutions to exclude potential beneficiaries from using the resource is costly or difficult ii) the benefits consumed by one individual will subtract the benefits available to others. Therefore, a CPR can be distinguished from public goods and private goods although it shares some attributes of both. Like public goods, the commons is shared and difficult to exclude individuals from using by physical or institutional means and, like private goods, one person's consumption subtracts from the quantity available to others. These attributes strongly influence People's incentives to produce, manage and consume. Some aspects of forests such as multiple uses and the need to internalize externalities, the spatial variability of productivity, and the challenge of administrative efficiency owing to the extensive area they cover give them the characteristics of common-pool resources. Assigning private rights to common pool resources based on a clear definition of ownership together with a mechanism to adjudicate disputes needs a costly social investment. This will be even more difficult in the context of poverty, natural resource dependency and uncertainties of production over time and space. On the other hand, unless means are devised to exclude non-authorized users and unless harvesting or use limits are devised and enforced, problems of congestion, overuse and potential destruction could result. These situations make common property regimes a comparatively rational solution to certain problems of common pool resources management. In the absence of management and authority systems that might control the level of

use in relation to productivity, a common pool resource is said to be in an open-access situation (Yemiru, 2009).

2.2 Common property regime

The term "common property regime" refers to a particular social arrangement regulating the preservation, maintenance, and consumption of a common-pool resource. Common property regimes arise in situations where appropriators acting independently in relationship to a common-pool resource generating scarce resource units would obtain a lower total net benefit than what is achieved if they coordinate their strategies in some way, maintaining the resource system as common property instead of dividing it up into bits of private property. Common property regimes typically protect the core resource and allocate the fringe through complex community norms of consensus decision-making. Common resource management has to face the difficult task of devising rules that limit the amount, timing, and technology used to withdraw various resource units from the resource system. Setting the limits too high would lead to overuse and eventually to the destruction of the core resource, while setting the limits too low would unnecessarily reduce the benefits obtained by the users. In common property regimes there is no free access to the resource, and common-pool resources are not public goods. While there is relatively free but monitored access to the resource system for community members, there are mechanisms in place which allow the community to exclude outsiders from using its resource. Thus, in a common property regime, a common-pool resource has the appearance of a private good from the outside and that of a common good from the point of view of an insider. The resource units withdrawn from the system are typically owned individually by the appropriators. A common property good is rivalled in consumption. Common property regimes typically function at a local level to prevent the over exploitation of a resource system from which fringe units can be extracted. There are no examples of common property regimes which solve problems of overuse on a larger scale, such as air pollution. In some cases, government regulations combined with tradable environmental allowances are used successfully to prevent excessive pollution, whereas in other cases - especially in the absence of a unique government being able to set limits and monitor economic activities excessive use or pollution continue (Ostrom, 1990).

2.3 Challenges of governing common pool resources

An important challenge in governing common-pool resources lies in the fact that stocks and flows of these resources are often difficult to define with great precision. These resources can be fugitive (e.g., fisheries and wildlife) and often cannot be stored. They are often used at different geographic scales, and these uses are often in conflict: local forest users accrue benefits when the forest is used for timber production, whereas global users of forests benefit from standing trees as they sequester a major global pollutant. Further, the use of common-pool resources often presents negative externalities to those who do not necessarily benefit from such use. For example, harvesting of forest may lead to the deterioration of water quality downstream from the location where the timber is harvested. Protecting a CPR from overuse requires that users or external authorities create rules that regulate its use. Devising such rules requires the joint effort of a large proportion of the resource users. Given that it is costly and that all resource users will benefit from new rules protecting the resource, creating such rules it requires that the users overcome collective-action dilemmas. Groups of community with longer traditions of mutual trust enable resource users to reciprocate in behavior are more likely than other groups to succeed in devising and sustaining successful institutions. CPR's and their users are not only found in isolated communities lacking connections to the external world. On the contrary, today most users of CPR's interact with other people in an institutional environment that is external to the one regulating the CPR's and imposes constraints on the regime governing it. They are forced to seek external legal authorities to protect the institutions governing the common-pool resource. An external political process determines how much support such users will receive from their national government in enforcing a self-organized regime. This is particularly important when "outsiders" begin to use a common-pool resource illegally or would like to gain access to it (Ibid).

2.4 The design principles illustrated by long enduring CPR institutions

The evolution of institutions to govern collective actions in using the common pool resource is a mechanism for reducing uncertainty in complex, uncertain environments and hence, designing principles are used as a clue about how to reduce uncertainty, to bring trust and reciprocity in order to sustain collective action towards social dilemmas (Michael *et al.*, 2010).

In order to manage the CPR's by the designing principles the necessary conditions that have to be considered were over a long period peoples shared a past and expected to share in the future to share their reputations as reliable members community. The norms of the community has to be feasible to live in closer interdependence without excessive conflict. A reputation for keeping promises, honest dealings, and reliability in one arena is a valuable asset. The resource systems extremely meet the criterion of sustainability. The institutions meet criterion of institutional strength, in that the rules have been devised and modified over time according to a set of collective-choice and constitutional-choice rules. Now the task is to begin to explain their sustainability and robustness(strong and health), given how difficult it must have been to achieve this record in such complex, uncertain, and interdependent environments in which individuals have continuously faced substantial incentives to behave opportunistically. In 1990 Elinor Ostrom devised a set of seven design principles plus eighth principle used in the larger, more complex cases that characterize all of the robust institutions for managing common-pool resources such as forest. By "**design principle**" it means an essential element or condition that helps to account for the success of these institutions in sustaining the CPRs and gaining the compliance/agreement of generation after generation of appropriators to the rules in use (Ostrom, 1990).

DP 1: Well-defined boundaries

This principle stipulated the presence of well-defined boundaries around a community of users and boundaries around the resource system this community uses. Each component helps to internalize the positive and negative externalities produced by participants, so they bear the costs of appropriation and receive some of the benefits of resource provision. Individuals or households who have rights to withdraw resource units from the common-pool resource (CPR) must be clearly defined and the boundaries of the CPR must be well defined (Michael *et al.*, 2010).

Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself. Defining the boundaries of the CPR and specifying those authorized to use it can be thought of as a first step in organizing for collective action. Without defining the boundaries of the CPR and closing it to "outsiders," local appropriators face the risk that any benefits they produce by their efforts will be reaped/to get

result by others who have not contributed to those efforts. The presence of boundaries concerning who is allowed to appropriate from the CPR has been used as the single defining characteristic of "common-property" institutions as contrasted to "open-access" institutions. The basic features of the designing principle was one principle is not complete without presence of other principles i.e., designing principles are dependent of each other. For instance, in principle 1 simply closing the boundaries and fixing users is not enough and hence, in addition limiting appropriation and mandating provision is needed for the sustained use of the resource (Ostrom, 1990).

DP 2: Congruence between appropriation and provision rules and local conditions

Ostrom's second principle refers to Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, materials, and/or money to facilitate the sustainability of management system (Ostrom, 1990).

The first condition under this principle is there has to be a congruence between institutional rules (appropriation and provision rules) and local conditions. Ostrom emphasizes local conditions of the CPR, such as its spatial and temporal heterogeneity. For example, Arnold, Cox *and et al.*, (2010:7) describes practices in Peruvian irrigation systems: Under normal conditions farmers are given water sufficient to cover the requirements of their fields, when water scarcity threatens, this principle is modified and actions are taken to ensure that each household has access to a subsistence minimum.

They are also identified local conditions as involving the predominant culture, ideology, and customs of a community. Whereas they highlighted the negative consequences that result when externally imposed rules do not match local customs. For example, the scholars observed that the rules designed by the Dhulikhel municipality imposed a total ban on the harvest of forest products and that these rules did not match the resource conditions and contradicted customary rules of villagers, who had traditionally allowed activities such as the collection of leaf litter for animal bedding and fallen twigs for firewood. In turn, the effectiveness of monitoring and compliance with rules was very low, and the forest had come under high extraction pressure. A donor-initiated forestry cooperative in the Palcazu Valley of Peru is also

came to similar conclusions regarding the need for this internal-external type of congruency (Michael *et al.*, 2010).

The second condition is that congruence exists between appropriation and provision rules. Congruence between appropriation and provision rules is between costs incurred by users and the benefits they receive via their participation in collective action. In successful systems, individuals have an expectation that the benefits to be derived from participation in and compliance with community-based management will exceed the costs of investments in such activities. Some scholars have pointed to the importance of users perceiving the match between appropriation and provision rules as fair, relating this condition to a principle of equity and what is considered equitable may vary depending on how much of a resource is available. Appropriation and provision rules are applied to everybody while varying with each farmer's needs reinforced a commonly shared sense of equity and facilitated the sustainability of the management system. Thus, the benefits obtained by users from a CPR, as determined by appropriation rules, are proportional to the amount of inputs required in the form of labor, material, or money, as determined by provision rules (Ibid).

DP 3: Collective-choice arrangements

Regarding principle 3, Ostrom (1990:90) states, most individuals affected by the operational rules can participate in modifying the operational rules. CPR institutions that use this principle are better able to tailor their rules to local circumstances, because the individuals who directly interact with one another and with the physical world can modify the rules over time so as to better fit them to the specific characteristics of their setting. This principle focus on the importance of local knowledge in natural resource management in which local users have first-hand and low cost access to information about their situation and thus a comparative advantage in devising effective rules and strategies for that location, particularly when local conditions change. The presence of good rules, however, does not ensure that appropriators will follow them rather appropriators themselves designed and initially agreed to the operational rules. It is not even an adequate explanation for the continued commitment of those who were part of the initial agreement. Individuals or participants will adopt contingent strategies to generate optimal equilibria without external enforcement. They adopt resolute strategies to cooperate so long as everyone else cooperates. If anyone from the participants deviate from the participants all others

will deviate immediately and forever. By this model if information is freely available for the members it is possible to produce stable cooperative behavior over the long run and hence, it reduces investment on monitoring & sanctioning activities. A lack of a functional collective-choice arrangement is frequently correlated with CPR management failure.

DP 4: Monitoring

Under this principle (Michael *et al.*, 2010) stipulates that, Ostrom states two main sub-components and these are presence of Monitors and the condition that Monitors are members of the community with a cooperative behavior or otherwise accountable to those members. Monitors have a responsibility to actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are the appropriators. Monitoring makes those who do not comply with rules visible to the community, which facilitates the effectiveness of rule enforcement mechanisms and informs strategic and contingent behavior of those who do comply with rules. Monitoring is a byproduct of particular ways of managing the commons, and the costs of monitoring are kept low. In many cases the local users of CPR's hired people for regular monitoring and paid them through contributions from each member household. Monitors may not perform satisfactorily if they do not directly benefit from improved resource conditions. Thus, it may be important that monitors are accountable to those who most depend on the resource. Scholars have also pointed to the importance of environmental monitoring, that is, the acquisition of information about the conditions of the appropriated CPR. With environmental information, community members can elaborate and adapt appropriation and provision rules that help to guarantee the sustainability of the resource. Community whose members engaged in environmental monitoring enjoyed higher levels of information sharing than a community depended on the information provided by multiple external authorities.

DP 5: Graduated sanctions

Ostrom (1990: 125) stipulates that, Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both. Sanctioning deters participants from excessive violations of community rules. Graduated sanctions progress incrementally based on either the severity or the repetition of violations. In robust institutions,

monitoring and sanctioning are undertaken not by external authorities but by the participants themselves. The initial sanctions used in these systems are also surprisingly low.

Ostrom basically notified that Graduated sanctions help to maintain community cohesion while genuinely punishing severe cases; they also maintain proportionality between the severity of violations and sanctions, similar to the proportionality between appropriation and provision rules. In robust, self-governing CPR's the term "quasi voluntary compliance" is useful. Unless there is quasi voluntary non-compliance are subject to coercion if they are caught. According to Levi tax payers will adopt a strategy of quasi-voluntary compliance when: rulers keep their bargains and the other constituents will keep theirs. So the compliance of each depends on the compliance of others since no one wants to be a sucker. Levi argues that strategic actors are willing to comply with a set of rules if they perceive that collective objective is achieved and others also comply with the rule. Levi considers coercion as an essential condition to achieve quasi-voluntary compliance as a form of contingent behavior. If someone breaks the rule and apprehended by a local guard or monitor temptation to break the rules will have three results: first, it will stop infraction from continuing and may return contraband harvest to others. Second, it will convey information to the offender that someone else situation is likely to be caught, thus increasing confidence in quasi-voluntary compliance. Third, a punishment in the form of fine, plus loss of reputation for reliability, will be imposed.

Regarding costs of monitoring Ostrom (1990) in her book addressed as the costs are low in many long-enduring CPR's as a result of the rules in use. Once appropriators have made contingent self-commitments, they are then motivated to monitor other people's behaviors, at least from time to time, in order to assure themselves that others are following the rules most of the time. Contingent self-commitments and mutual monitoring reinforce one another, especially when appropriators have devised rules that tend to reduce monitoring costs. Personal rewards for doing good jobs or for individual who gains status and prestige for being a good protector of the commons are given to appropriators who monitor the commons. When internal monitoring is accomplished as part of a specialized position accountable to the other appropriators, several mechanisms increase the rewards for doing a good job or exposing placards to the risk of losing their positions.

DP 6: Conflict-resolution mechanisms

According to Ostrom (1990), conflict resolution mechanisms that are characterized by low transactions costs are a necessary aspect of an effective CPR management scheme. To ensure both the fairness and the continuity of the institutions, each stakeholder must have recourse to a forum established for the purpose of dispute resolution. As any set of rules and regulations is subject to different interpretation by different individuals, and because all organizations are bound to have some free-riders, it is important that a forum exist for the dispensation of justice and punishment to those accused of non-compliance. As with monitoring and graduated sanctions, an external source of governance is not required for this function and hence, tribunal court of the territory is vital (Frederick, 2007).

Conflict over an exhaustible resource is inevitable in CPR management, necessitating the presence of established mechanisms for conflict resolution to maintain collective action. Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials. When conflict resolution mechanisms are not available or easily accessible, successful CPR management appears more difficult (Michael *et al.*, 2010).

In theoretical models of rule-governed behavior, the rules that structure the strategies available to participants are unambiguous. In field settings, applying the rules is never unambiguous, even when the appropriators themselves are the monitors and sanctioners. For individuals who are seeking ways to slide past or subvert rules, there are always various ways in which they can "interpret" a rule so that they can argue they have complied with the rule, but in effect subverting its intent. For instance, if some individuals are allowed to free-ride by sending less able workers to a required labor day, others will consider themselves to be suckers if they send their strongest workers, who could be using that time to produce private goods rather than communal benefits. This situation should not continue over time, only children and old people would be sent to do work that would require strong adults, and the system would break down. Even individuals who intend to follow the spirit of a rule can make errors. If individuals that comply with the set of rules over a long period of time could face personal problems honestly

like forgetting about a labor day and when the worker is sick or unavoidably in another location there must be some mechanism for discussing and resolving what constitutes an infraction. If individuals who make honest mistakes or face personal problems that occasionally prevent them from following a rule do not have access to mechanisms that will allow them to make up for their lack of performance in an acceptable way, rules may come to be viewed as unfair, and conformance rates may decline. Although the presence of conflict-resolution mechanisms does not guarantee that appropriators will be able to maintain enduring institutions, it is difficult to imagine how any complex system of rules could be maintained over time without such mechanisms. Those which are selected by the community as their leaders are the basic resolvers of the conflict (Ostrom, 1990).

DP 7: Minimal recognition of rights to organize

Effective CPR management regimes need an over-arching governmental policy framework that facilitates, or even encourages, community-level institutions capable of natural resource management. The legislation enabling community forest management provides the broad framework for local forest protection institutions. The most basic requirement is for the government to recognize the rights of local people to devise their own institutions regarding CPR's (Frederick, 2007).

This principle stipulates that external government agencies do not challenge the right of local users to create their own institutions. An external government agency imposing its own rules on a community managing a CPR may suffer from a government failure if the externally imposed rules do not correspond to local conditions. Appropriators frequently devise their own rules without creating formal governmental jurisdictions for this purpose. The external governmental officials give at least minimal recognition to the legitimacy of local rules enforcement to govern commons. But if external governmental officials presume that only they have the authority to set the rules, then it will be very difficult for local appropriators to sustain a rule-governed CPR over the long run. In a situation in which one wishes to get around the rules created by the appropriator's one may go to the external government and try to get local rules overturned. Violations of this principle can be associated with less successful community-based resource management regimes. Community-based resource management projects developed in Sudano-Sahelian West Africa in the 1990s, which involved the devolution of

resource management authority to rural communities through the assistance of non-governmental organizations, failed in part by not recognizing local knowledge and existing institutions at the early stages of the devolution process (Michael *et al.*, 2010).

DP 8: Nested enterprises

The last principle refers to the condition that the institution should be part of a larger institutional setting (Anindya *et al.*, 2014). In successful systems, governance activities are organized in multiple layers of nested enterprises. Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises. All of the more complex, enduring CPRs meet this last design principle. Many scholars, particularly those focusing on pastoral and irrigation systems, have stressed the importance of nesting smaller common-property systems in larger and still larger ones, given the high probability that the social systems have cross-scale physical relationships when they manage different parts of a larger resource system and thus may need mechanism to facilitate cross-scale cooperation. It is important to ensure that a property rights regime has clearly defined boundaries, and that to the extent possible, those boundaries are consistent with the natural boundaries of the ecological system. It is not just user and resource boundaries that are important; a match between these boundaries may be important as well, and institutional nesting is an important way to accomplish this in many situations. Nesting may occur either between user groups and larger governmental jurisdictions, or between user groups themselves. Intercommunity connections can be thought of as horizontal linkages, whereas connections between multiple jurisdictional levels can be thought of as vertical linkages. Establishing rules at one level without rules at the other levels, will produce an incomplete system that may not endure over the long run (Michael *et al.*, 2010).

2.5 Case study of community forest management in rural India

One of the main objectives of CFM in rural India was to examine how well the CFM institutions conform to the design principles delineated by Ostrom (1990). However, most of the design principles are either only partially or implicitly represented in Andhra Pradesh. The two design principles (minimal recognition of rights to organize and collective choice arrangements) deviates from the CPR management theory as expounded by Ostrom, due to the intrinsic governmental oversight of the program. Unlike the case studies from which Ostrom's design

principles are synthesized, the vast majority of forest protection taking place under CFM in Andhra Pradesh is not self-originating because the basic institutions enabling the program are derived from legislative orders. Thus, the extent of government involvement is far greater than Ostrom (1990) suggests, which means that the seventh design principle is effectively moot within the institutional set of CFM. The third design principle (collective-choice arrangements) are ostensibly guaranteed in the national forest policy and the state legislation defining CFM in Andhra Pradesh. Although the local communities have some latitude to devise their own specific rules and regulations, they have no direct input in to the creation and modification of the basic CFM institutions. This is, of course, a violation of collective-choice arrangements that is a consequence of the government origins of the program. This is a structural design weakness that may eventually affect the functioning of the other design principles and, thus, may have a long-term impact on the success of the program. For example, the ability to revise the institutions to adapt to changing local conditions may be hampered due to the violation of collective-choice arrangements (Frederick, 2007).

Many of the design principles are present, to a greater or lesser degree, in the institutions of CFM is encouraging. But clearly weaknesses remain at the state level that affect the implementation and effectiveness at the local level. The design principles that are directly applicable to CFM (e.g., monitoring) must be readdressed in order to strengthen them. The degree of adherence to each design principle as implemented as a CFM institution was variable, and was found to be deficient entirely lacking in some cases. The key is to begin making progress towards the full realization of the design principles, as represented by the specific institutions of CFM to the extent possible given the governmental origin of the program. This is a difficult task because the standardization of certain institutions, in order for them to be more congruent with the design principles, must also preserve the ability of individual forest protection villages to adapt the local-level institutions to their own local circumstances. Thus, the CFM program will be constrained in its ability to evolve if it cannot reconcile the need for flexibility at the local level with uniformity at the state level, which is inherently needed for the wider implementation of the program. Other designing principles were partially implemented in Andhra Pradesh. The fundamental nature of the CFM paradigm is somewhat paradoxical: a decentralized system of forest management is designed to empower local people, but is guided by mostly centralized institutions devised and promoted by the government (Ibid).

2.6 Emergence of participatory forest management in Ethiopia

Participatory Forest Management is captured worldwide as one option for sustainable forest management through active involvement of the community. It was with this context that PFM in Ethiopia has been taking place since the mid-1990s through the pilot projects implemented, primarily by NGO's such as FARM-Africa/SOS Sahel Ethiopia in close collaboration with the regional governments of Oromia and the Southern Nations, Nationalities and Peoples Regional States (Ministry of Agriculture, 2012).

In Ethiopia, the basic agreement on community involvement in participatory forest management is formulated on a contractual agreement between public officials (forestry department) and forest user groups (organized local community groups). The first and pioneer community participatory forest management approach was born in Ethiopia by the name of WAJIB, "Waldaya Jiraattota Bosonaa" which is the synonymous term to Forest Dwellers Association, literally. Since then four forest priority areas namely Chilimo, Bonga, Adaba-Dodola and Yabelo forest areas were put under participatory forest management program and this program was financed by FARM Africa/SOS Sahel and GTZ. Oromia and SNNPR Bureaus of Agriculture show an interest to work closely with these two funding agencies for the full accomplishment of the program (Bedada, 2010).

2.7 Land use and land cover changes

Land cover refers to the observed biophysical cover on the earth's surface including vegetation, bare soil, hard surfaces and water bodies. Whereas land use is the utilization of land cover type by human activities for the purpose of agriculture, forestry, settlement and pasture by altering land surface processes including biogeochemistry, hydrology and biodiversity (Atalel, 2014).

Land use and land cover changes may be grouped into two broad categories as conversion and modification. Conversion refers to changes from one cover or use type to another (e.g. from grassland to cropland), while modification involves maintenance of the broad cover or use type in the face of changes in its attributes e.g. thinning of a forest or a change in composition (Hussein, 2009).

Land cover changes due to human activities drive land use and hence a single class of cover could support multiple uses (forest used for combinations of timbering, slash

and burn agriculture, fuel wood collection and soil protection). On the other hand, a single system of land use can maintain several covers as certain farming systems combine cultivated land, improved pasture and settlements (Atalel, 2014).

2.7.1 Global overview of forest cover change

Quantification of global forest change has been lacking despite the recognized importance of forest ecosystem services. Earth observation satellite data shows that global forest loss (2.3 million square kilometers) and gain (0.8 million square kilometers) from 2000 to 2012 at a spatial resolution of 30 meters. The tropics were the only climate domain to exhibit a trend, with forest loss increasing by 2101 square kilometers per year. Brazil's well-documented reduction in deforestation was offset by increasing forest loss in Indonesia, Malaysia, Paraguay, Bolivia, Zambia, Angola, and elsewhere. Intensive forestry practiced within subtropical forests resulted in the highest rates of forest change globally. Boreal forest loss due largely to fire and forestry was second to that in the tropics in absolute and proportional terms (M. Hansen *et al.*, 2013).

2.7.2 Trends of forest cover change in Ethiopia

There is no reliable figure on the trends of forest cover in Ethiopia. However, as some historical sources indicate high forests might have once covered about 35–40% of the total land area of the country. Deforestation accelerated towards the beginning of the 20th century and in 1960, closed natural forest was estimated to cover only about 3.37%. It is believed that, in Ethiopia, agricultural activities must have started about 5000 years ago and wide spread deforestation started about 2500 years ago. In 1981, the estimated rate of deforestation stood at 200 thousand hectares per year and it is expected that this figure will be much higher today and may continue like this unless some alternative options are made available to the rural population. It has been estimated that high forests covered 16% of the land area in the early 1950s, 3.6% in the early 1980s and only 2.7% in 1989 (Paulos, Not Defined).

Natural forests and woodlands covered 15.1 million ha in 1990. This area declined to 13.7 million ha in 2000. In 2005, the forest cover had further declined and was estimated to cover 13.0 million ha. In other words, Ethiopia lost over 2 million ha of her forests, with an annual average loss of 140, 000 ha between 1990 and 2005. In 2010 it is estimated at 12.3 million ha, 11.9 % of the total land area. Of this, the remaining closed natural high forests is 4.12

million ha or 3.37% of Ethiopia's land area. The area of forest is unevenly distributed in the country. Oromia, Southern Nations and Nationalities Regional State and Gambella region account for 95%. The major issue is the annual destruction of the natural forest for agricultural expansion. This is estimated to currently total about 59,000 ha per annum in the three main forested regional states of Oromia, SNNPR and Gambella. Only Oromia regional state which contained over 50% of the high forest in the country is estimated to have lost 31% of its forest as a result of agricultural expansion (Million, 2011).

2.7.2.1 The causes and consequences of deforestation

2.7.2.1.1 Causes of deforestation

Today, one only can find some stands of natural high forests within Oromia regional state, SNNPR and Gambella regional states. The economic contributions of forests to the natural development as well as to the household livelihood are not adequately documented. A variety of forest products services that constitute a major source of livelihood for rural households are not formally traded or not monetarily valued. Therefore, forestry's contribution is under estimated to the national economy. As a result, forestry trends to be undervalued in the national policies and priorities. Forests and wood lands are therefore, converted to other land uses as the economic values of these areas are unrecognized. The basic causes of deforestation are similar throughout the country. They stem from growing demand for land and forest products and the lack of sustainable resource management due to the economic, social and institutional constraints. The high population growth rate and the subsequent rising demands for crop and grazing land, construction material, fuel wood, charcoal, resettlement poverty and low public awareness are the main factors responsible for the decline of forest areas. Moreover, inadequate regulation and enforcement of existing laws designed to protect and manage forests are either insufficient or non-existent. Limited capacity and infrastructure to enforce existing instruments in the forestry has aggravated the rate of deforestation. Poor valuation of forest and wood land resource, under-development of none timber forest products, limited involvement of local people, lack of off farm employment opportunity, gap between sustainable yield supply and demand of forest products, and conflict of interest in the existing high forest area are another driving factors for deforestation (Nebiyu, 2009).

2.7.2.1.2 Consequences of deforestation

State of forest, people and their needs for natural resources must be at the center of efforts to achieve their sustainable use and development. The different ways in which people use (and abuse) natural resources is determined by a complex web of relationships. These relationships link not only the biophysical but also the social, cultural and economic "environment". Locally, the effects of deforestation are well known. Removal of forest cover leads directly to a loss of animal habitat, and thus a decline in animal diversity and abundance, a loss of watershed moderation, and thus increased spring runoff, soil destabilization, which can culminate in large-scale erosion and land slips, a reduction in local microclimate attenuation, and thus hotter summers, and a drying of the forest, and thus an increased risk of fire. These impacts contribute directly to a decline in the well-being of human populations in deforested areas, whether or not their primary livelihoods are forest-based. The destruction of the natural forests aggravated soil erosion, deterioration of water quality further drought and flooding, reduction of agricultural productivity and finally to an even increasing poverty (Ibid).

2.8 Application of remote sensing and GIS to monitor forest cover change

Remote Sensing is a powerful technique for surveying, mapping and monitoring earth resources. This technology combined with GIS which outshine in storage, manipulation and analysis for geographic information and socio-economic data to provide a wider application. Land resource and environmental decision makers require quantitative information on the spatial distribution of land use types and their conditions as well as temporal changes. The potential of remote sensing and GIS in the field of forestry become established over many years through the use of aerial photos and satellite image interpretations in forest cover change detection analysis, for the generation of forest cover map and inventory analysis. Remote sensing together with GIS brings a multitude of tools to better analyze the scope and rate of deforestation. Images of earlier years are compared to recent scenes, to tangibly measure the differences in the sizes and extents of forest cover change. Data from a variety of sources are used to provide complementary information. Satellite image data can be used to efficiently monitor the status of existing clear cuts or emergence of new ones, and even assess regeneration condition. In countries where cutting is controlled and regulated, remote sensing serves as a monitoring tool to ensure companies are following cut guidelines and specifications (Meseret, 2009).

2.8.1 Image Pre-processing

Raw satellite image is full of errors and will not be directly utilized for features identification and any applications. It needs some correction. Pre-processing is done before the main data analysis and extraction of information. Pre-processing involves two major processes: geometric correction and radiometric correction. Pre-processing aims to correct distorted data in order to create more faithful representation of the original scene, this typically involves the initial processing of raw image data to correct for geometric distortions, to calibrate the data radiometrically, and to eliminate noise present in the data (Habtamu, 2011).

2.8.2 Image enhancement

Image enhancement is used to increase the sharpness of the image by assigning the image maximum and minimum brightness values to maximum and minimum display values, and it is done on pixel values, and this makes visual interpretation easier by increasing the visual discrimination between features in a scene and assists the human analyst (Ibid).

2.8.3 Image classification

Classification of remotely sensed data involves clustering the pixels of an image to a (relatively small) set of classes, such that pixels in the same class are having similar properties. The majority of image classification is based on the detection of the spectral response patterns of land cover classes. Classification depends on distinctive signatures for the land cover classes in the band set being used, and the ability to reliably distinguish these signatures from other spectral response patterns that may be present. There are many different approaches to classifying remotely sensed data. However, in common they all fall under two main topics: unsupervised and supervised classification technique (Mohd *et al.*, 2009).

2.8.3.1 Unsupervised classification

According to Mohd *et al.* (2004), in unsupervised classification, an algorithm is chosen that will take a remotely sensed data set and find a pre-specified number of statistical clusters in multispectral or hyper spectral space. Although these clusters are not always equivalent to actual classes of land cover, this method can be used without having prior knowledge of the ground cover in the study site.

2.8.3.2 Supervised classification

Supervised classification does require prior knowledge of the ground cover in the study site. The multispectral or hyper spectral data from the pixels in the sample area or spectral signatures from spectral library are used to train a classification algorithm training sites on the image - either a print or a monitor display - to identify the classes. Once trained, the algorithm can then be applied to the entire image and a final classification image is obtained (Mohd *et al.*, 2009).

2.8.4 Accuracy of image classification

The accuracy is essentially a measure of how many ground truth pixels were classified correctly. When looking at the land cover map, it is important to remember that no map is a perfect representation of reality. There are always errors in maps and we need to keep in mind how accurate they are, and whether that level of accuracy is sufficient for the ways we want to use the map information. The result of an accuracy assessment provides us with an overall accuracy of the map based on an average of the accuracies for each class in the map (Habtamu, 2011).

2.8.5 Post-classification approach

Post classification is among the most widely applied techniques for change detection purpose. Numerous studies have been carried out using post-classification approach. In post-classification change detection approach two images from different dates are classified and labeled. The area of change is then extracted through the direct comparison of the classification results (Ibid).

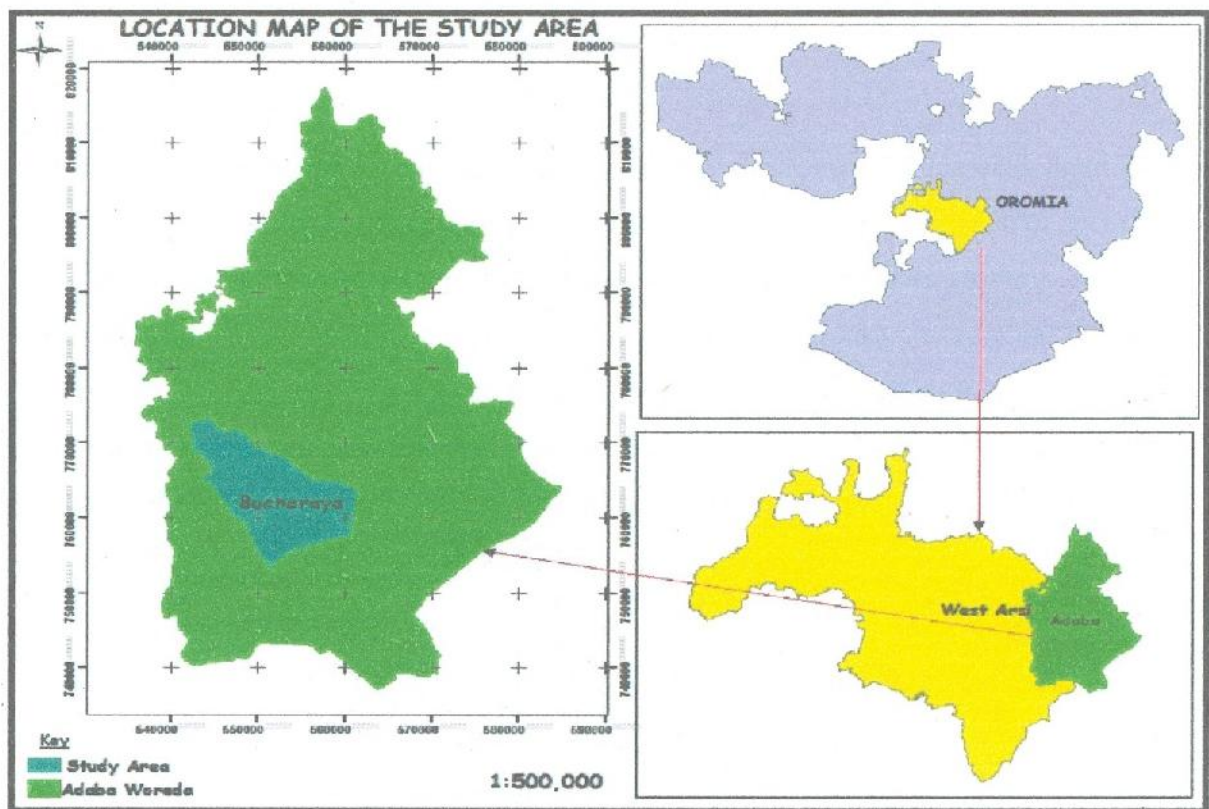
CHAPTER THREE: THE STUDY AREA AND RESEARCH METHODOLOGY

3.1 Description of the study area

3.1.1 Location

Bucha raya kebele is located in the Oromia National Regional State (ONRS) of Ethiopia in the West Arsi Zone in Adaba woreda that is situated 370 km from Addis Ababa via Shashemene road with a total land area of 18620.743 hectares. The study area is managed under the forest priority area of Adaba-Dodola district and shares boundary lines with Adaba town and rural kebeles of Adaba woreda such as Bubisa, Gama, Ejersa chumlugo & Koma wetticho. The geographical location of the study area was found between the latitude of $06^{\circ}54'$ and longitude of $39^{\circ}27'$.

Figure 1: Location map of the study area



Source: Compiled by researcher

3.1.2 Vegetation and Wildlife

Bucha raya is one of the richest kebele in Adaba-Dodola FPA in vegetation coverage and diversity of wild animals. Vegetation of the area ranges from wooded grass land to afro alpine. Alpine, Afro and sub Afro Alpine vegetation provides in the area above 3100m sea level. Below the Afro Alpine there are broad leafed forests which are dominated by *Juniperus excelsa*, *Podocarpus falcatus*, *Hagenia abyssinica* sparsely distributed leafed tree species. There are different types and endemic species of wild animal like mountain Nyala & menelik's bushbuck in Bucha raya kebele associated with the natural forest which forms their natural habitat. Other wild life species includes monkey species; Anubis baboon, colobus baboon (guereza monkey) and vervet monkey and endemic bird species such as Golden back woodpecker, Red winged love bird and Yellow fronted forest oriole are also available in the area. However, the wild animals that inhabit in the area were migrating to the neighboring woredas of Harena buluk, Nansabo, Dinsho and Gobba (BOFED, 2011).

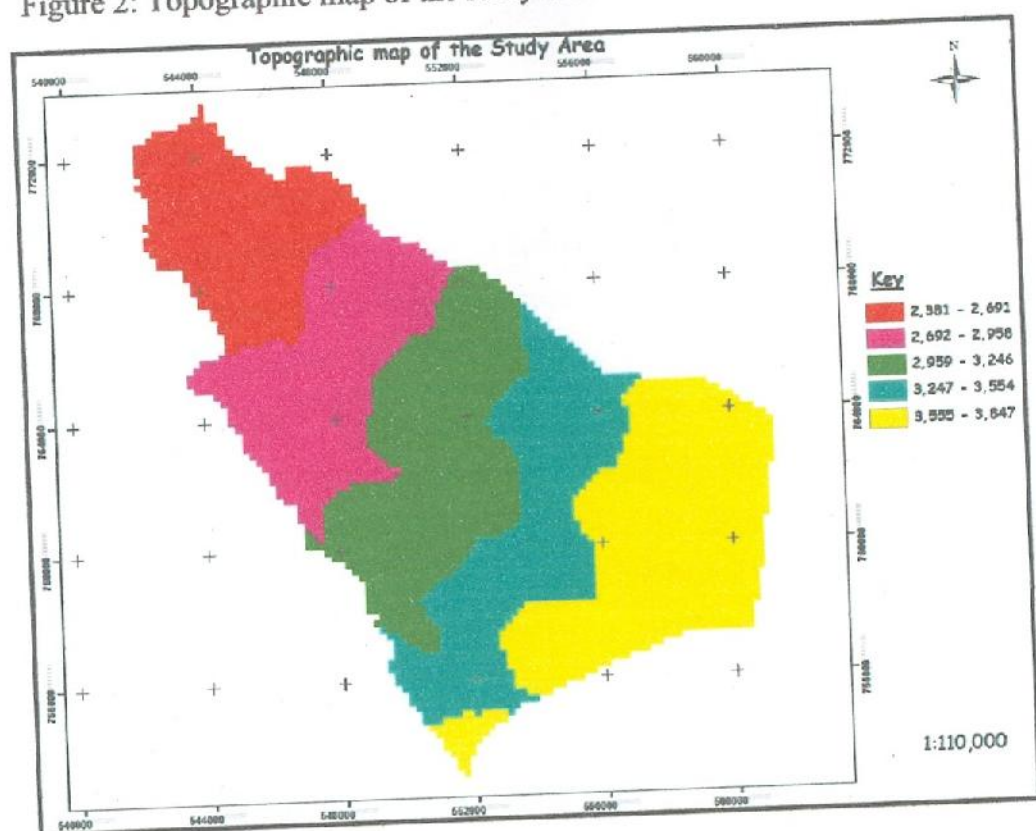
3.1.3 Climate

Bucha raya kebele is dominantly characterized by agro-climatic zones of Dega with about 85% and Woina Dega contributes only 15%. The main annual temperature of the area is found between 2^oc to 13^oc. However, there is a slight variation of temperature from month to months. With increasing altitude, the climate gets colder and wetter. In elevations over 3000 m, night frosts are frequent. Rainfall of the study area is bimodal, with the main rainy season occurring between June and October and the Belg rainy season during the months of March and April. The dry season lasts from November to February. The average annual mean rainfall of the study area ranges from 2200-3000 millimeters (BOFED, 2011).

3.1.4 Relief and Soil

Data extracted from Digital Elevation Model shows that the topographic landscapes of the study site belongs to rugged, made up of mountain chains with an altitude of 2,381m above sea level at the foothills of a mountain range (part of Bale massif) with peaks of over maximum elevation of 3,847m. According to BOFED, 2011 the major soil types available in the area includes Orthic luvisol & Eutric cambisol.

Figure 2: Topographic map of the study area



Source: Compiled by researcher

3.1.5 Socio-economic conditions

3.1.5.1 Economic activity

According to the data of Bucha raya kebele administration, the total population of the area was 3740 in the year 2014. According to the data from Adaba woreda Agriculture office, agriculture is the major economic activity for the livelihood of the community in the kebele. Crop production and livestock rearing are the specific economic opportunities for the area. Since, majority of the kebele is characterized by the agro-ecological zone of dega the major crop types commonly used by the people includes wheat, barley and pulses. In some parts of the area that have a woina-dega nature the major crops grown includes teff and cereal crops. The study area has a high potential for livestock rearing and the major livestock feeds in the area are common grazing land and crop residues. However, the society gives more emphasis to quantity than quality due to lack of awareness and animal health infrastructure. Therefore, the benefit that the society gets from their livestock is very low compared to their cost.

3.2 Research Design

The study was conducted based on the efficacy of the local institution of WAJIB in managing Bucha community forest from the perspective of designing principles illustrated by Ostrom for successful management of CPR's by effective local institutions. This study was conducted on 73 sampled members of WAJIB institution from three forest blocks of the community forest. The management practices of the community forest was examined by descriptive study based on the designing principles. The relevant data for the study was gathered by applying both qualitative and quantitative methods. Socioeconomic data for the study was collected from field observation, interview of respondents, key informant interview and focus group discussion. Digital data that shows trends of forest cover before and after establishment of local institution for managing Bucha community forest was also extracted from satellite imagery. The qualitative data obtained from socioeconomic survey was triangulated and elaborated based on the designing principles. Quantitative data obtained from classification result is also analyzed using change detection techniques to examine forest cover analysis before and after the establishment of local institution of WAJIB in the study area.

3.3 Data sources & materials

To investigate this study both primary and secondary sources of data are used. The major primary data required for the study is extracted from satellite images in order to identify historical and recent land-use/land cover. The image data used for this study was downloaded from USGS in January 2015 and these are: Landsat TM 1990, ETM+ 2005 and OLI/TIRS 2014. Digital elevation model (DEM) of the study area, with 30 meter resolution from the Shuttle Radar Topography Mission (SRTM) of NASA, is obtained from GIS lab, BDU. This data were used to observe the relationship between topography, mainly altitude and slope for forest cover change by using DEM and Arc GIS 10.1 software.

Table 1: Summary of data source and material

I. Satellite Image Data		
Image Type	Path and Row	Resolution (meter)
Landsat-TM	168/55	30 x 30
Landsat-ETM+	168/55	15 x 15
Landsat-OLI/TIRS	168/55	15 x 15
II. Materials		
Type	Description	Source
Instruments	GPS	Adaba woreda office of rural land administration & environmental protection
Software	ArcGIS 10.1, ERDAS IMAGINE 2013, Global Mapper13 & DEM data	GIS Lab

Another alternative for primary sources of data includes information gathered from respondents with the help of structured interview of the respondents, semi-structured interview of key informants and focus group discussion. The relevant secondary sources of data for this study was collected from published and unpublished materials of books, research papers, articles and journals by browsing from different web to describe the background information of the study area.

3.3.1 Image Pre-processing

In order to make analysis on the digital data of the image first of all raw data of the image that have flaws or deficiencies has been removed by applying geometric and radiometric correction. Avoiding of geometric distortion is performed by establishing the relationship between the image coordinate system and the geographic coordinate system or geo-referencing and projection to

UTM coordinate system, zone 37N of WGS-84 spheroid and datum for all images. Whereas, radiometric distortion was corrected by applying haze reduction for all images but noise reduction is applied for the image of last period or 2014.

3.3.2 Image enhancement

In order to improve the visual appearance of an image for better interpretation image enhancement techniques were used for this study. At the beginning layer stacking of multiple bands of image into one file using ERDAS IMAGINE 2013 software was applied and then resolution merge is applied for the image of 2014 in order to improve the spatial resolution of the image from 30m to 15m. Enhancement techniques like contrast stretching & histogram equalization were also applied for all images to maintain the relative distribution of gray levels.

3.4 Sample size and sampling design

The study employed sampling procedures to select household samples that represent the whole population. Among the total 9 kebeles in Adaba-Dodola forest priority area district, Bucha raya kebele was selected purposively for the following main reasons:

- The uniform distribution of community organization among kebeles
- Limitation of resources: time and finance, which could put a pressure if distant, and off-road kebele is to be selected

Bucha raya kebele have 3 WAJIB forest blocks with a total number of 90 households. The sample size for collecting socio-economic data for this research was determined using Cochran's formula as indicated in Hussein (2014). Thus, this study employed the following formula to calculate sample size from 3 forest blocks:

$$n = \frac{N}{1 + N(e)^2}$$

Where: **n** designates sample size the study used;

N designates total number of households within WAJIB forest blocks;

e designates maximum variability or margin of error 5% (.05);

1 designates the probability of the event occurring.

Therefore:

$$n = \frac{N}{1+N(e)^2}, \quad n = \frac{90}{1+90(0.05)^2} = 73$$

Thus, the sampled household size is **73 WAJIB members** (respondents). Out of the sampled household the number of male and female is 65 & 8 respectively.

Table 2: Summary of the sampled kebele administration and forest blocks

Name of the Kebele Administration	Name of the WAJIB	Total number of Households	Number of households selected	Total area of selected forest blocks in hectare
Bucha raya	Karayu wajitu	30	24	341
	Haro kamad	30	25	459
	Bebe ajamjam	30	24	370
Total	three	90	73	1170

Source: Compiled by the researcher

Although, Adaba-Dodola forest priority area district have nine kebele administration it was difficult to assess all these kebeles, which are found largely scattered and due to limitations in time and fund. Among the nine kebeles, Bucha raya kebele is selected as a study area from which samples are drawn. This kebele was selected due to its accessibility and representativeness to answer the research questions adequately. The samples were taken from 73 households that are managed under WAJIB forest blocks of the kebele.

3.5 Methods of Data Collection

A method of collecting essential data for the research is an important part of any research work. There are various research instruments that is used for this study to collect data. The research incorporates both qualitative and quantitative methods such as interview questionnaires, key informant and in-depth interviews, focus group discussion questionnaire, transect walk, data extracted from satellite image and data collected from secondary sources.

3.5.1 Interview questionnaires

One of the major task of this study during the field trip to Bucha raya kebele was conducting structured interviews. Questionnaires that have both open-ended and closed-ended questions were distributed to the sampled households in the selected forest blocks of WAJIB. The sample included 73 household heads in the three forest blocks found in Bucha raya kebele. The researcher has made a field visit in the forest blocks of the study area to gather the base line data for the research work. During interview of respondents the investigator or the researcher in this case asked a prepared set of questions in the same wording and order as specified in the interview questionnaire.

In this case the questions that are administered to the respondents include general back ground information of the respondents, their cooperative behavior and performance in collective action for community forest management, performance of WAJIB approach for the sustainable use of the community forest, the causes and impacts of forest cover change and the recommended community based forest management practices are also assessed by the interview questionnaires. Here the researcher managed different wordings during data collection process and the interview questioner was translated to the local language (Oromifa) in a uniform understanding of each questions by different respondents.

3.5.2 Key informant and in-depth interviews

This research work considered data collected through key informant interviews for triangulation purpose and to increase the quality and reliability of data collected from interview. Close-ended interview questionnaires were prepared to dig information from two local elders of the kebele, the chiefs of three forest blocks, one expert from Adaba woreda rural land administration & environmental protection office and two experts from Adaba-Dodola forest priority area district Adaba branch and the main office. The basic information gathered in this case was about the role of different stakeholders in the implementation of WAJIB approach and

the previous and current condition of the forest resource. Apart from the information taken from the above key informants in order to get a deeper insight to the conditions in the study area, a detail investigation is made about the sustainability of WAJIB approach, benefits and cost of the approach, cooperative behavior of the community and their trust on WAJIB institution and other issues relevant to answer the research questions. Unlike the key informant interview where experts and others were asked about their knowledge and opinion regarding management of the community forest, this detailed case investigation is carried out with people which are part and parcel of the local community who have a better understanding of the day to day activities in the forest blocks within the neighborhood. The information gathered through this approach is used for triangulation and helped the researcher to understand the local context much more clearly.

3.5.3 Transect walk

The researcher traversed the Bebe ajamjam, Karayu wajitu and Haro kamad forest blocks systematically. A local informant who was one of the WAJIB members escorted the researcher. Everything encountered, observed, noticed and mentioned by an informant is discussed and recorded based on the checklist. The transect walk is quite instructive to receive a deep insight into the spatial structure of each forest blocks in the study area and hence, observation checklist was prepared for the transect walk.

3.5.4 Focus group discussion questionnaires

The researcher conducted focus group discussions during the field survey in order to validate the data collected from respondents. For this study the researcher conducted three focus group discussion within three forest blocks. The number of peoples that are participated in the discussion was arranged by five peoples within each group discussion & totally 15 peoples were selected from women, elder and youth members of the community in order to collect relevant information for the study. According to the information provided by the community the peoples that are nominated for focus group discussion have more idea about the approach of WAJIB. The group discussion mainly based on close-ended interview questionnaires. The questions that are included in the questionnaire address the main research questions such as trends in forest resource availability, ethical and cooperative behavior of the community for collective action, protection of the forest before and after the establishment of WAJIB, trust and belief of the

people on WAJIB approach, community forest management practices of WAJIB approach and other questions that are relevant for this study.

3.5.5 Satellite images and spatial data

The major primary data required for the study was gathered from satellite imagery. The relevant data about land use/ land cover types of the study area within different periods of time was extracted from Landsat images of TM (1990), ETM+ (2005) and OLI/TRS (2014). Before extracting data of the satellite imagery preliminary field visit and second field work stage has been applied:

3.5.5.1 Preliminary field visit

The preliminary field visit has been made to provide an overall overview of the study area, to identify the various land-use/ land cover types and to collect GPS readings of the various features and land-use/land-cover types. These data was used for designing of final image classification and testing sample site, which is used for land-cover map validation of the subsequent supervised classification.

3.5.5.2 Second field work stage

The second field visit was made to verify the various land-use/land-cover types identified through satellite image manipulation and to consult the local community. These data has been used for designing of final image classification and testing sample site, which is used for land cover map validation. At each sampling site 30 reference points were randomly taken for each land use type using Garmin 72 GPS receiver for ground truth verifications. In addition to these data, photographs are taken at each site and essential information was generated, that helped the identification of trends, causes and impacts of forest cover change in the study area.

3.5.5.3 Post-field phase

Based on the final training sample site, which were generated during field work stage, all the available images were classified in to five major land-use/cover types by applying supervised classification method and maximum likelihood algorithm with the support of ERDAS IMAGINE 2013 software. In relation to this, the year 2014 land-use/land cover classification result was evaluated by employing accuracy assessment technique using ERDAS IMAGINE 2013 software to investigate how the result reflects the reality on the ground.

3.5.6 Secondary documents

For this study secondary sources of data has been collected from various sources. These data were collected from different government institutions like Bucha raya kebele administration, Adaba-Dodola forest priority area district Adaba branch & the main office and Adaba woreda rural land administration & environmental protection office. In addition relevant data from published and unpublished books, research papers, articles and journals that described the study area were browsed from websites.

3.6 Methods of Data Analysis

In order to meet the general and specific objectives of the study both qualitative and quantitative methods of data analysis were used. Descriptive statistics has been applied for this study to analyze the quantitative data. The qualitative data obtained from the interview of community forest members, key informants and focus group discussions were contextually analyzed and triangulated. Besides this, the summarized data was displayed in diagrams and tables to look for possible relations between variables. The data gathered through different instruments has been triangulated for the verification of validity of gathered data.

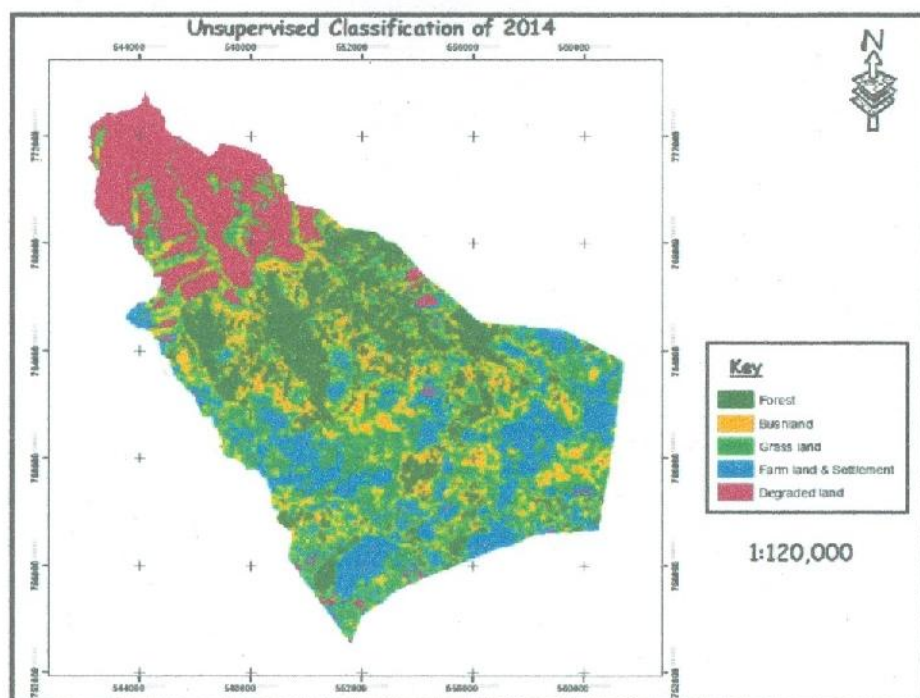
3.6.1 Image classification

Image classification is the process of sorting pixels into a finite number of individual classes, or categories of data based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to those criteria. There are two primary types of classification algorithm that has been applied to remotely sensed data of the study area. These are unsupervised and supervised. Unsupervised method of classification is useful when no previous knowledge or ground truth data of an area is available. Unsupervised classification approach was adopted for this study for pre-field visit purpose.

3.6.1.1 Unsupervised image classification

Based on the characteristics of Landsat imagery of the year 2014 the number of land cover types were determined to run unsupervised classification that aided the preliminary field visit to the study area. In the year 2014 the major land-use /land cover types were classified as; forest, bush land, grassland, farmland & settlement and degraded land. With the support of ERDAS IMAGINE 2013 software the map of unsupervised image classification for Landsat imagery of the year 2014 was produced (Figure 3).

Figure 3: Unsupervised image classification of the study area in 2014



Source: Compiled by the researcher

Table 3: Land use land cover of the study area using unsupervised image classification in 2014

No.	Class name	Area (ha)
1	Forest	3807.11
2	Bush land	3666.6
3	Grass land	3945.01
4	Farm land & Settlement	3719.31
5	Degraded land	3481.2
Total		18619.252

Source: Compiled by the researcher

3.6.1.2 Supervised image classification

During preliminary field visit to the study area various land cover classes were taken by systematic sampling using GARMIN 72 GPS devise. These samples were used to representative signatures for the various land cover types identified. The OLI/TIRS 2014 satellite image was classified by supervised classification using the sample training signature prepared from the GCPs collected for the OLI/TIRS 2014 image. For Landsat TM 1990 and ETM+ 2005 images, visual observation of the spectral information of the known land cover categories observed from unsupervised classified Landsat OLI/TIRS image (Figure 3) and from visual observation of the supervised classified OLI/TIRS image were used. From supervised classified Landsat OLI/TIRS 2014 image, five major land use land cover classes were identified as forest, bush land, grassland, farmland & settlement and degraded land.

Table 4: Description of land cover categories of the study area for change detection (1990–2014)

Land use/cover type	Land use/cover description
Forest	Area of land covered with large trees and plants
Bush land	Area covered with mainly shrubs and other small sized plant species.
Grass land	Area of land covered with pasture lands & grazing areas dominantly covered with grasses.
Farm land & Settlement	Areas of land ploughed for growing various crops and areas composed of rural villages
Degraded land	Area of land with in and around forest that have at least no vegetation cover.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Evaluation of Bucha CFM Based on the Designing Principles of Ostrom

4.1.1 Design Principle 1: Clearly defined boundaries

The characterization of sampled households is important to get background information of the respondents. Among the whole respondents 65 of them are male and the number of females are 8. Majority (95%) of respondents found between the ages of 18 – 64 only 10% were found between the ages of 65 – 88. Majority (90%) of the respondents were not educated; only 10% of them were educated. Among the total respondents 75% were hired as a member of the community forest during the establishment of WAJIB (2003/2004), 14% were hired in 2007 and 11% were hired in 2012. All of the sampled household's life system were traditionally attached to the forest to provide basic services like food, fuel wood, housing, fodder and medicinal plants.

The first Ostrom design principle requires that individuals or households with the rights to withdraw resource units from a common pool resource are clearly identified. To achieve this it is also necessary to clearly define the boundaries of the resource. The analysis of this principle is, consequently, discussed in two parts namely: (1) the definition of boundaries for the forest resources used by the communities, and; (2) the clarity of Bucha community forest resource users' boundaries.

4.1.1.1 The boundaries of forest resources

In examining the boundaries of the Bucha community forest resources it is important to recognize its formal boundary. As the boundaries are effectively defined by the resource users, the most practicable approach to identifying the boundaries for the forest resources was to ask the people whom might be community forest resource users. Most of the respondents from the household survey data (82%) didn't aware of the time local institution of WAJIB has been established in the kebele. However, data provided by the forest development committee member of WAJIB implied that WAJIB has been established in the kebele in 2003/2004 based on the mutual agreement made between Rural Land & Natural Resource Administration Authority (RLNRAA) and the community. The respondents suggested that before the entrance of WAJIB boundary of the community forest is not clearly known and hence, only boundary of the kebele is known. According to the informant after the establishment of WAJIB the forest was divided in to three forest blocks namely Haro kamad, Karayu wajitu and Bebe ajamjam with the areal coverage of 470 ha, 340 ha and 360 hectares respectively with the total area of 1170 hectares.

After the forest was managed under WAJIB institution different descriptions are given by the community members regarding spatial boundary of the Bucha community forest:

- From Webicho river to Wachokora river
- From Wachokora river to Witicho river
- From Webicho river to Witicho river
- From Wachokora river to Koma Witicho kebele administration
- From Webicho river to Koma Witicho kebele administration
- From farm lands to the forest

From the above descriptions, only 38% of the community forest members have boundary awareness of their community forest. Thus, Bucha community forest members are not well informed of the boundaries of their forest area even though they are the primary stakeholders responsible for community forest resource management.

4.1.1.2 Clearly defined boundaries of users

Another aspect of the principle of clearly defined boundaries is concerned with a clear definition of users with legal rights to use the community forest resources. According to the information obtained from the respondents there are selected criteria's for being the member of local institution of WAJIB and these are; person who have interest to conserve the forest, person who has paid tax for more than 5 years, person who stays within the forest, person whose settlement & assets are within the forest. Data obtained from Adaba-Dodola FPA district, Adaba branch shows that the institution of WAJIB have three internal committees responsible for the management of the community forest and these are; forest development committee, forest rent determining committee and forest products marketing committee. These committee members were elected within three year interval based on the proclamation of cooperative. However, 85% of the surveyed respondents are not aware of the time frame of those committee members in power.

Elders of the kebele suggested that before the entrance of WAJIB users of the forest were peoples of the Adaba woreda. According to the data obtained from the informant, after the establishment of WAJIB legal users of the forest were 90 (77 men and 13 women) that are arranged by 30 members within each forest blocks. Besides this according to WAJIB official of

the kebele 45 people were not registered as a members of the community forest in which 43 of them are males and only 2 of them are females and hence, their number was increasing through time. Despite the fact that legal users of the forest are arranged by 30 members within each forest block the number of peoples that are actually using the forest is different from this fact. The number of households that have permit to use the forest resource are not only those which are registered as members of the community forest, other sections of households that are not legal users of the forest are still using the forest together with the members. So, the boundaries that have given households the legal rights to use forest resource were found to be hidden in the permits issued to households to collect particular permitted resources. Thus, it was understood that these peoples were free-riding of the forest resources. For example, the informants suggested that non-members of the community forest collects fuel wood informally. Generally, the first designing principle was partially applied in the kebele.

Figure 4: Non-WAJIB member collecting fuel wood informally



(Photo: Author, 2015)

4.1.2 Design Principle 2: Congruence between appropriation & provision rules & local conditions

This principle addresses operational rules for harvesting forest resources. To understand the rule of congruence between appropriation and provision rules and local conditions as it applies to the Bucha community forest for the sustainable use of the forest resources, it was divided into

two parts: (1) congruence between appropriation rules and local conditions and; (2) congruence between provision rules and local conditions.

4.1.2.1 Congruence between appropriation rules and local conditions

To understand the first part of Ostrom's (1990) second design principle, interviewees were asked to explain whether the operational rules they use in harvesting the community forest resources restrict them in terms of time, place, technology and quantity or quality of the forest products that they harvest from the community forest.

4.1.2.2 Time restrictions

The study revealed that restrictions of the periods regarding harvesting forest resources for timber was clearly established. The time restrictions of using the forest resources for timber was from July to October and from February to May. However, for fuel wood the harvesting time is not clearly identified. The informant from elders pointed out that practically the community forest members were not used the forest products based on the time schedule because they are living within the forest that makes them to use when they wish. Generally, it was understood that there was no specific time restrictions for all types of forest products.

4.1.2.3 Choice of technology

Households are asked the technology they are allowed to use for harvesting forest resources. Officially, they are only allowed to use machete and an axe. Fewer than half of the respondents identified that they are allowed to use an axe & machete and hence, majority of the households were not clear on the technology to use for harvesting fuel wood. A substantial number of the households reported that they are not allowed to enter into the forest with a saw because they are only allowed to harvest fallen trees for cooking. Some reported that they are only allowed to carry an axe in case they want to cut fuel wood. Others reported that they are not supposed to carry any tool for cutting trees when they go to the community forest to collect fuel wood because they are only supposed to collect fallen fuel wood.

Table 5: Type of technology allowed for cutting fuel wood in the study area

Type of technology allowed for cutting fuel wood	Number of respondents n= 73
Are allowed to enter with a saw	20
Are allowed to carry an axe and machete	40
Are not allowed to carry any tool	10
Have not been told the tools to use	3

Source: Compiled by the researcher

Amongst the households who responded to this question on choice of technology 55 % pointed out that when they go to harvest fuel wood they are only allowed to carry a machete or an axe. 27% of the respondents choose saw in harvesting fuel wood from the forest whereas, 13% of the respondents choose as if it is not allowed to carry any tool. However, 4% of the respondents not to know the rules is surprising.

4.1.2.3.1 Quantity and Quality of forest products

The WAJIB officials of the kebele reported that for collecting the fuel wood households are allowed to use only trees that are fallen down. However, specific weight or quantity of back load & donkey load per day for fuel wood is not yet decided in the study area. The following figure shows the member of WAJIB that collected unrestricted quantity of fuel wood from Bucha community forest.

Figure 5: Women collected unrestricted quantity of fuel wood from the community forest



(Photo: Author, 2015)

For construction purposes the institution of WAJIB allows the member households to use an old trees that are not fallen down. Each year two old trees within each forest blocks are decided for this purpose based on the submission order of member households. Despite this fact when I go to the community forest for field observation, trees that are not permitted were harvested informally. The following figures shows trees that are harvested without any permit for fuel wood purpose.



Figure 6: Mother tree informally harvested in the community forest

(Photo: Author, 2015)

4.1.2.4 Congruence with local ecological conditions

It is clear that there are appropriation and provision rules, although these do not cover all resources and have largely not been formally implemented. One of the key informant from the chiefs of forest block explained that though forest products like timber that are used for construction purposes are scheduled from July to October and from February to May with a consideration of seasonal abundance of resources it is not formally implemented by all members of the community. Likewise the study found that forest products used for fuel wood are not scheduled like that of timber. Since, the quantities of fuel wood collected was not specified it affects the seasonal abundance of forest resource.

In summary, restricting the households in terms of the equipment to use for harvesting fuel wood (e.g. an axe or machete), only taking dead wood or fallen trees for fuel wood, using of two trees that are not fallen down as a timber for construction per year seems to be an excellent attempts to match the use of timber & fuel wood to the local peoples condition, to maintain sustainable use of the resources. Thus, these rules are generally congruent with the local conditions with the exception of the lack of specific time & quantities of fuel wood harvested.

4.1.2.5 Congruence between provision rules and local ecological conditions

The households were asked to explain the overall provision rules of WAJIB and whether these rules maintain sustainable use of the forest resources and improve their livelihood. Data

from surveyed households indicated that significant members of WAJIB picked their provision rules as; protecting the forest from land grab & charcoal production, using of dead wood & old tree that not fallen, using from area closure for animal fattening, prohibiting expansion of settlement beyond 50 meters and conservation of the forest from deforestation. The responses from households indicated a lack of understanding or consideration for the ecological conditions and sustainability of the ecosystem and related ecosystem services. In fact, the community was almost entirely focused on what was good for their short term needs rather than on sustainability of the resources on which their livelihood depends. For instance, informal cutting of the trees by both settlers (members & non-members) was found to be exist in the kebele.

However, despite the fact that the households response showed a lack of consideration of the ecological issues, the restrictions from cutting trees for fuel wood or harvesting timber in the Bucha community forest, shows that the rule of congruence between appropriation and local conditions has been established. However, the big challenge is that other peoples that are not legitimate users of the forest have not sense of ownership like that of legal users of the forest.

Moreover, according to the data from survey of the member households almost all respondents said that after the entrance of WAJIB the benefits they obtain from the forest has been improved. These benefits includes bee keeping, formal construction of new houses as a replacement for old ones; capital return from animal fattening; share of return from tourists & legal hunting of wild animals and share from legal sell of forest products like lumber to forest products marketing committee of WAJIB. Besides this, according to the chairperson of general assembly of WAJIB the financial capital deposited in the bank by the name of Bucha community forest was 28,000 birr and hence, this money was distributed equally to all members based on the mutual agreement of all members.

In conclusion, congruence between the appropriation and provision rules and local conditions has been partially achieved in the kebele. Expectations of non-members on the community forest may underlie some of the delays in making more rapid progress on this principle.

Failure of leadership at both the community & government levels were identified by the informants from elders and WAJIB officials of the kebele as the key barriers to being able to change collective choice rules. On the other hand involvement of the communities in the regular meetings of WAJIB has been achieved in the area. The regular meetings of members made once in a month and twice in a month for the WAJIB officials of the kebele. Although the operational rules were crafted by the agreement between the government and community, the community didn't get the chance to revise the rules. Therefore, the third designing principle is not applied in the kebele.

4.1.4 Design Principle 4: Monitoring

The fourth principle of Ostrom states that sustainable CPR management can only be guaranteed through effective monitoring hence, the monitors are not external authorities rather they are appropriators themselves and this study tried to determine if regular monitoring is undertaken by the Bucha community forest members.

The study found that monitoring condition of the forest & behavior of the users of the forest resources has been developed in the kebele. Monitoring responsibilities of behavior of the users of the forest resources has been undertaken by all members of WAJIB through one to five organization at household level. Majority of the households (89%) explained that the rules allow them to monitor the behavior of those destroying the forest resources. These respondents testified that once they see a person destroying the forest resources they report the incident to the chief of their one to five organization at sub-kebele (got) level. After this depending on the seriousness of the incident the information was disseminated hierarchically to; chief of that got, chief of the forest block, chairperson of the general assembly of WAJIB of the kebele, farachu raya forest conservation union, Adaba-Dodola FPA district Adaba branch, Adaba-Dodola FPA main office and finally to the Oromia regional state forest & wildlife enterprise.

One informant household revealed that 'if we get somebody destroying the forest we just make a first call to chief of our got but if the person isn't yet there we just make a call to chief of our forest block and the person is decided to get warning. However, the report is given carefully so that the violators do not know who gave the report to the chief of forest blocks. Some of the households from WAJIB community noted that they report those violating the rules to the kebele advisory committees of elders who then take the violators to the general assembly of WAJIB of

the kebele. This kebele advisory committee of elders comprise of two elders per forest blocks which is totally six kebele elders who are meant to receive reports on the violators of the rules. This kebele advisory committee of elders does the job voluntarily, for the most part, but may occasionally get a little pay when they participate in stakeholder meetings at district level.

The government forest management bodies like Adaba-Dodola FPA, Adaba branch and Adaba-Dodola FPA main office argued that they can check on the activities of those using the forest and that they do receive reports of illegal activities.

Moreover, kebele chiefs of forest block do not have the power to arrest anybody and hence, they report the situation to the advisory committee of elders of the kebele while the advisory committee of elders report to the WAJIB general assembly of the kebele. The study also found from the organizational informant of WAJIB that the communities can complain non-members since they are not part of the agreement, there is no specific rules for monitoring incident to the forest by non-members.

The respondents in the Bucha community forest were asked to comment further on how well they thought the monitoring rules were functioning. A majority of the respondents (85%) to this question reported that monitoring works because people fear the consequences and forest destruction has gone down. In contrast, other respondents (15%) pointed out that implementation of the rule isn't achieved because some members & large number of non-members informally poaching the forest especially during the night time.

Overall, despite some informal practices especially by non-members this principle of Ostrom has been implemented in the kebele.

4.1.5 Design Principle 5: Graduated sanctions

The fifth design principle has important implications for the sustainability of Bucha community forest, because circumstances eventually arise where members themselves are tempted to cheat. According to Ostrom (1990) violators of the operational rules were assessed & punished based on severity or repetition of the violations and hence, there has to be proportionality between the severity of violations and sanctions.

This study was interested in understanding if the Bucha community forest rules enable the households to appropriately punish the users of the forest resources who violate the operational rules arrangement. Of the sampled respondents of Bucha community forest, 83% reported having penalty structure if there was a violation of rules of WAJIB like absence from the regular meetings, informal expansion of settlement at a distance of 50m from previous houses, poaching of the forest, informal expansion of farm lands and charcoal production. However, 17% of community forest members explained that they are not fully aware of the penalty structure of WAJIB for the violation of the rules. The following figure shows a women that hasn't aware yet about sanction rules of WAJIB.

Figure 7: Women unaware of sanction rules of WAJIB



(Photo: Author, 2015)

One household that is a member of WAJIB explained the process for sanctioning the violators of the rules in the Bucha community forest, as follows:

'The person is warned two times, at the first day the person is warned orally that what you are doing is not wanted, this is what you are supposed to do, then the person is left to go and warned not to repeat the same mistake, if the person is caught again another day for the second time he is reminded: 'What did we tell you on the other day? Then the kebele elders told the person that this was a last chance to stay as a member of WAJIB and finally the warning letter was given for the person of guilty of the incident that says this was the last chance from losing

the membership. Another time if the person was caught of the same mistake the person will be forced to pay 2,000 birr unless the person was automatically dismissed from the membership and the situation was taken to the court'.

The study revealed that from the survey of the respondents 55% of the households reported that most of the time violators of the rule were both members & non-members, 14% of the households explained that violators of the rule was only members of WAJIB rather than non-members, 31% of the households pointed out that it was non-members that are violating our rules. This finding was supported by one household informant who is a community leader and stated that when we look the households in the kebele separately those which are not members of WAJIB are mostly breaking our rules than the members. But when we look generally both members & non-members were violator of the rules of WAJIB.

According to the chairman of the general assembly of WAJIB of the kebele the major offences on the community forest that results sanction were; land grab which results 10 birr per one meters of land, another incidence was cutting of mother trees that results penalty of 2000 birr for one mother tree by replacing it with two tree plants and absence from the regular meetings for two times results warning but if the person was again made the same mistake it was decided to exit the person from the legal membership of WAJIB and another person automatically replaced based on the decision made at the meetings of all members.

79% of the surveyed households responded that the sanction structure worked based on the seriousness & repetitions of the offences but there was a fear to punish all violators of the rules. Other households seemed unaware of punishments. Though the sanctions made on those breaking the rules was based on the seriousness & repetitions of offences another household informant reported that there is a fear to punish all violators of the rules as there was a fear to be injured by the violators.

Despite graduated sanctions are based on the repetition & seriousness of offences there was a problem of applying the punishments on all violators of the rules of WAJIB that shows the practice of free-riding in the kebele. Overall this designing principle was partially implemented in the study area.

4.1.6 Design Principle 6: Conflict resolution mechanisms

According to Ostrom (1990), conflict resolution mechanisms that are characterized by low transactions costs are a necessary aspect of an effective CPR management scheme. This study was interested in understanding if the Bucha community forest management arrangements of WAJIB institution provided participating households with an accessible process for resolution of conflicts among the forest resources users, or between forest resources users and non-members, or between forest resources users and WAJIB officials of the kebele. The study found that 95% of sampled households pointed that there is a kebele advisory committee of elders that is responsible for conflict resolution between the various resources users, non-members and their officials (e.g. chief of the got & forest block). However, when issues prove too tough to handle for these kebele advisory committees of elders they forwarded to the WAJIB general assembly of the kebele.

The Bucha community forest members of WAJIB responded that:

'We have six old men in our kebele [kebele advisory committee of elders] and two within each forest block that has been appointed to discuss such issues. If the user of the forest is in conflict with the chief of the got, then they discuss all those issues here but when it is very difficult to handle the matter that is when they call the management from general assembly of WAJIB in the kebele'.

'If the user of the forest is in conflict with other user of the forest from the same forest block, then elders of the kebele together with chief of the got & forest block discuss & finish the issue but, if the issue is difficult to handle it will be forwarded to general assembly of WAJIB of the kebele'.

'If the users of the forest from different forest blocks are in conflict, then elders from both forest blocks together with chiefs of both forest blocks discuss & finish the issue but, if the issue is big it will be forwarded to the general assembly of WAJIB of the kebele'.

The informant clarified that if users of the forest are in conflict with non-members the conflict is resolved by kebele administration.

According to the data taken from informant if the conflict is between WAJIB officials of the kebele, then meeting of all members is conducted and a resolution is given. However, in some instances if the conflict is serious the Adaba-Dodola FPA, Adaba branch & main office are involved by establishing different committees from the sectors of Adaba woreda office of rural land administration & environmental protection, office of cooperative, office of woreda administration and office of security affairs.

Despite the fact that members of WAJIB are aware of the conflict resolution mechanisms, field interview with WAJIB official of the kebele indicated that conflict resolution in the kebele is not active as in the past. During the past those households in conflict over forest resources were easily negotiated by the local elders. However, after the forest was decided to be managed by the agreement made between the community & government households belief on conflict resolution was changed. Therefore, if people are in conflict they want to get the final decision from the court.

In summary, Bucha community forest members have several provisions for conflict resolution. First, kebele advisory committee of elders usually resolves smaller conflicts related to forest resource use. Second, more complicated conflicts are forwarded to government (Adaba-Dodola FPA, Adaba branch & main office). Third, conflicts between members & non-members of WAJIB has been resolved by the kebele administration. Fourth, conflicts between WAJIB officials of the kebele was resolved by the meetings of all members of WAJIB. Thus, findings implied that the Bucha community forest conflict resolution mechanisms are largely established but they are not complete since, there was strong belief of WAJIB members on the government than local elders of the kebele for tough conflicts.

4.1.7 Design Principle 7: Minimal recognition of rights to organize

This principle stipulates that government recognizes the rights of local people to devise their own institutions regarding CPR's. This study is conducted to understand whether the government recognizes the rights of members of Bucha community forest to devise their own rules & undertake administrative duties. The study revealed that the rule of official recognition of rights has been more or less realized. For instance, out of respondents of WAJIB, 17% of the members said that they have no awareness of government body that gives recognition for the establishment of WAJIB & with whom government body that members of the community forest has make

relationship. However, 83% of them felt that the government (Adaba-Dodola FPA, Adaba woreda administration, Adaba woreda office of cooperative, office of agriculture, office of security affairs, office of culture & tourism, office of rural land administration & environmental protection and Bucha raya kebele administration) gives recognition for the WAJIB members to devise the rules of managing community forest and they have good relationship with Adaba-Dodola FPA, Adaba branch & main office. These households felt that if the households hold a meeting and write what rules they want to devise and forward them to the government then they thought the government would accept the rules. This shows that the communities have not had an independent opportunity to devise their own rules, even though from the discussion it seems they do, but they have not taken it as the government seems willing to engage with the communities on the establishment of the rules. During group discussion women reported an argument that supports this idea, when the forest management agreement signed much feedback was not received from the community and once we signed the agreement we didn't get the chance of devising the rules. From these it was understood that it is difficult to sustain local rules over the long run. The young men also raised supporting idea where users of the forest are going to the government and trying to get local rules over turned. This shows how hesitant the government is in devolving power to the communities.

In summary even though the households feel that the government can recognize their efforts in formulating their own local institution for community forest management it hasn't been complete because rules devised by the community were not recognized by the government that makes the principle was partially implemented in the study area.

4.1.8 Design Principle 8: Nested enterprises

This principle states that in successful systems, governance activities are organized in multiple layers of nested enterprises. Nesting may occur either between user groups and the larger governmental administration, or between user groups themselves. This principle is available only for complex and enduring CPR's. Thus, for this study this principle was not considered.

Summary of the designing principles of Ostrom (1990) for Bucha community forest

The major objective of this study was to evaluate the extent to which governance arrangements for governing the Bucha community forest has been characterized as successful or robust institutional arrangements. The study used Ostrom's (1990) common pool resources design principles as an evaluative framework in understanding the extent to which the governance arrangement for Bucha community forest can be characterized as a robust WAJIB institution. The analysis indicates that in the Bucha community forest Ostrom's (1990) design principles are present to some extent.

Table 6: Summary of Ostrom design principles as they appear at Bucha community forest

Design Principle		Bucha community forest institution of WAJIB
1	Clearly defined boundaries	No
	(a) of resources	
	(b) of users	
2	Congruence	Partially, yes
	(a) Between appropriation rules and local conditions	
	(b) Between provision rules and local conditions	
3	Collective Choice arrangements	No
4	Monitoring	Established, yes
5	Graduated sanctions	Partially, yes
6	Conflict resolution mechanisms	Partially, yes
7	Minimal recognition of rights to Organize	Partially, yes

Source: Compiled by the researcher

Overall, it can be concluded that the findings of this study shows that the governance of WAJIB institution has not achieved all design principles of Ostrom and it is categorized under failed institutional regime.

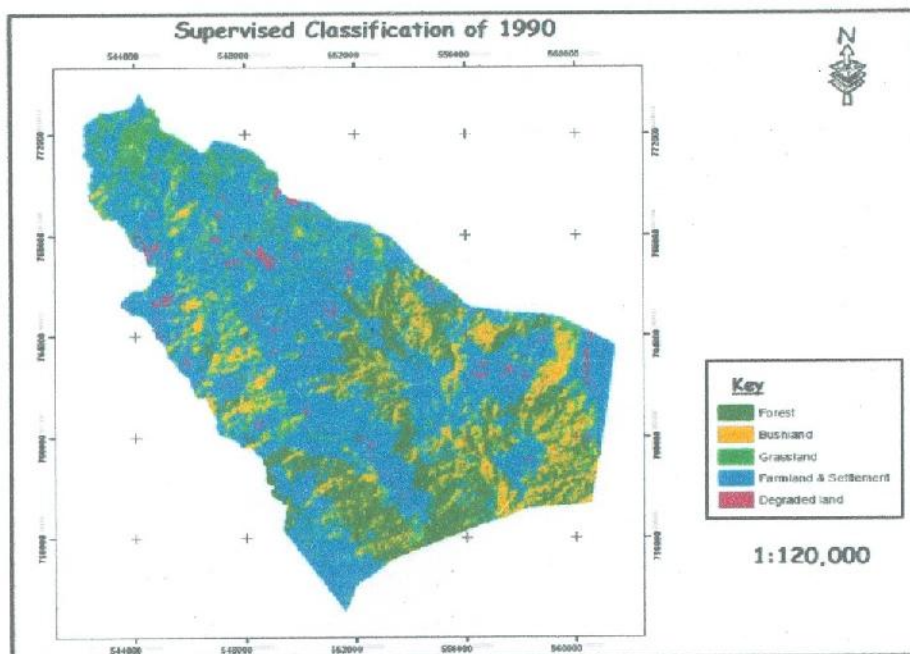
4.2 Land use and land cover

Based on the final training sample site, which were generated during field work stage, all the available images were classified in to five land-use/cover types by applying supervised classification method and maximum likelihood algorithm with the support of ERDAS IMAGINE 2013 software. In relation to this, the year 2014 land-use/land cover classification result was evaluated by employing accuracy assessment technique using ERDAS IMAGINE 2013 software to investigate how the result reflects the reality on the ground. Likewise, the years 1990, 2005 and 2014 forest cover maps are also extracted independently from each land use land cover maps.

4.2.1 Land use/land cover map

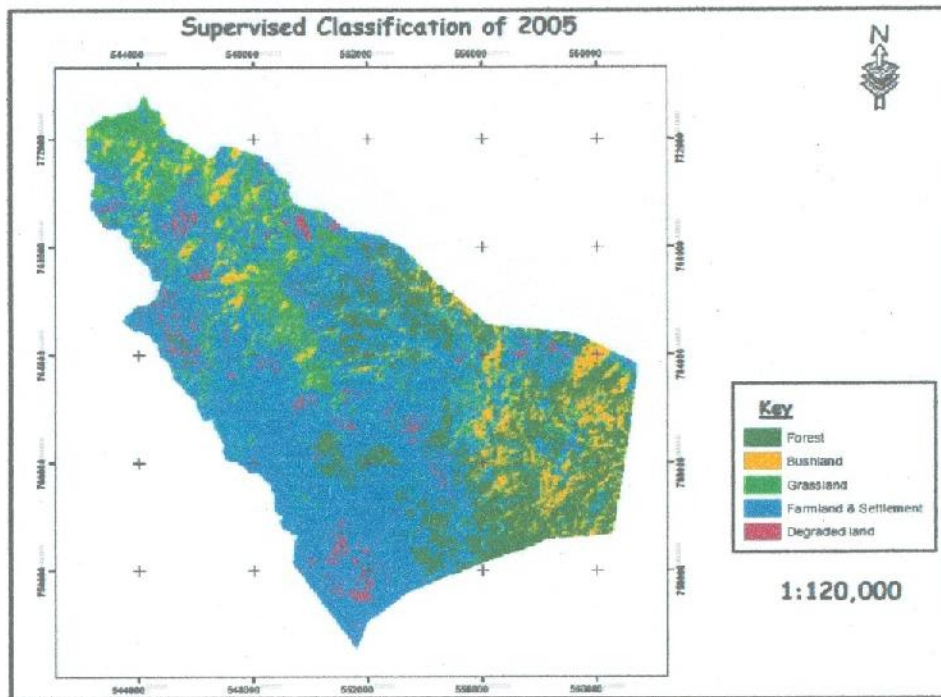
Land use/land cover unit of the study area were categorized in to five types; these are: Forest, Bush land, Grass land, Farm land & Settlement and Degraded land. The three dates of land use/land cover classification map of the study area is presented in the figure 8, 9 and 10.

Figure 8: Classified land-use/ land-cover map of the study area in 1990



From the 1990 land use and land cover map interpretation, the areal coverage of forest was accounted for **3101.49 ha** or 16.6% from the total areal coverage of the study area. The bush land, grass land, farm land & settlement and degraded land occupied 15.5%, 8.87%, 55.17% and 3.74% respectively.

Figure 9: Classified land-use/ land-cover map of the study area in 2005



From the total land coverage, farmland & settlement were accounted for about 10517.8 ha (56.48%) in the year 2005. The areal coverage of the forest was accounted for about 3123.4 ha or 16.7% in the year 2005. Bush land and grass land take the share of 2084.69 ha (11.2%) and 1937.9 ha (10.4%) respectively. The remaining area was covered with degraded land 955.462 ha (5.13%).