PhD Dissertation

Sustained Environment (Bale Mountains - Ethiopia)

UNISA university of south africa

Area of Study:

Environmental Management of Watershed Ecosystems

Research Topic:

An Investigation of the Nature, Causes and Effects of Long Term Environmental Degradation on Watershed Natural Resources; A Case of Belbela-Wadecha Watershed Ecosystem, Central Ethiopia

PhD Dissertation

Submitted in Fulfilment of the requirements of the Degree of Doctor of Philosophy

By

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(February 2021)

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'Building a Lasting Biotic-Home Together'

Declaration

I, Adugna Jabessa Shuba, hereby solemnly declare that this Dissertation, entitled 'An Investigation of the Nature, Causes, and Effects of Long Term Environmental Degradation on Watershed Natural Resources – A Case of Belbela-Wadecha Watershed Ecosystem, is wholly of my own account. The Thesis has not been submitted to any academic institutions for any other degree or qualification in its present form or similar version. All secondary materials used in this study have been duly acknowledged.

Adugna Jabessa
BSc, MSc

Dedication

To my beloved mother, Worknesh Mekonnen, for her accordance of extraordinary love and care, that shaped me to what I am today.

Abstract

Land degradation is a process in which the value of the biophysical environment is affected by a combination of nature and human-induced processes acting upon the land. It is viewed as any change or disturbance to the land perceived to be undesirable. Soil degradation is one aspect of land degradation and others are vegetation or water resource degradation.

The Belbela-Wadecha watershed ecosystem in its current state is practically a degraded phenomenon, and thus the previous benefits it could provide would have been affected, as a result. As can be perceived from physical observation, vegetation has vanished, soils are eroded, gullies have formed, reservoirs are filled up with sediments, canals are blocked / clogged, dam water storages have declined, and flooding have caused major damages. Reportedly, malarial incidents have become high because of formation of damp soils due to the stagnation of water. As a result, existing economic, social, and environmental benefits have been affected in a way imposing hard and unusual way of experience of pattern of life.

Since 1985, different LandSat satellites have been used to observe Earth from space and provide data that help the public and scientific community to understand the state and condition of Earth's surface through time. In order to assess the land change, remote sensing (RS) imageries from the LandSat satellites have been used.

Satellite remote sensing can help to enhance largely the capabilities of monitoring the actual state of land uses in a comprehensive and timely manner. It fulfills the requirements for monitoring and mapping the status of agricultural land use and land change, because satellites deliver objective and timely (every 5-6 days) information regularly. The high spatial detail of satellite images (10-meter pixels) enhances tracing these activities at different scales: from the single field level (study area) and even up to country level.

In this study, the methodologies that were deployed to assess land degradation (land cover changes) of the study area relied on the processes of remotely sensed imageries using different satellites of LandSats 4-5 Thematic Mapper (TM), and LandSats 7 and 8. The main dominant bands were bands 1, 2, 3, 4, 5, 6 and band 7 based on the types of LandSats. In general, Green,

Red and Blue (RGB) colors and reflectance of vegetation in Near Infrared (NIR) bands were used in the analysis.

In addition, qualitative primary data was sought through focus group discussions, questionnaire survey and secondary information from document analyses to explore the causes and effects of environmental degradation in Belbela-Wadecha watershed ecosystem in Central Ethiopia. The participating communities were also involved from the beginning through Participatory Action Research (PAR), in identifying causes of degradation in the watershed responding to them through a pilot trial project.

The combination of data collected from satellite remote sensing, Participatory Action Research process, physical ground observation, questionnaire survey, focus groups discussions and the secondary data was analyzed qualitatively and quantitatively and the results interpreted to help in designing future directions in watershed resource management.

Furthermore, the integration of the results of both qualitative and quantitative research analyses helped in making conclusions and recommendations towards improving the natural setting of the ecosystem. The main findings and conclusions hinged on ensuring parallel and harmonious operation of both environmental management and agricultural irrigation systems with a view to achieve sustainable environmental, social and economic well-being. Because of ecosystem restoration and sustainable downstream irrigation agriculture, it was hoped that this would lead to the improvement of livelihood sustenance through economic, social and environmental benefits.

Keywords: Watershed degradation, LULC, NDVI, Natural resources, Poverty, Environment, Ecosystem, RS, Infrared, GIS, PAR, IWRM, Enforcement of laws, Development, Sustainability

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Acknowledgements

First of all things, extraordinary thanks go to the almighty God for his glorious guidance and real-world protection given to me in making this work happen – only through his invincible strength and mystical wisdom!

This study was undertaken through the University of South Africa under the direct supervision of Professor Dr. Soul Shava to benefit both the environment and subsequent irrigation in Belbela-Wadecha watershed area. I would like to express to him my heartfelt gratitude for his inestimable contribution, right from the beginning, and constructive criticisms that set directions and moved the work to the next stage each time involved in the process. His tremendous professional and material support has been educative all the way through and responsiveness without exception to my repeated questions was exemplary. His support has been the cornerstone to this research study. I simply do not know how to thank him enough. I also would like to express my warmest thanks to Professor Dr. David Modise whose rich experience and knowledge and the decisive initiatives taken to making this study come to the fore will always be remembered in my life being. I am also most grateful to Professor Dr. Michael Antwi who has been a rich source of support right from my early days in the University in journeying my study work and paving further ways in the process. Any comment he has made on the work has been of great value contribution that yielded support taking the work to a further level. Words can hardly express my gratitude to him.

I would also like to express my earnest thanks to the staff of the University of South Africa, Akaki branch, for their unreserved support to making the research study journey a success story. I am also hugely indebted to the University of South Africa for its financial support without which this study would not have come to the fore.

My profound gratitude goes to my friend Deksyos Tarekegn for taking the pains in going the extra mile with me and finding the support for my work, including formatting, to the level of the required standards. His other generous supports also include moral, material, and shared his busy schedule joining me on the field visits numerous times. Words cannot express my gratitude to him enough.

I am also thankful to the local Government of Ad'aa Woreda for supporting this study from the start to finish. I would also like to express my deepest gratitude for the dedicated effort exerted by Dajanee Haayiluu for liaising between local Government officials and the sample site farmers without whom the journey would not have been as easy. I thank also Taaddasaa Kabbabaa for taking the pains that, amid his busy schedule, he managed to respond to my frequent and sometimes repeated questions pertaining to material acquisitions from the Woreda offices, to help contribute to the success of the research study.

Special thanks go to the farmers of both Kebeles of Godino and Qoftuu who sacrificed their busy schedule to respond to my long questionnaire list and participated in focus group discussions. I would like to extend my gratitude to the Qoftuu farmers who spent more time discussing to arrive at a consensus to offer a pilot plot of land for demonstration purposes and in planting trees on the delineated pilot area of land and fencing the perimeter of the scheme to protect against possible external damage.

I would also wish to express my sincere appreciations for the supports rendered by my colleagues, Abity Getaneh, Surafel Mamo, Tilahun Girma, Abebaw Zeleke, and Getnet Selamu. I further wish to express my appreciation to Tasfaayee Roobalee for his support in introducing me to the relevant key personnel involved in the study area. My thanks should also go to Hassen Nuur and Dr. Girma Mekonnen for their encouragement and material support offered to contribute to the start-up activities in my journey of this research study.

Finally yet importantly, many fervent thanks go to my lovely family, my wife – Frezewud Kebede – for her prayers and my daughters – Eskedar and Solyana (Rajanii), for the invaluable moral support they always furnished me with during my study period. I am also appreciative of their patience for bearing with me that I have not had enough family time to share with them. I am also immensely indebted to my wonderful children abroad, my daughter Sara and my son Olaanii for the immeasurable moral support they gave me throughout my study tenure.

Abbreviations and Acronyms

BM^3	Billion Meters Cubed
CDM	Clean Development Mechanism
CFM	Conceptual Framework Model
CIFOR	Center for International Forestry Research
CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency
CSE	Conservation Strategy of Ethiopia
EHRS	Ethiopian Highland Reclamation Study
EPA	Environmental Protection Authority
FAO	Food and Agricultural Organization of the United Nations

FGD	Focus Group Discussion
FRC	Forestry research Center
GGWSSI	Great Green Wall for the Sahel and Sahara Initiative
GHGs	Green House Gases
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
HPI	Human Poverty Index
ICRAF	International Center for Research in Agroforestry
ILRI	International Livestock Research Institute
IPCC	International Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
IWSM	Integrated Watershed Management
Km^2	Kilometer square
LULC	Land Use and Land Cover
LULCC	Land Use Land Cover Change
MEDaC	Ministry of Economic Development and Cooperation
MLC	Maximum Likelihood Classifier
MM^3	Million Meter Cube
MoA	Ministry of Agriculture
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MoWIE	Ministry of Water, Irrigation, and Energy
NAP	National Action Plan
NASA	National Aeronautics and Space Administration
NCS	National Conservation Strategy
NDVI	Normalized Differential Vegetation Index
NEPAD	New Partnership for Africa's Development
NGOs	Non-Governmental Organizations
NIR	Near Infrared (Band)
NMSA	National Meteorological Services Agency

NWFPs	Non-Wood Forest Product
OIDA	Oromiya Irrigation Development Authority
OLI	Operational Land Imager
PAR	Participatory Action Research
PCA	Principal Component Analysis
RFM	Restoration Framework Model – for sustained upstream environment and downstream irrigation development
RS	Remote Sensing
SCS	Soil Conservation Service
SDGs	Sustainable Development Goals
SLMPs	Sustainable Land Management Projects
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Education, Science and Cultural Organization
UNFCC	United Nations Convention on Climate Change
UNISA	University of South Africa
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WCED	World Commission on Environment and Development

1 Introduction and Background to the Study

1.1 Introduction

This chapter presents the background of the study and will give a brief statement of the problem that provides the reader an over view of aims of the study. The problem statement contained in this section will relate to the Belbela-Wadecha watershed environment in Ada'a-Liban Woreda East Shoa Zone, Oromiya National Regional State where the study area description is discussed also.

The chapter further deals with the objectives of the study in which the main objective of the study relates to the investigation of the nature, causes and effects of environmental degradation, on watershed natural resources, mainly reflecting on the vegetation and soils. The purpose and aim of the study was to secure a parallel operation of sound environmental functions and sustained irrigation development.

1.2 Background to the Study

Continued deforestation due to human impacts on environment has resulted in climate change to the extent that the normal climate characteristics that have been experienced by humanity for centuries long have now adversely been changed and the effect is being practically felt. As a result, according to Santra (2016), environmental conferences such as the Stockholm Conference (1972), the Nairobi Conference (1982), the Rio Earth Summit (1992), the Kyoto Summit (1997), the Johannesburg Earth Summit (2002), among other milestone events, have been organized and attended by political leaders, policy makers, scientists, academia, consultants, NGOs, private sectors, among other personalities and institutions.

The outcome of 'Rio' Earth Summit, the biggest ever summit attended by leaders and other high personalities, lies in five formal documents, namely two conventions, two statements of principles, and an action program. The Framework Convention on Climate change that relates to global warming issues, and the Convention on Biological Diversity that deals with global biological conservation issues are formal and important binding documents set forth to be taken up in the fight against environmental threats. The two statement documents are The Forest Principle, for protection against exploitation of forest resource in rampant manner, and the Rio Declaration on Environment and Development that sets out 27 guiding principles in the environment protection endeavor. Agenda 21 sets an action plan for sustainable development through integration of goals of environmental protection and economic development. One of the resolutions that have been taken up during Rio Summit held in Rio de Janeiro (1992) was "To integrate environment and development in decision making", Agenda 21 (1992: 64). This study, in this light, intends to explore the integration of sustainable development into watershed management with a view towards harnessing sustainable irrigation agriculture development and sound environment in response to natural resource degradation.

The major cause of soil degradation in sub-Saharan Africa is human activities. An assessment made on 145 watersheds globally, indicated that expanding human demands for resources have intensified watershed degradation (Revenga et al., 1998). According to FAO (1984), cited in Hawando (undated) the highlands of Ethiopia covering 27 million hectares are degraded, of which 14 million is eroded very seriously with two million hectares having reached a point of no return. Pearson (2013) argues that Ethiopia loses a large amount of fertile soil, almost two billion metric tons annually, through run-off water mainly from cultivated land. As a result, as argued further, the soil depth of the country is reduced by about 50cm annually, resulting in the decline of agricultural productivity.

The Belbela-Wadecha watershed natural resources, particularly, vegetation and soils are affected due to environmental degradation of the watershed ecosystem induced by human activity. The degradation is attributed mainly to deforestation including, cutting down of trees for securing farmland, obtaining fuel wood, economic benefits, bad farming practices, overgrazing, burning of forests, and human resettlements.

Wide ranges of efforts are being made in general worldwide to curb watershed degradation. In this regard, the Government of Ethiopia (GoE) has formulated and put in place policies and promulgated provisions necessary for environmental sustenance. However, it is evident that further unreserved commitment would be needed and both the people and the Government require massive resource mobilization. Enforcement of laws seems to be a gray area that again requires a dedicated move by the people and the Government structures to realizing environmental policy provisions.

The constitution of the Federal Democratic Republic of Ethiopia, Proclamation No 1/1995, GoE (1995) has clearly stipulated environmental protection functions, in its various sections of provisions. Some of the stipulations include, sub- articles 89(5) and (6), and 92(2) and (3) that specifically state that environment shall not be damaged or destroyed and that it should be protected.

It also states that the communities in a given environment have the right to full consultations and to the expression of their views in the planning and implementation of environmental policies and projects that affect them directly and that the citizen shall have the duty to protect the environment. In addition, it says the Government has the duty to mobilize people for their common benefits and development, and that it should also promote the participation of the people in the formulation of national development policies and programs including that, the Government has the duty to support the initiatives of the people in their development endeavors. Hence again law enforcement procedures on such directives and other related issues needs to be seriously monitored.

In Belbela-Wadecha watershed ecosystem, as a result of natural resources degradation, removal of natural land cover and soil erosion action has occurred due to soil erosion agents, especially, rainfall that have washed away soil particles down the slope, taking organic matter that would otherwise support plant growth along the flow. This has left the land surface that was once productive and a source of livelihood of many in the watershed environment barren and unproductive. According to Hurni (1982), ploughing on steep slopes also has resulted in extreme soil degradation at Andit Tid Soil Conservation Research Program (SCRP) research site in Northern Shewa, in Ethiopia as shown in Figure 1-1.

Figure 1-1: Ploughing Steep Slope
Source: (Hans Hurni, 1982)

Subsequent to soil erosion, precipitation would quickly change to overland flow, leading to fast moving floodwater down the slope, giving no or little chance for percolation and infiltration to take place as the vegetation cover has already vanished. This adversely affects groundwater recharge, which in turn results in the drying up of springs at the foot hills that feed streams, rivers and water reservoirs behind the dam used for irrigation and other purposes.

In addition, the transported soil particles would deposit in the downstream reservoirs, thereby decreasing their useful storage space that is supposed to be filled with water that serves as the irrigation water supply. The remaining available water volume in the dams of the watershed would therefore only serve a certain portion of the irrigable area, resulting in the reduction of irrigated agricultural land, which negatively impinges on agricultural production and adversely affects the livelihoods of the watershed farming communities.

Sustainably managing the watershed ecosystem ensures a regulated environment in which vegetation is kept intact, soils are not exposed to erosion, and subsequently the useful lifespan of the reservoir would increase. Furthermore, the probability of flood occurrences will decrease and recharge to ground water would increase. Hence, the researcher argues that, the role of watershed is immense in regulating the ecosystem and maintaining a healthy environment. It is also important for ensuring sustainable supply of water to the reservoir through the stream systems resulting from infiltration and percolation process of running rainwater from the upper catchment, thereby benefiting irrigation practices that withdraw water from the storage reservoir behind the dam.

In this regard, the sustainable watershed management approach ensures that the farming activities downstream of the reservoirs would not be hampered by shortage of irrigation water supply for crop growth, thereby enabling maintenance of good productive potential of the land and income generation from agriculture. Moreover, apart from sustaining a regulated watershed ecosystem, which is beneficial for both upstream and downstream communities in constituting a healthy environment, the approach would also benefit the area by making the watershed environment a potential source for the sustainable supply of irrigation water. Hence, both a healthy environment and irrigation agriculture can be integrated and operated side-by-side on a sustainable basis.

"Watersheds have been viewed as useful systems for planning and implementing natural resource and agricultural development for many centuries" (Ali, 2011). Accordingly, this research explored the Belbela- Wadecha watershed ecosystem as a case study for the investigation of the nature, causes and effects of the long-term degradation on the watershed natural resources, namely vegetation and soils. The study will help in the planning and implementation of action towards the sustainability of natural resources for securing environmental benefits and sustainable agricultural development.

There are two theoretical aspects guiding the study, namely: i) GIS and Remote Sensing techniques which are used to determine the long term effects of degradation on the landscape, that is Land Use and Land Cover Change (LULCC) and ii) Participatory Action Research (PAR) which augmented the LULCC mapping and also guided the community participatory restorative action pilot project. The study intended to engage the communities around Belbela-Wadecha Dam from the beginning in responding to the effects of watershed degradation as their observations are drawn from real life experiences.

In addition, an input from an Ecologist / Agronomist for the physical identification of plant species and analysis of vegetation on the ground helped to give information on what the vegetation in the area was like in the past.

Therefore, the objective of this study was to investigate the nature, causes and effects of environmental degradation induced by humanity over time on watershed natural resources, particularly on vegetation and soils. It also explored community participatory action towards watershed restoration and management. It is hoped that this will constitute towards sound ecosystem management and sustainable irrigation development in the area.

1.3 Study Area Description

1.3.1 Introduction

This sub section discusses general background information of the study area relating to its geographic location, climatic characteristics, Land Use Land Cover types, and some other items of the study area such as socio-economic conditions. However, for convenience purpose, this sub-section, prior to presenting information on the study area (discussed under sub-article 1.7, 'The Research Area Description'), briefly discusses general information relating to Ethiopia and the drainage basin of the study area including Woreda (the second biggest administration unit in a regional state accountable to the zonal administration which is accountable to regional state) information.

1.4 Brief Background of Ethiopia

The following items under this sub-article are based on, unless stated otherwise in between, the Ethiopian Highlands Reclamation Study, Vol.1 (EHRS, 1986).

1.4.1 Location

According to Ministry of Water Resources, Irrigation and Energy (MoWIE) (2018) and Zegeye (2018), Ethiopia is located between latitude 3^{o}N to 15^{o}N and longitude 33^{o} E to 48^{o} E encompassing an area of about 1.13 million km^{2}. The altitudinal variation of the country ranges between two extremes, from 125m below mean sea level (mbsl) at Denakil Depression to 4543m above mean sea level (masl) at Ras-Dejen, Dashen peak. Ethiopia is a country that is characterized by a topography that consists of a complex blend of massive highlands, rugged terrain, and low plains. The Great Rift Valley of the eastern Africa divides the country into two plateaux and stretches from northeast to southwest with 40–60 km wide flat-lying plain in the east, south, and west borders of the country. It creates three major relief regions in the country: the Western Highlands, the Eastern Highlands, and the low-lying Rift Valley and Western Lowlands.

It was also mentioned that the central and western highlands on the western side of the Great Rift Valley stretches to the west into the Nile River basin system and covers about 39% of the land mass and 70% of the surface water of the country. Ethiopia's neighboring countries are the Sudan to the west, Kenya to the south, Republics of Djibouti and of Somalia to the east and southeast respectively and Eritrea to the northeast.

1.4.2 Geology and Physiographic

Ethiopia is located on a Precambrian crystalline basement, which is dominated by various schists, gneisses, granites and slates, which are exposed in areas where geological erosion has been great, especially along plateau fringes in the northern, western and south parts of the country (EHRS, 1986). EHRS (1986) further explains that sedimentary limestone was deposited several hundreds of meters over this basement foundation some 100 to 200 million years ago, which are capped by successive flows of lava, mainly consisting of basalt that have accumulated to a thickness of several thousand meters in some areas. It was expressed also that the formation of the rift system coincided with the period of intense volcanic activity.

The physiographic landscape of the country is characterized by the highlands complex of mountains and plateaux contrasting with the lowlands of the Ogaden and around the country's periphery.

1.4.3 Climate and Zonation

Ethiopia has a diversified climate ranging from semi-arid desert type in the lowlands to humid and warm (temperate) type in the southwest (Beyene, 2010; Hurni, 1982; Osman, 2001; MoWIE, 2018), with described high inter and intra-annual rainfall variability in Ethiopia. The mean annual rainfall of Ethiopia ranges from a low of 141mm in the arid areas of eastern and northeastern borders of the country to a high of 2275mm in the southwestern highlands (Berhanu et al., 2013). The complex topographical and geographical features of the country have a strong impact on these spatial variations of climate and different rainfall regimes in Ethiopia (National Meteorology Service Agency, 1996; Zeleke et al., 2013).

Areas situated below 1500 masl are generally termed the hot zone (traditionally called Kolla), while those above this contour is classified traditionally as Woina-Dega and Dega, meaning the cool (neither hot nor cold) zone and cold zones respectively. The 1500 masl contour is adopted as a dividing line between highlands and lowlands (EHRS, 1986).

In addition, from time immemorial, Ethiopia has depended overwhelmingly on traditional agriculture cropping and livestock production that rely on local climatic conditions (rainfall and temperature) and which are determined by altitude. Although there is no precisely defined agreement that the three zones (Kolla, Woina-Dega and Dega), correspond to particular altitudes and/or temperatures or rainfall, the Kolla is generally cited as being below 1500masl, the Dega above 2500 masl and the Woina-Dega as falling between these two limits. Woina-Dega is cited as the most favorable climate for human living and suitable for the growth of many crops.

On the other hand, MoWIE (2018) further classifies the climatic condition of the country traditionally into five climatic zones based on the altitude and temperature variation. It ranges from the high altitude cold areas locally termed “Wurch” to the low lying hot climatic area locally known as “Berha.” Table 1-1 and Figure 1-2 represent their physical characteristics and spatial distribution. The statistical interpretation of precipitation and temperature data recorded over a long period determine the climate of the country.

However, traditional classifications, such as the five climatic zones, have been proven to have tangible benefits to the community operating in such environments. This is because this traditional classification has been operating since time immemorial and its characteristic nature is well known to the local communities. Furthermore, this knowledge is important as an inter-generational system inheritance. Table 1-1 and Figure 1-2 depict this traditional climatic zonation.

Table 1-1: Traditional Climatic Zones of Ethiopia and their Physical Characteristics

*Source: NRMRD-MoA, 1998

Zones	Altitude (meter)*	Mean Annual Rainfall (mm)*	Length of growing periods (days)*	Mean Annual Temperature (^{0}C)*	Area share (%)
Wurich (cold and moist)	Greater than 3200	900 -2200	211 -365	below 11.5	0.98
Dega (cool and humid)	2300 – 3200	900-1200	121 -210	11.5 -17.5	9.94
Weynadega (cool and sub humid)	1500 -2300	800 -1200	91 -120	17.5 – 20.0	26.75
Kola (Warm and semi-arid)	500 -1500	200 -800	46 -90	20.0 -27.5	52.94
Berha (Hot and arid)	Less than 500	Under 200	0-45	Above 27.5	9.39

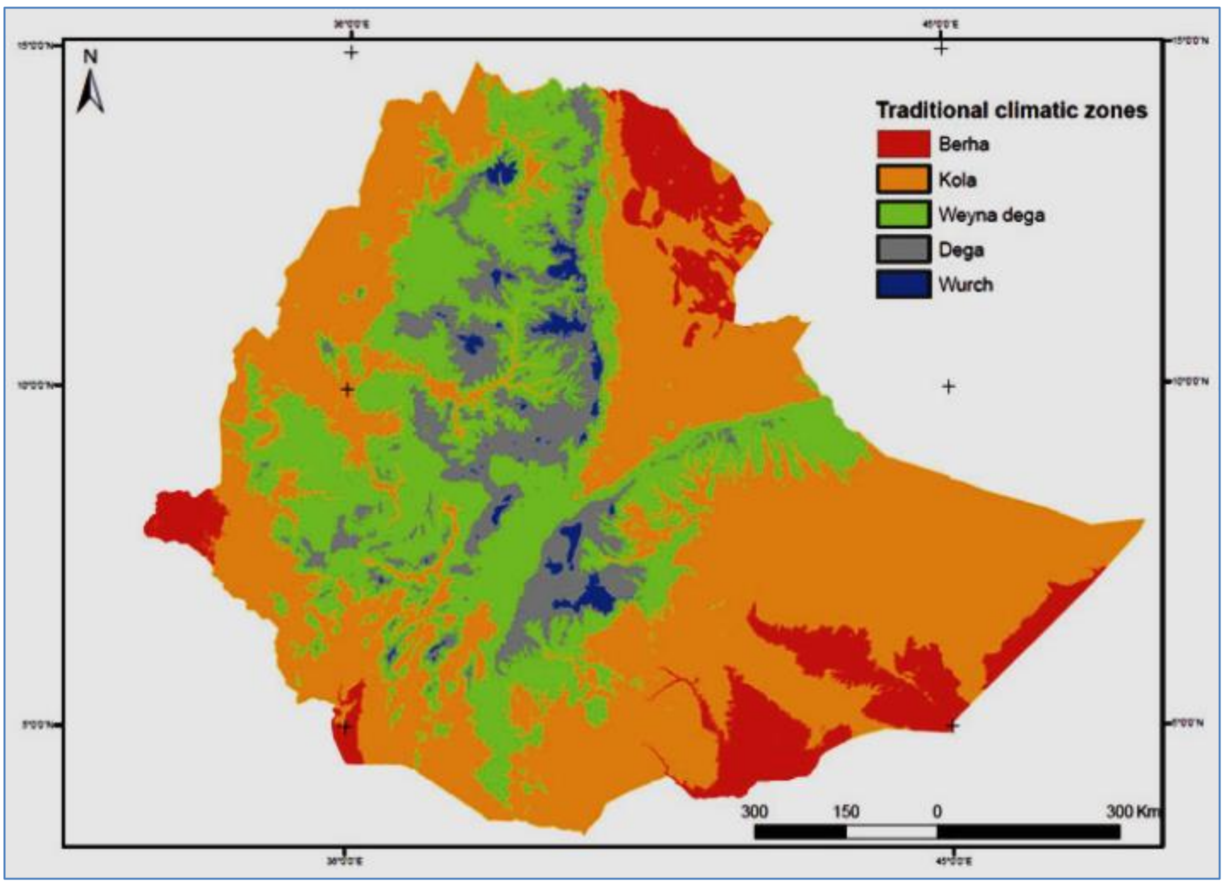


Figure 1-2: Traditional Climatic Zones of Ethiopia
Source: NRMRD-MoA, 1998

The Inter-Tropical Convergence Zone, the northeast trade winds and the southeast monsoon, mainly influences the rainfall in Ethiopia. Most of the highlands of the country experience the main rainy season, known locally as "Kremt", which generally runs from July to mid-September. The southwest highlands receive the greatest rainfall, and this decreases in parts of the northwest highlands. Much of annual rainfall in the highlands averages between 1000mm and 1800mm and falls between June and September. Bimodal rains take place in southern and eastern areas, with the first peak occurring around April and the second around September.

Although the country is located completely within tropical latitudes, it enjoys a generally temperate climate in the highlands, and climate varies significantly with altitude.

Ethiopia has not been affected by severe cyclonic winds. However, some strong winds occur along the eastern escarpment of the highlands. Cold dry winds occur from November to January at high altitudes.

1.4.4 **Hydrology**

There are many rivers in Ethiopia, of which the twelve basins (shown in Table 1-5) originate from the highlands of the country, which are also the source of major water resources for the neighboring countries. Of these, the most well-known is the Abay (Blue Nile), having many tributaries including Muger, Jemma, Guder, Didessa, Dabus and Beles. The Awash River is an exception to the westward flow of the majority of the rivers. The Awash river is important for agricultural irrigation, rising in the highlands west of Addis Ababa but flowing east through the northern half of the Rift Valley, finally terminating in Lake Abe.

There are small rivers flowing into the closed lake basins within the rift valley. The Omo River, which flows southward into Lake Turkana, drains the southern highlands. The main river system of the eastern plateau, the upper reaches of Wabi-Shebelle (the main river system on the plateau), originates in the Chercher highlands. This is on the east side of the Rift Valley and partly in the Chilalo mountains of Arsi, under the influence of the southeasterly surface tilt of the geological strata, with most of the rivers flowing toward or into Somalia.

Although little information is available on Ethiopian ground water resources, geological and climatic conditions imply that reserves of subterranean waters may well be considerable

(EHRS,1986). There are also numerous thermal and mineral springs, especially in the Rift Valley system.

1.4.5 Soils

A number of soils types in the country, with the exception of Cambisols and Lithosols, are derived from volcanic parent materials. These include Nitosol, Vertisol, Acrisol, Luvisol, Phaeosem and others (EHRS, 1986). It is indicated that, by international standards, potassium, nitrogen, cation exchange capacity and organic matter content are high; calcium and magnesium are at international average levels, while phosphorus is low in Ethiopian soils. All major soils, with the exception of the lithosols and the vertisols, have good workability, drainage, and adequate soil depth. Vertisols have a narrow workability range of moisture outside of which they are hard when too dry and very sticky when too wet.

1.4.6 Vegetation

EHRS (1986) states that, virtually all major types of natural vegetation are found in Ethiopia because of its diverse climate, topography and soils. The vegetation types range from deserts to tropical forests to alpine grasslands. Ethiopia has a broad vegetation pattern related primarily to altitude and rainfall. The highland forests consist of an upper canopy of tall trees ranging from 30 to 50m and this increases to a range from 40 to 60m with increasing humidity. With decreasing humidity, highland forests transitions to mountain woodland where the elevations are over 2400m. Higher elevations (over 2700m) and decreasing humidity leads to a transition to a mountain savannah of shrubs, small trees and grasses. At an elevation of 3400m and above subalpine and alpine vegetation consists of only short grasses. Figure 1-3 depicts vegetation distribution by Altitude and Rainfall. In addition, Table 1-2 illustrates vegetation disturbance in Ethiopia showing vegetation cover loss in hectares over about a ten-year period.

The broad-leaved moist forests, which are found mainly in the moist humid parts of the southwest highlands where rainfall is distributed more uniformly and in other higher rainfall areas of southern highlands, are characterized by a high density and great variety of species.

1.4.7 Wildlife

Wildlife in Ethiopia includes 100 species of animals and over 800 species of birds, many of which are endemic to the country (EHRS, 1986). About 4% (64790km^2) of the total land area of the country is occupied by 37 designated wildlife areas consisting of nine national parks, 14 sanctuaries or reserves and 14 controlled hunting areas. The major wildlife areas include Semien Mountains, Rift Valley lakes, the Bale Mountains, Nech-Sar and the Awash Park. Wildlife forms a potentially valuable resource base for tourism.

1.4.8 Tourism

A number of other touristic attractions other than wildlife conservation areas characterize Ethiopia. It is an ancient nation reflecting ancient and peculiar artifacts and buildings, including rock-hewn churches and unique and diverse cultures, which have not been properly and scientifically accounted for in the sense that they potentially contribute to the nation building and economic endeavors. In addition, the United Nations Education, Scientific and Culture Organization (UNESCO) have registered a number of tangible and intangible heritage assets, but they are not well conceived in terms of modernization and promotional activities. A lot of effort is needed to upgrade and widen heritage resources for tourism purposes.

1.4.9 Agriculture

Agriculture is the mainstay of the Ethiopian economy. It provides employment opportunities for about 85% of the Ethiopian labor force, contributes 45% to the GDP and generates 90% of the total export earnings of the country (MEDaC, 1999).

With respect to other animal populations, Ethiopia possesses a huge number of domestic livestock resources, rated first in Africa and tenth globally (FAO, 2006). Livestock resources include oxen, cattle, sheep, goat, horse, mule and ass. They comprise 40% of gross agricultural outputs. However, modernization of the utilization of the livestock resource is still minimal such that facilitation of technological support is needed to enable the resources play a meaningful role in further buttressing the national economy for the wellbeing of the society.

Taking care and management of these livestock as related to, inter alia, feeding, breeding, housing and health care, is important for ultimate economic benefits. In this regard, deployment of this function generates employment opportunities in addition to other benefits, including food, energy (bio-fuel from cow dung), draft power for plowing, transport, fertilizer (manure) and clothing (leather).

Table 1-2: The Vegetation Cover Disturbances of Ethiopia in Hectares

Source: Cited in EHRS, 1986, World Bank.

Vegetation Type	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
High forest	270,897	118,355	99,601	73,025	57,182	48,235	66,036	76,412	73,875	76,723
Wood land	83,720	77,929	75,460	79,195	83,379	85,365	86,611	91,038	95,633	96,323
Shrub land	44,678	51,432	56,752	59,377	77,242	70,164	68,051	65,548	61,854	58,685
Total	399,295	247,716	231.813	211,597	217,803	203,764	220,698	232,998	231,362	231,731

1.4.10 Population

Ethiopia is the second largest country in Africa after Nigeria, with a population of about 79 million and a population growth rate of 2.6 percent per year (UNFPA, 2008). This figure is based on the Summary and Statistical Report of the 2007 Population and Housing Census of Ethiopia. In addition, Table 1-3, according to www.csa.gov.et,, shows almost the same figure. The Ethiopian Highland Reclamation Study states that 88 percent of the Ethiopian population lives in the highlands of the country (EHRS, 1986).

Although at present there is no official population figure posted, at the above rate of growth, the population can be much higher than this figure. In this regard, the World Bank (cited in Karin et al. 2009) estimates that Ethiopia adds two million people every year. Based on this, it may account for not less than 100 million of people at present, of which the male and female population is nearly equal. Evidence shows that the youth section of the community significantly predominates the population (Karin et al., 2009). In addition, it was sated that the population will increase to 124 million and 135 million for low-growth and high-growth scenarios respectively, by 2030 (World Bank, cited in Karin et al., 2009). Subsequently, this will pose a consequence of high competition incident over natural resources because of poverty issues unless diversified income-generating activities are put in place to minimize or stop the pressure on the natural resources.

Table 1-3: Comparison of the 2007 Census and Projections for July 2008
(Based on the 1994 census)

Region	2007 Census	2008 Projection	Difference, % (Census)
Addis Ababa	2,738,248	3,147,000	-0.15
Afar	1,411,092	1,449,000	-0.03
Amhara	17,214,056	20,136,000	-0.17
Benishangul Gumuz	670,847	656,000	0.02
Dire Dawa	342,827	428,000	-0.25
Gambella	306,916	259,000	0.16
Harari	183,344	209,000	-0.14
Oromiya	27,158,471	28,067,000	-0.03
SNNPR	15,042,531	15,745,000	-0.05
Somail	4,439,147	4,560,000	-0.03
Tigrai	4,314,456	4,565,000	-0.06
Total	73,821,935	79,221,000	

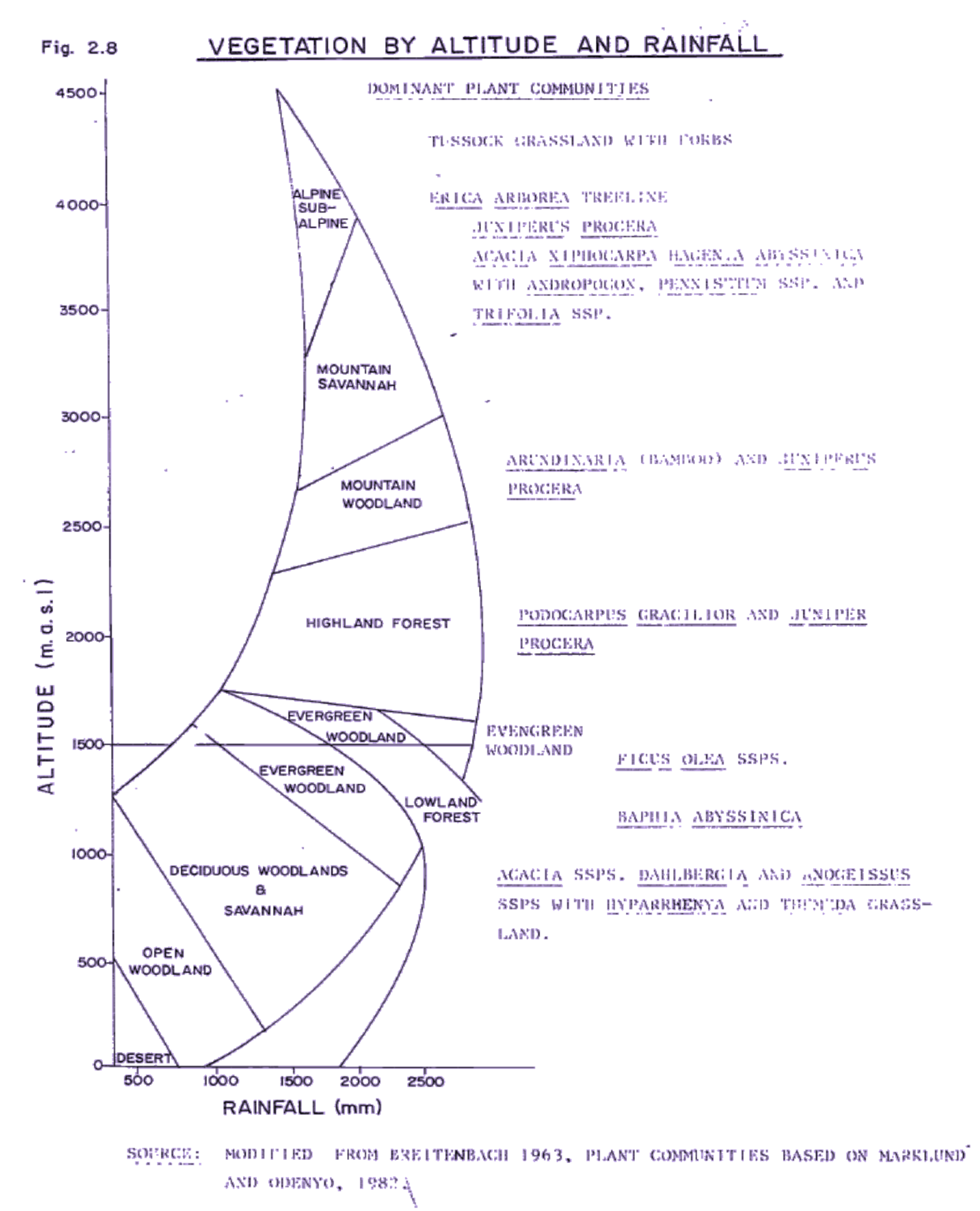


Figure 1-3: Vegetation by Altitude and Rainfall
Source: Cited in EHRS, 1986, World Bank.

1.5 Drainage Basin (Awash River) of the Study Area

The study area is located in one of the twelve river basins of Ethiopia, the Awash River Basin. The basin consists of three parts, Upper Awash. Middle Awash and Lower Awash. The watershed under study is found in the Upper Awash sub-basin. Akaki and Modjo rivers are the two major tributaries of the sub-basin, of which the Modjo tributary partly originating from Jerer (Yerer) Mountains is the river that drains the study area, Belbela-Wadecha watershed, a sub-catchment of the Modjo River.

According to Halcrow (1989), the Upper Awash sub-basin is situated in the highlands of central Ethiopia, with a geographic elevation of higher than 1500 masl. It drains an area of 11300 km^2 and its land use pattern is estimated at 67%, 25%, and 5%, being intensively cultivated, moderately cultivated, forest land (bush, grassland wood) respectively, and the remaining area being urban and rural settlement areas, including alpine vegetation.

The Ethiopian Highland Reclamation Study (EHRS) (EHRS, 1986) states, that the land resource of the highland is threatened seriously by degradation, which in turn as threatens economic and social development.

Halcrow (1989) states that the climate of the Awash River Basin falls under the influence of the Inter Tropical Convergence Zone characterized by heavy summer rains in June and July. The mean annual temperature in the basin is around 15^{o}C. It was indicated also that the sunshine hours vary from a daily mean of 9.4 hours in December to three hours in July and the mean annual wind speed of 0.9m/s at Addis Ababa and a mean annual relative humidity of 60.2%.

1.6 Woreda (District) area Description

1.6.1 The Woreda Physical Setting

The study District (Woreda), Figure 1-4, has six neighboring Woredas, Berehna Aleltu in the north, Akaki in the west, Kersana Kondaltiti in the south west, Lome in the east, Dugda Bora in the south and Gimbichu in the north east where a large area drains into Belbela-Wadecha watershed system.

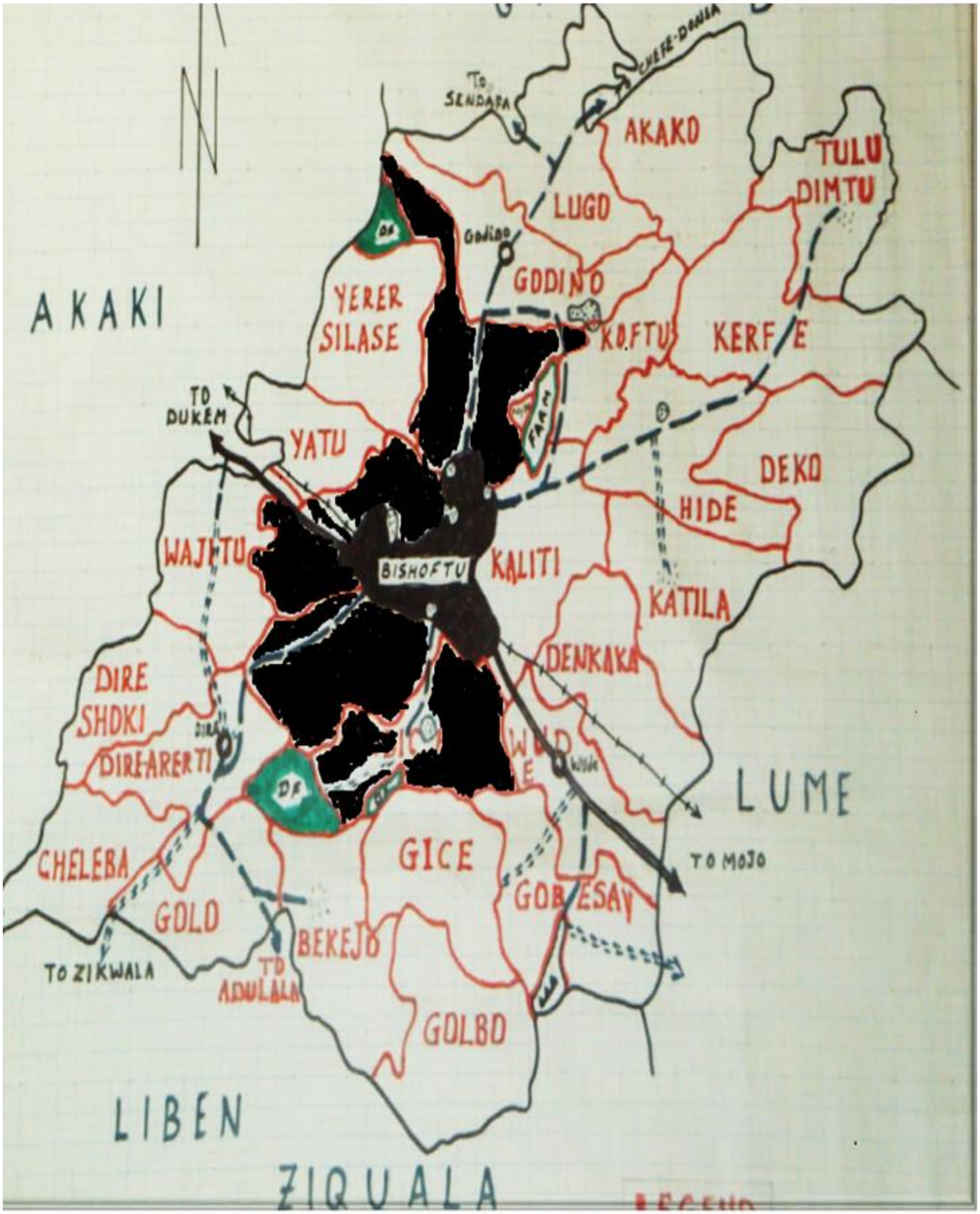


Figure 1-4: Map of Ada'a Woreda

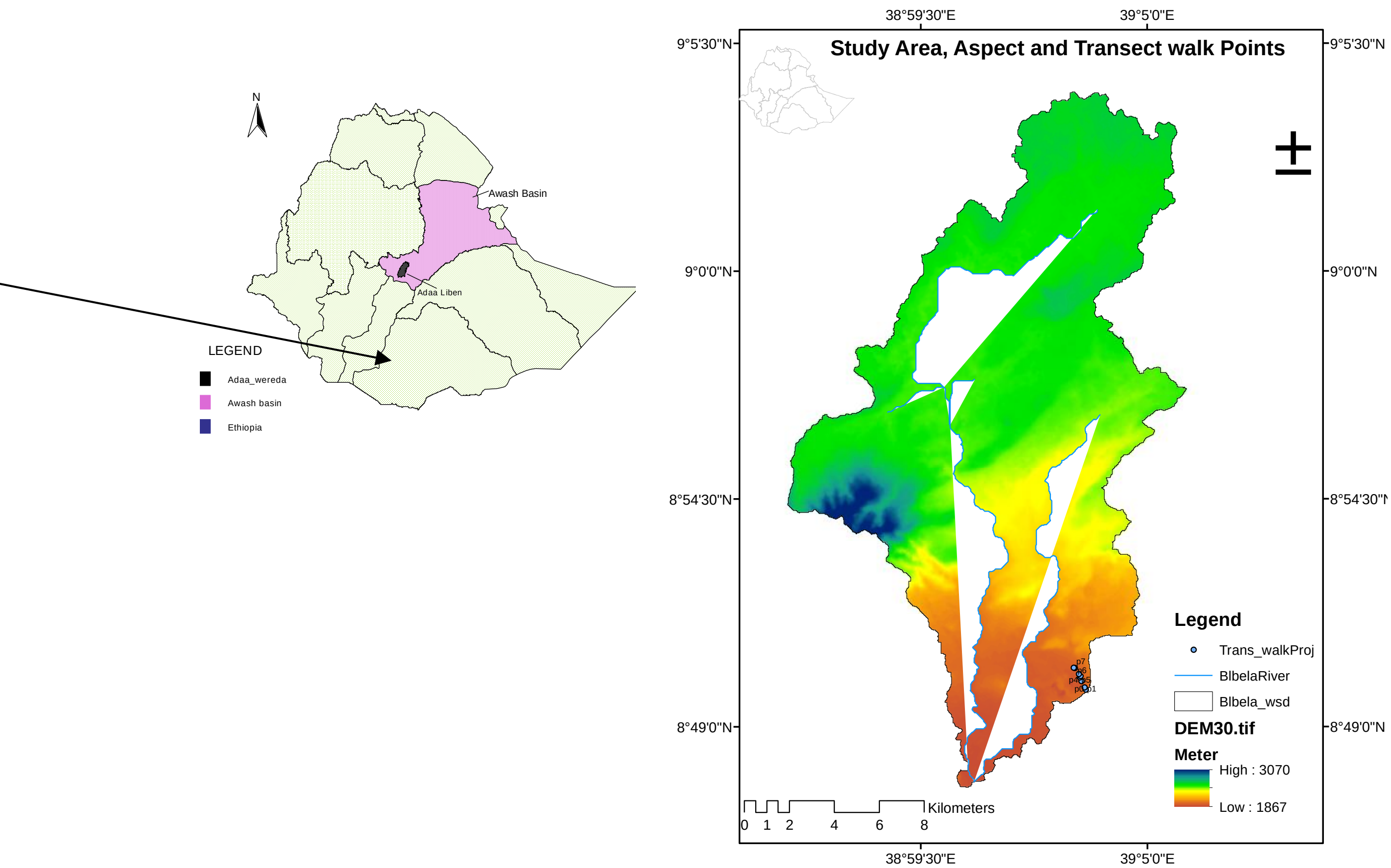
Source: Woreda Agricultural Bureau

1.7 The Research Area Description

1.7.1 Geographic Location

The study area is geographically located between 39.12/38.92 East longitude and 8.77/9.09 North latitude with elevation that varies between 1867 and 3070 meters above sea level. The area location is in Ada'a Liban Woreda, East Shoa Zone, Oromiya National Regional State, Ethiopia, at a distance of 55 km east of the capital, Addis Ababa (Figure 1-5). In the study area, agriculture is the main source of income for both food and income generation. The Belbela-Wadecha sub-catchment covers an area of about 275.29 km^2. It is located in the eastern part of the capital of Ethiopia.

The area is characterized by the agro-climatologic condition of Woina Dega as the average elevation of the area including the pilot scheme is 1900 meters above sea level (masl) and that falls between 1500 and 2500 masl indicating it is neither Kolla (below 1500 masl) nor Dega (above 2500 masl) as stated under climate and zonation section 1.4.3.

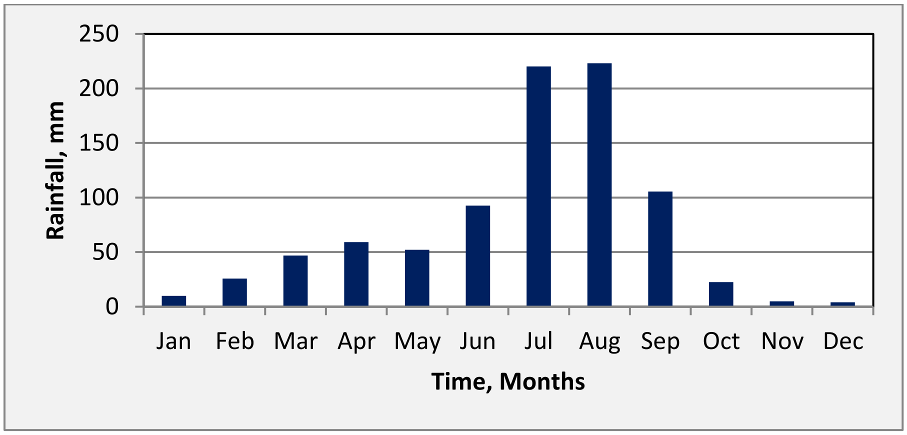


<u>**Figure 1-5: Land Geographical Location of the Study Area**</u>

1.7.2 Climate of the Study Area

The precipitation for the Belbela-Wadecha area originates from south-west equatorial air stream, which moves northwards with inter- tropical-convergence zone (NMSA, 1996). The climate in the area is wet to sub-humid according to the Thonthwaite's system of defining climate or moisture regions (NMSA, 1996). The mean annual rainfall as recorded by the nearest meteorological station at Debre-Zeit Air Force is 866.6 mm (Wakena, 2008). The study area is located in the region where June through September is the main rainy season. According to Wakena (2008), the June to September rainfall contributes about 74% of the mean annual precipitation.

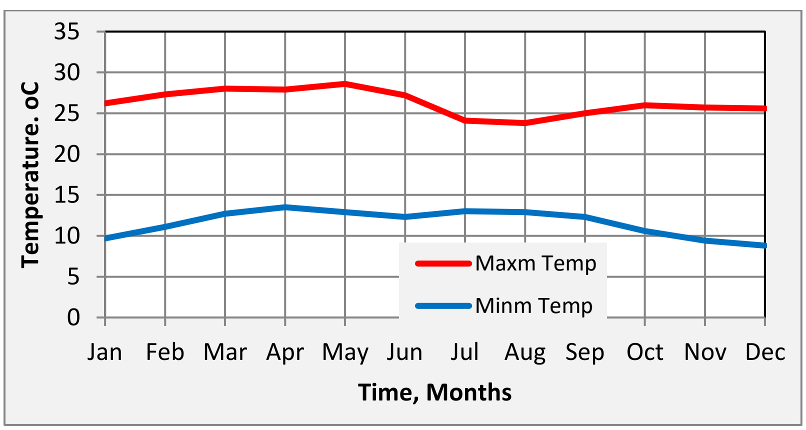
The Rainfall in the study area is bi-modal with the main rainfall season being between June and September where mean minimum and mean maximum values are 93mm and 223mm respectively and the second rainy season is between February and May that has a mean minimum and mean maximum values of 26mm and 59mm respectively. Figure 1-6 shows the plot of the long-term mean monthly.



<u>Figure 1-6: Mean Monthly Rainfall at Debre-ZeitAir-Force Station</u>

Source: Wakena, 2008

From the 54 years of records at Debre-Zeit meteorological station for the study area, the hottest months are April-May, where the mean maximum temperature reaches 28.6^{o}C and the coldest months are Nov-Dec where the mean annual temperature drops to 8.8^{o}C (Wakena, 2008). Figure 1-7 shows the plot of mean monthly maximum and minimum temperatures.



<u>Figure 1-7: Mean Monthly Maximum and Minimum Temperature at Debre-Zeit Air-Force Station</u>

Source: Wakena, 2008

Relative humidity records show that the mean monthly value is 61.3% with a mean minimum monthly of 53% in February and reaches maximum of 76% in August. According to the records found at Debre-Zeit Air Force station, wind speed has varied value with time. Wind speed records of 12 years show that the highest value occurs between February and May, with a mean monthly value of 1.7 m/sec, and the lowest between June to September with mean annual value of 1.3 m/sec (Wakena, 2008).

The mean annual sunshine hours obtained from the monthly data based on 12 years of records at Debre-Zeit Research Center meteorological station gauge is about 8.2 hours, the maximum being 9.8 hours in the month of December and the minimum 5.5 hours in the month of July (Wakena, 2008).

1.7.3 Geomorphology and Soils of the Study Area

The soil of the study area is dominated by clay vertisol (black cotton soil) and is brown in color, with a type of clay mineral that is assumed of great importance with respect to soil water storage (Wakena, 2008). The average soil depth is about 0.65 to 1.05m, with a medium infiltration rate and medium water holding capacity (Maidment, 1993; OIDA, 2002). The land is highly suitable for the cultivation of most irrigated crop.

1.7.4 Land-Use–Land-Cover

The Woreda unit administers the land area under the Belbela-Wadecha watershed. The Land use is largely agricultural farming, more than 70% of the area, is cultivated for crop production and the rest is apportioned for other land uses including livestock rearing, shrubs, forests, uncultivable formations.

As animal population is high, overgrazing is quite an issue at stake to the land area in addition to the vanishing of forests at an alarming rate. The soil characteristics of the research area are susceptible to erosion due to the use of traditional cultivation system, slope and soil-water erosion; Figure 1-8 shows the trend of resource degradation over the period 2001 to 2005. Table 1-4 shows the land use pattern.

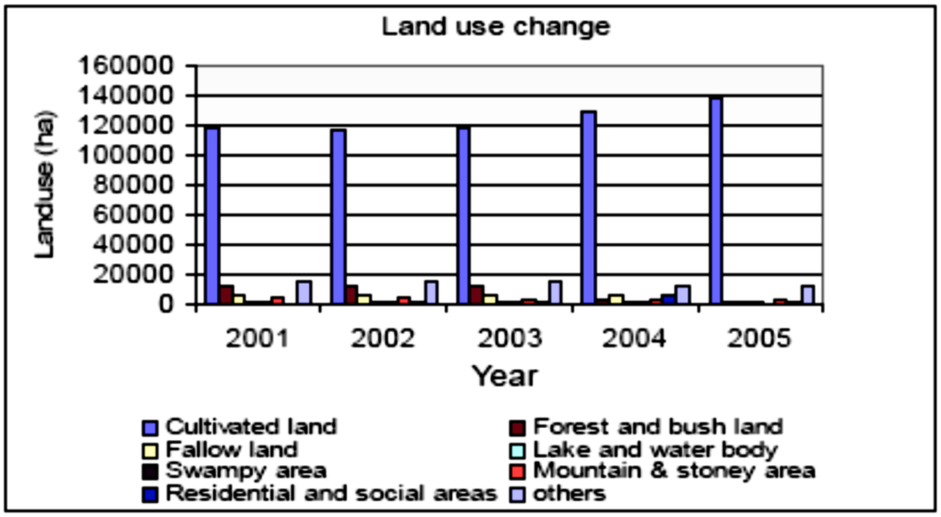


Figure 1-8: The Ada'a Liben District Land Use Change
Source: - Ada'a Woreda Bureau of Agriculture (2005)

Table 1-4: Land Use Pattern of Ada'a Liben Woreda
Source: - Ada'a Woreda Bureau of Agriculture (2005)

Land use Type	Area in Hectare
Cultivated	106,607.50
Forest land	2,489.00
Grazing land	5,395.38
Bush land	13,834.06
Others	32,730.59
Total	**161,056.53**

1.7.5 Hydrology

There are two major rivers in the study area, namely Wadecha and Belbela Rivers. Both rivers are un-gauged and no flow records are available. Wakena (2008) has estimated the water resource potential of Belbela-Wadecha sub-basins using the SCS curve number methodology (USDA-SCS, 1972). According to Wakena (2008), the surface runoff generated from the annual mean rainfall of 887.0 mm is 285.4mm with the average annual rainfall-runoff coefficient 0.32. This gives the mean annual runoff generated from the study area of about 46 million cubic meters per year. Figure 1-9 illustrates the Plot of Annual rainfall and Annual runoff.

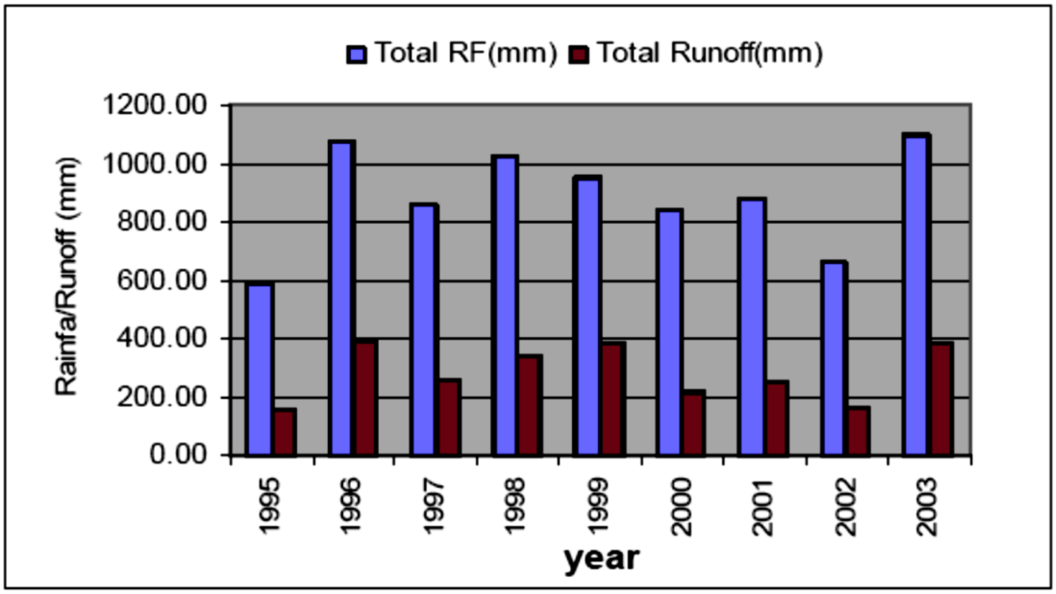


Figure 1-9: Annual Rainfall-Runoff Relationship for Belbela-Wadecha Sub-Catchment.

Source: Wakena, 2008

1.7.6 Irrigation Development

In the 1980s, two small micro earth- dams were constructed across Belbela and Wadecha rivers mainly for the purpose of small-scale irrigation. The Wadecha micro dam is 18 meters high with an original gross capacity of 15.16 Mm^3. The Belbela micro dam has original gross capacity of 12.1 Mm^3. The Belbela-Wadecha reservoir system serves an irrigated area of 2529 ha. According to the Woreda Agricultural Office (Ada'a-Liben Woreda Office of Agriculture, 2005) the Woreda has an irrigation potential of 5,441 ha. The same report has recorded that the existing irrigated area by farmers using diversion and springs as a source of water is more than 3,500ha, Figure 1-10.

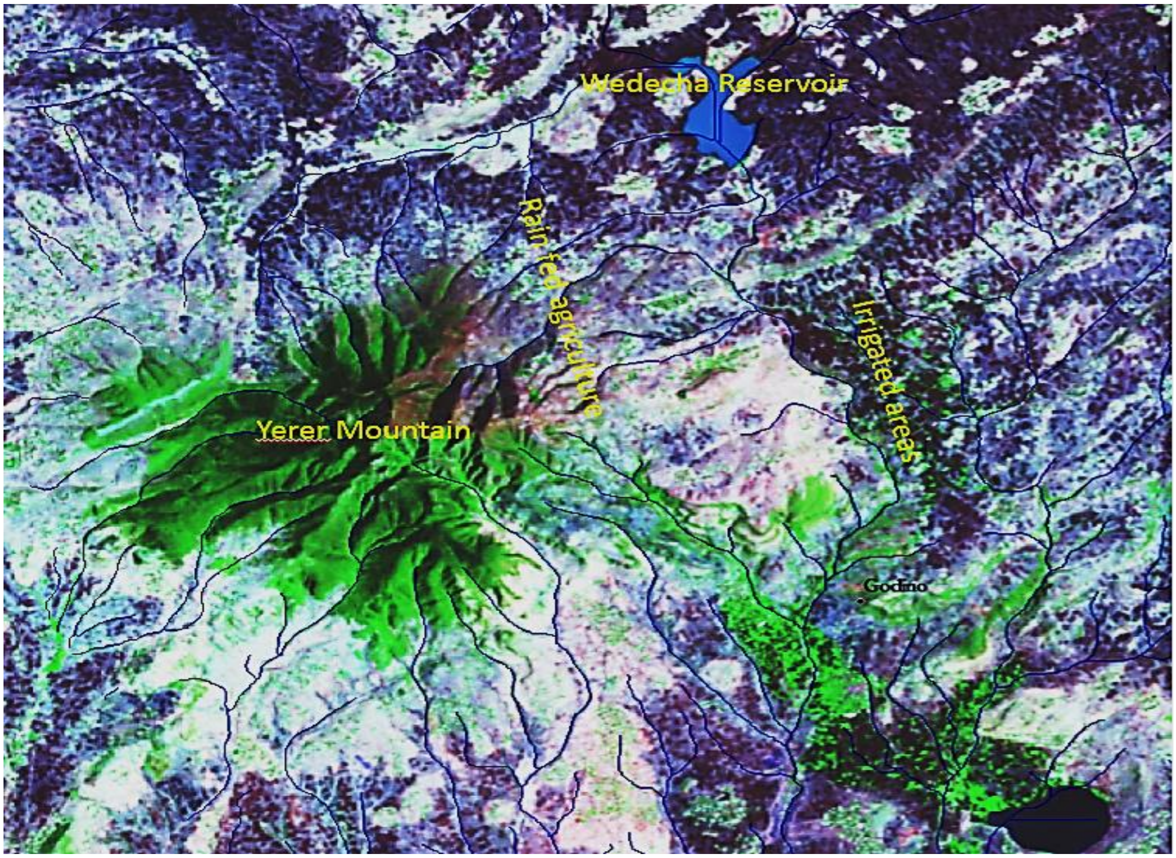


Figure 1-10: Irrigation Development Area: Belbela–Wadecha Watershed Setting

1.7.7 Problems Cited

The annual reports of Ada'a-Liben Woreda Office of Agriculture (2015 & 2016) note that environmental issues including soil degradation due to over cultivation, overgrazing, and rapid deforestation rate and low soil and water conservation practices including rainfall variability had been observed.

The report further noted that participatory action in which issues including identification of problems, planning, implementation, and monitoring and evaluation should be given due focus could be the way forward towards the amelioration of the environmental issues.

1.8 Statement of the Problem

1.8.1 Introduction

Ethiopia possesses about 122 BM^3 of renewable surface water resources (Ethiopian Water Policy, 1999) per annum generated from twelve river basins, Figure 1-11. Most of the rivers are trans - boundary in nature, with the exception of Awash River which terminates within the boundary of the country in Lake Abe. Table 1-5 shows the water resources potentials of all the basins and Figure 1-12 indicates the associated runoff.

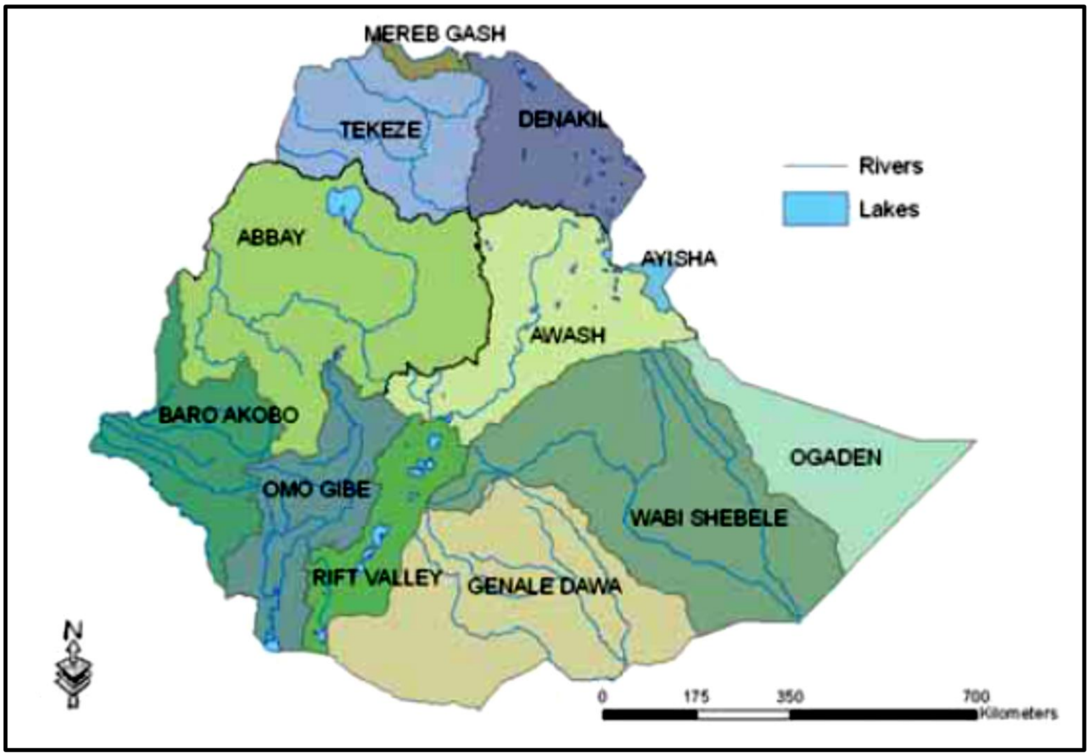


Figure 1-11: Ethiopian River Basins Map
Source: (IWMI 2007)

Table 1-5: Surface-Water Resources of Major River Basins

Source: Water Sector Development Program 2002 – 2016

No	River basin	Catchment are (km^2)	Annual runoff (BM^3)	Specific discharge ($l/s/km^2$)
1	Abbay	199,812	52.6	7.8
2	Awash	112,700	4.6	1.4
3	Baro-Akobo	74,100	23.6	9.7
4	Genale-Dawa	171,050	5.8	1.2
5	Mereb	5,700	0.26	3.2
6	Omo-Gibe	78,200	17.9	6.7
7	Rift-Valley	52,740	5.6	3.4
8	Tekeze	89,000	7.63	3.2
9	Wab--Shebele	200,214	3.15	0.5
10	Afar-Danakil	74,000	0.86	-
11	Ogaden	77,100	0	-
12	Aysha	2,200	0	-
Total	1,136,816		122.00	

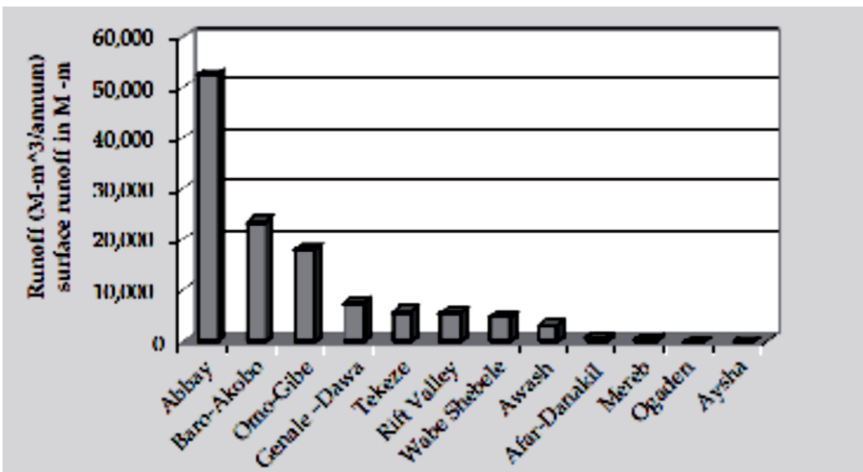


Figure 1-12 Runoff from the Ethiopia River Basin

Source: (MoWR, 2002)

Awash River basin is the most developed basin in the country. Although various studies have been undertaken in the basin and are still being done, including Master Plan for the development of surface water resources in the form of different large and medium scale irrigation projects on the main river course and tributaries, a few have been documented (Bekele, 2016) . The nation's major economic development projects are situated and operated within this river basin. The researcher therefore believes that the water resources in this river basin are being used most effectively compared to the rest of the eleven river basins in the country. The Awash River has many tributaries that collect water that flows from the highland catchment areas into the river system including Akaki, Kaleta, Borkena, Modjo, Mille, Logiya rivers among others, all running through cultivated agricultural land, deep gullies, and steep slopes.

Currently however, from the physiographic perspective, the watershed ecosystem of Belbela-Wadecha is seriously degraded. The watershed's natural setting is adversely affected, calling for intervention (Wakenna, 2008). The study area for this research, Belbela- Wadecha watershed ecosystem, being one of the degraded watershed systems of Modjo River catchments that have been supporting the livelihoods of the communities in the watershed environment now appeals for immediate intervention to help revive the watershed ecosystem.

In addition, the research area, other than supporting the human communities, has been supporting animal and plant biodiversity, contributing to climate regulation and has been a good source of irrigation water that has been stored in the Belbela and Wadecha cascaded micro earth dams. These dams have been a blessing to many residents in the watershed system from a social, economic and environmental wellbeing point of view.

The micro earth dams that are found in Belbela-Wadecha watershed are now silted up due to physical land degradation. The sedimentation in the reservoirs indicates that the water storage in the dams would be unduly lower by volume when compared to the corresponding contemporary design volume as the space that was meant for useful water storage is now occupied by severe sediment discharges. The dams were supposed to serve 1600 hectares of land for 30 years of design life (Wakena, 2008). The researcher argues that the differences between the figures of irrigable areas referred to above and the current situation may be attributed to the changes in irrigation hours and improvisation of additional sources of irrigation water.

The Belbela and Wadecha dams are cascaded ones with an irrigable capacity of 1600, as shown above (900ha and 700ha respectively). One may deduce that the current reduction in the area of the irrigable land can be a result of the decline in the useful storage volume of irrigation water further resulting in lower harvest with a concomitant reduction in the gains of the beneficiary communities thus adversely affecting their livelihoods. Efforts of forestry development, which began in Europe as a science in the late 1700s in response to wood shortages and watershed problems, Lewis (2005) showed a good result of regulated logging activities and environmental wellbeing that encourages restoration of watersheds.

Over the past few decades, degradation of natural resources has received a wider global attention resulting in the recognition of its serious consequences on all forms of lives. Subsequently, it has been taken on board as a topical subject matter nationally and internationally, triggering the initiation and formulation of environment related agenda on how to establish a springboard for designing the future direction for the restoration of a healthy watershed environment. Accordingly, huge effort has been exerted worldwide to revive impaired watershed ecosystems.

The researcher argues that the global effort in environmental protection would still need to be underpinned by certain practical measures in a way that would assure more sustainability of watershed ecosystems and sustainable benefits to watershed beneficiary communities. The researcher assumes that the success in managing each watershed environment sustainably is contingent upon addressing properly and specifically the peculiarities of each site.

In relation to this, Ali (2011: 228) stated, "Effective watershed management is an ongoing process that must be flexible enough to adapt to the unique characteristics of different watersheds as well as changing circumstances with a single watershed". He also mentioned that in the past, development of water resources, forestry and agriculture gave little regard to watershed management and upstream and downstream linkages.

In connection with this, this study will look into watershed natural resources degradation in Belbela-Wadecha watershed and their effects, including formation of barren land, soil erosion, gulley creation; reservoir sedimentation and, blockage of canals among others. The study will also try to propose way forward and prospects towards ameliorating the current state of the watershed ecosystem operations, with a possible scaling-up function where appropriate.

1.8.2 **The Problem**

The Belbela-Wadecha watershed ecosystem in its current state is practically a degraded phenomenon, and thus the previous benefits it could provide would have been affected as a result.

As can be perceived from physical observation, vegetation has vanished, soils are eroded, gullies have formed, reservoirs are filled up with sediments, canals are clogged, dam water storages have declined, and flooding has caused major damages. Reportedly, malarial incidents have become high because of formation of damp soils due to the stagnation of water.

In addition, incomes of the watershed beneficiaries may have declined and that might have affected health care, schooling, dietary needs, feeding habits, acquisition of fuel wood, and clothing among others. A decrease in the area of development would most likely have affected food security and hampered marketing benefits.

Furthermore, environmental wellbeing would most likely have been threatened because of natural resources degradation of the watershed ecosystem. Therefore, unless this ecosystem is restored through halting natural resources degradation, it is unlikely to secure a sustainable livelihood for humans, animals and plants. It is perceived also that this would affect the ongoing huge development plans in the basin.

The foregoing sustainable watershed management approach therefore proposes the research's focal area whereby a healthy environment and sustainable irrigation development run in parallel and in harmony. The study primarily takes into account of the objectives of the study where the specific objectives are the key issues to be addressed in such a way that revitalization of the watershed ecosystems and sustainable operations of irrigation development functions are ensured.

1.9 Research Focus

Environmental degradation on watershed natural resources, particularly vegetation and soils, has resulted in the vanishing of forests and other natural vegetative covers which has triggered erosion of soils down the catchment area and that further resulted in severe sediment deposition downstream in the cascaded micro-earth dams of Belbela and Wadecha reservoirs.

This phenomenon has affected both upstream and downstream of reservoirs, where the upstream landscape has been changed into a barren land and has become susceptible to soil erosion agents that have transported soils down the valley and resulted in their deposition into the reservoirs. The downstream irrigation farms have also suffered from shortage of irrigation water supply due to the reduction of useful storage volume because of increased sediment deposition transported from upper catchment. This has resulted in the shrinkage of irrigable land, thus caused reduction in agricultural production, which further affected the farming communities' living patterns, the irrigation beneficiaries.

The peasant farmers that were adversely affected found themselves in a state of poverty-stricken condition and have become dependent on outside assistance to maintain life, when they could have been more productive and self-sufficient.

This study therefore, will focus on the investigation of the nature, causes and effects of degradation on natural resources, especially the biophysical landscape (vegetation and soils) of the watershed area, with a view toward revitalizing the watershed ecosystem through restoration of vegetation and land cover. It is of utmost importance that the full involvement of the community in every cycle of project making would ensure the effectiveness of the project supporting that no environmental problems and reservoir sedimentation would take place and no decrease would occur in the downstream irrigable area. Subsequently, a healthy environment may be re-established because of watershed restoration, which would further benefit irrigation agriculture development supporting economic gains of the affected communities.

1.10 Objectives of the Study

The main objective of the study is to investigate the nature, causes and effects of human environmental degradation triggered on watershed natural resources, particularly on vegetation and soils of Belbela-Wadecha watershed ecosystem. It also aims towards securing a sound environment and ensuring sustainable irrigation development through participatory watershed restoration and management.

1.10.1 Specific Objectives

The specific objectives of the study are:

- To evaluate the government policies on watershed management practices involving irrigation development.
- To assess the current status of irrigation development and its impacts on the ecosystem of the Belbela-Wadecha watershed environment.

- To assess the livelihood practices of local watershed communities and their impacts on the watershed environment.
- To explore the experiences of the local watershed communities in preventing soil erosion, water loss and environmental conservation.
- To assess if there are any local bylaws to protect the watershed environment and the existence of enforcement procedures.
- To examine challenges and benefits of local communities in the attempt to restore the watershed functions.

1.10.2 Research Questions

From the above objectives, the following research questions are formed:

Main research question:

What are the long-term effects of environmental degradation on watershed natural resources, vegetation and soils in the Belbela-Wadecha watershed ecosystem?

Sub-questions:

- What government policies existing on irrigable agriculture development and watershed environmental management?
- What is the current status of irrigation development and what are its impacts on the Belbela-Wadecha watershed ecosystem?
- What are the impacts of the livelihood practices of the local communities on the Belbela-Wadecha watershed ecosystem?
- What practices do the Belbela-Wadecha watershed communities have in preserving natural resources of the area?
- How do the Belbela-Wadecha watershed communities discharge environmental protection responsibilities?
- What benefits do farmers in Belbela-Wadecha obtain from watershed ecosystems and what challenges do they face?

1.11 Reflection on the Research Questions

According to Jesson et al. (2008: 18), "The research question provides the structure for the whole of the literature review." She also argues it guides literature search and leads into the relevant literature informing what data to generate, how and where including how to analyze the data.

This study looks at gathering relevant information towards addressing the research questions, to support bringing sound conclusion and recommendations to the fore with a view to putting parallel operations of sustained irrigation development and sound environment in place on a sustainable basis benefiting both social and economic functions, thus satisfying the objectives of the study.

Accordingly, Government policies on both irrigation development and watershed ecosystem management would be looked at as to how they affect environmental management and irrigation performance that further impacts on the livelihood of the Belbela-Wadecha watershed communities. In addition, it is important to know the impacts of the existing practices of the community on the conservation of the natural resources of the study area and mechanisms they employ for discharging responsibilities in environmental protection processes. The study also seeks to identify benefits and challenges accrued from the watershed system as reflected in their livelihood patterns.

The data collected will help guide the design directions for watershed management towards benefiting both irrigation agriculture development and setting sound environment that enhances socio-economic functions.

1.12 Purpose and Aim of the Study

Over thirty years of the researcher's practical field experience, he happened to come across barren catchments and degraded watersheds with downstream water storage dams being filled up with sediments and associated canals silted up, including Belbela-Wadecha watershed that is the focus of this study. This has resulted in the reduction of irrigation water supply within less than ten years of operation after the construction of the dams (Figure 1-13) and deterioration of land for agricultural development and the watershed environment, which further adversely affected the livelihoods of the beneficiary communities.

This might be further factored in terms of impacts on food security, health, schooling opportunities, poverty, modern livelihood patterns, flooding hazards, sufficient percolation of rainwater into sub–surface for groundwater storage, among others.

Given the above possible challenges, this study hopes to contribute towards participatory environmental restorative actions in the watershed ecosystems with a view to complementing the efforts being made by other scholars towards changing the communities living patterns for the better and maintaining a sound watershed ecosystem.

The intention of the study is therefore, to explore the effects of watershed degradation and the possibilities of participatory community ecosystem restoration accompanied by sustainable irrigation agriculture and other benefits that can be generated from sustainable use of the watershed environment. This can be more practical, if and only if, complemented with current policies and farmer inclusive initiatives that take into account the realities out there, giving due focus to the communities surrounding the watershed area. This will at the end enable the communities implement the policies effectively and efficiently, which in turn will make the farmers benefit more from the outcomes of their activities as a result of the revitalized watershed management that will positively impact on the communities' living patterns.

Attention will be given to check whether there is effective policy in place on watershed management and whether those policies promote the sustainable use of watershed resources reflecting on land, water and forests. The researcher argues that the robustness of the natural resources would ensure the wellness of watershed ecosystem and thus benefit the watershed community on a sustainable basis relating to environmental and economic gains. Hence, formulation and/or enactment of workable policies need to be explored for the benefit of the watershed communities.

The researcher presumes that both irrigation development and environmental conservation aspects are indispensable with each other in watershed ecosystems and that watershed environmental sustainability should be a condition precedent to irrigation development. It is thought therefore, that this joint function will cause the envisaged arrangement/initiative to materialize and realize sound environmental sustainability and irrigated agriculture development.

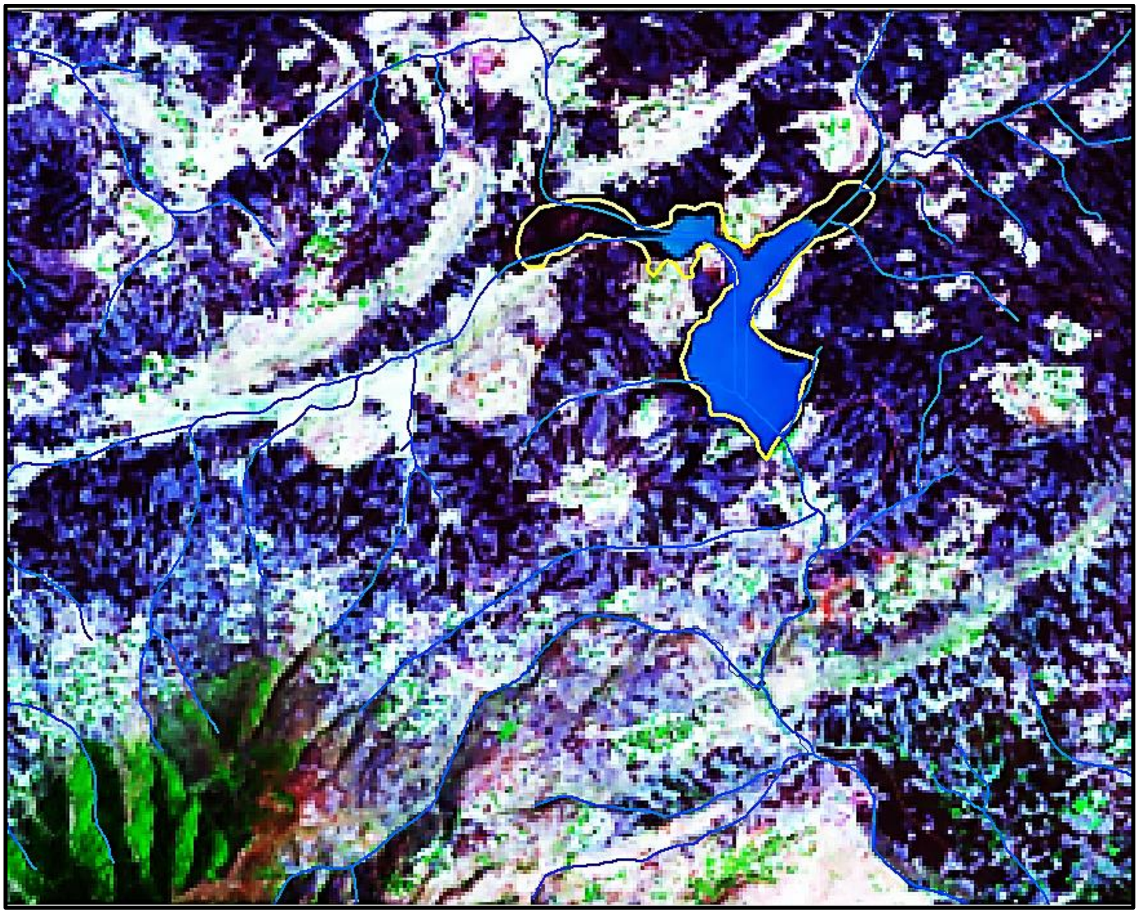


Figure 1-13: Reduction of Water Storage in the Reservoir (Wadecha)

1.13 Motivation and Significance of the Study

Ethiopia was once endowed with diverse natural resources of land, water and almost regular and sufficient rainfall patterns that could sustain reliable crop production for food supply and economic benefits. Nevertheless, this natural legacy is being affected seriously by the phenomenon of human impacts on the environment, including climate change, since time in the not-too-distant past.

Climate change and other human impacts on the environment have now resulted in a global agenda towards restoring a healthy environment for livelihood sustenance. Various actors including governments, NGOs, donors' institutions, private entities, and the public at large are all striving towards effecting environmental sustainability.

The challenge of the human induced environmental degradation in watershed areas does not only affect the natural environment setting and associated national development plans but also more severely impacts on the beneficiaries' socio-economic status. It further affects the donors' confidence positions in further funding of development opportunities, which would exacerbate the current miss- management of environmental resources.

In this regard, the researcher feels moved by the challenges noted above to take the initiative to contribute his part to the effort being exerted by the global actors in resolving the challenges of environmental management of watershed areas.

The study will explore impacts of irrigation development and the local community livelihood practices on the Belbela-Wadecha watershed ecosystem. It will also investigate possible role of participatory community action in developing a sound holistic environmental management process that integrates sustainable watershed ecosystem and irrigation scheme development. The researcher argues that increase in agricultural production should not come at the expense of soil, water, or biodiversity resources as has so often occurred in the past, which has resulted in the acute environmental degradation that posed adverse implications on environmental and livelihood sustenance.

The community participatory action largely takes into account the local resources, both human and material, including knowledge, which can be a permanent and meaningful local asset as well as appropriate technology for scaling up of watershed ecosystem management that would also ensure sustainable functions.

It is hoped that the study can be replicated to address similar challenges elsewhere where applicable. It can also contribute to the initiation of policy dialogues, inputs for research ideas, and further debate appropriate to watershed management. The recommendations from the study may serve as a basis for informed policy decisions to supporting the endeavor going on to improve the watersheds, the study area and other similar contexts in the country and beyond.

1.14 Definition of the Key Terms Used in this Study

- Afforestation "is the establishment of forest plantations on land that, until then, was not classified as forest. It implies transformation from non-forest to forest" (Patrick, undated).
- Biodiversity – is the variety of all forms of life, including genes, populations species, and ecosystems (World Development Report, 2010).

- Catchment area - refers to the area from which rainwater drains away into a watercourse.
- Classification- " Data having a common characteristic are placed in one class and in this way the entire data get divided into a number of groups or classes" (Kothari2004 123-124).
- Data processing- "Processing implies editing, coding, classification and tabulation of collected data so that they are amenable to analysis" (Kothari, 2004: 95).
- Deforestation - A non-temporary change of land use from forest to other land use or depletion of forest crown cover to less than 10% (Tilahun, 2010).
- Degradation – Is a deleterious change in the chemical structure, physical properties or appearance of a material from natural or artificial exposure.
- Desertification: – land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities (Zamba, 2007).
- Ecology: - "It is the study of influence of environmental factors on different aspects of life, e. g., morphology, physiology, growth, distribution, behavior and survival of living organisms. It is concerned with relationship between living organisms and their physical environment" (Mallick, 2015). It is a branch of biology dealing with the relationship of organisms with their environment & with each other.
- Ecosystem - A system formed by an ecological community & its environment that functions as a unit. "It is the study of interaction between biotic and abiotic components of the environment through exchange of matter and energy." (Mallick, 2015).
- Ecosystem Services - are the ecosystem processes or functions that have value to individuals or society (World Development Report, 2010).
- Environment - the surrounding of and influence on, a particular item of interest. The environment comprises biophysical, social, cultural, economic and political aspects.
- Forest - Forest means communities of plants either naturally grown or developed by planting, and in many respects are trees and other plants having woody character (Proclamation NO 542/2007- Federal Democratic Republic of Ethiopia).
- Irrigation- is defined as the artificial application of water onto cropland for the purpose of satisfying the water requirements necessary for growing different crops and plays a key role in stabilizing food production in a number of countries by either supplementing or replacing the need for natural precipitation for the purpose of food production (FAO, 1997).

- Natural Resource Management - is used to refer to decision-making by individuals and groups about natural resources allocated over time and space (Williams & Patterson, 1996).
- Poverty – from an income point of view, people are poor when they are in a state where their income (or consumption) is less than that required to meet certain defined needs (Sola, 2001). Extreme poverty is defined as living on $1.25 a day or less (World Development Report, 2010). In this work, the former definition is followed.
- Reforestation "is the establishment of forest plantations on temporarily unstocked lands that that were considered as forest in the recent past" (Patrick, undated).
- Soil degradation - involves both the loss of the soil in itself and loss of organic matter and other mineral nutrients of the soil (USAID, 2000).
- Soil erosion- is a process of losing soil particles and transporting it by water or wind until the point at which the transportation capacity is reduced and deposition takes place (Wirtu, 2004).
- Sustainable Development - "is that development which can protect the environment by satisfying the needs of the present generation keeping in view of the needs for development of future generation" (Mallick, 2015).
- Sustainable watershed management- Is a system of managing watershed resources that yields adequate and continuous flow of goods and services to meet the needs of the present and future generations (Cruz, 1999).
- Water uses – refers, inter alia, to in stream water uses, extractive water uses and environmental water uses (IWMI, 2005).
- Watershed- A watershed, catchment, or basin or drainage area refers to any topographically delineated area that can collect water and is drained by a river system with an outlet (Brooks et al. 1981 cited in Cruz, 1999).
- Watershed Assessment - the process by which information about watershed is collected with a view to establishing, within a defined framework of expectations, the current status and probable future direction of interactions between human beings and watershed natural resources, using certain criteria and indicators (Tilahun, 2010).
- Watershed Management - consists of those coordinated human activities, which aimed at controlling, enhancing or restoring watershed functions (Ali, 2011). It is the process of

guiding and organizing land and other resource uses in a watershed to provide desired goods and services without adversely affecting soil and water resources (Brooks et al., 1991).

- Poverty (definition):

Source: After Grimble et al. 2002

Absolute poverty	The degree of poverty below which, the minimal requirements for consumption (or survival) are not met. Can be measured in monetary terms (e.g. the U$$1 per day poverty line) or in terms of minimum calorific requirements plus essential non-food items. Indigence usually refers to those who do not have access to the necessities for human survival, while other forms of poverty refer to degrees of deprivation above that threshold.
Abject poverty	When households earn incomes insufficient to pay for the very necessities such as food, they are said to be living in abject poverty.
Extreme poverty	People living on less than 1$ per day.
Relative poverty	This reflects the distribution of poverty and levels of income inequality in a society. It may be defined as a ration or proportion of absolute poverty to the average or total income.
Human Poverty Index (HPI) for developing countries	The HPI has been developed by UNDP as a composite measure of poverty assessment. It covers factors such as the number of people expected to die under 40 years, adult illiteracy, people without access to safe water or health services, and underweight children.

1.15 Conceptual Framework

According to Sahoo (2012), an increase in population induces increased demand for natural resources, energy, food, and goods. Because of increase in consumption, large amounts of greenhouse gases and effluents are released, changing the Earth's atmospheric composition and its temperature regulating capacity.

In addition, increased demand for food, energy and settlements also contribute to land degradation. Land degradation takes place in two ways, natural and man-made. Natural land degradation is the process through which natural processes cause ecosystem and landscape disturbances. This study will not pursue the natural land degradation, it being beyond the scope of this study. Human induced degradation is due to human activities that cause natural setting perturbations and ecosystem imbalances. It is necessary therefore to restore these unstable areas and to promote environmental wellbeing if life has to sustain on Earth. Global efforts are being made towards sustaining environmental wellbeing, such as the United Nations Sustainable Development Goals.

Environmental degradation due to anthropogenic effects in the Belbela-Wadecha watershed environment has adversely affected the socio-economic conditions of the residents. The degradation is the result of human interference on land use and land cover accumulated over years.

This study intends to investigate the nature, causes and impacts of watershed ecosystem degradation through the application of remote sensing techniques and advances in GIS technology. The study also seeks to contribute toward long term responses to this environmental problem through the application of Participatory Action Research involving communities in the watershed area. This study therefore proposes a conceptual framework model for the nature and causes of watershed degradation and its likely consequences as illustrated in Figure 1-14:.

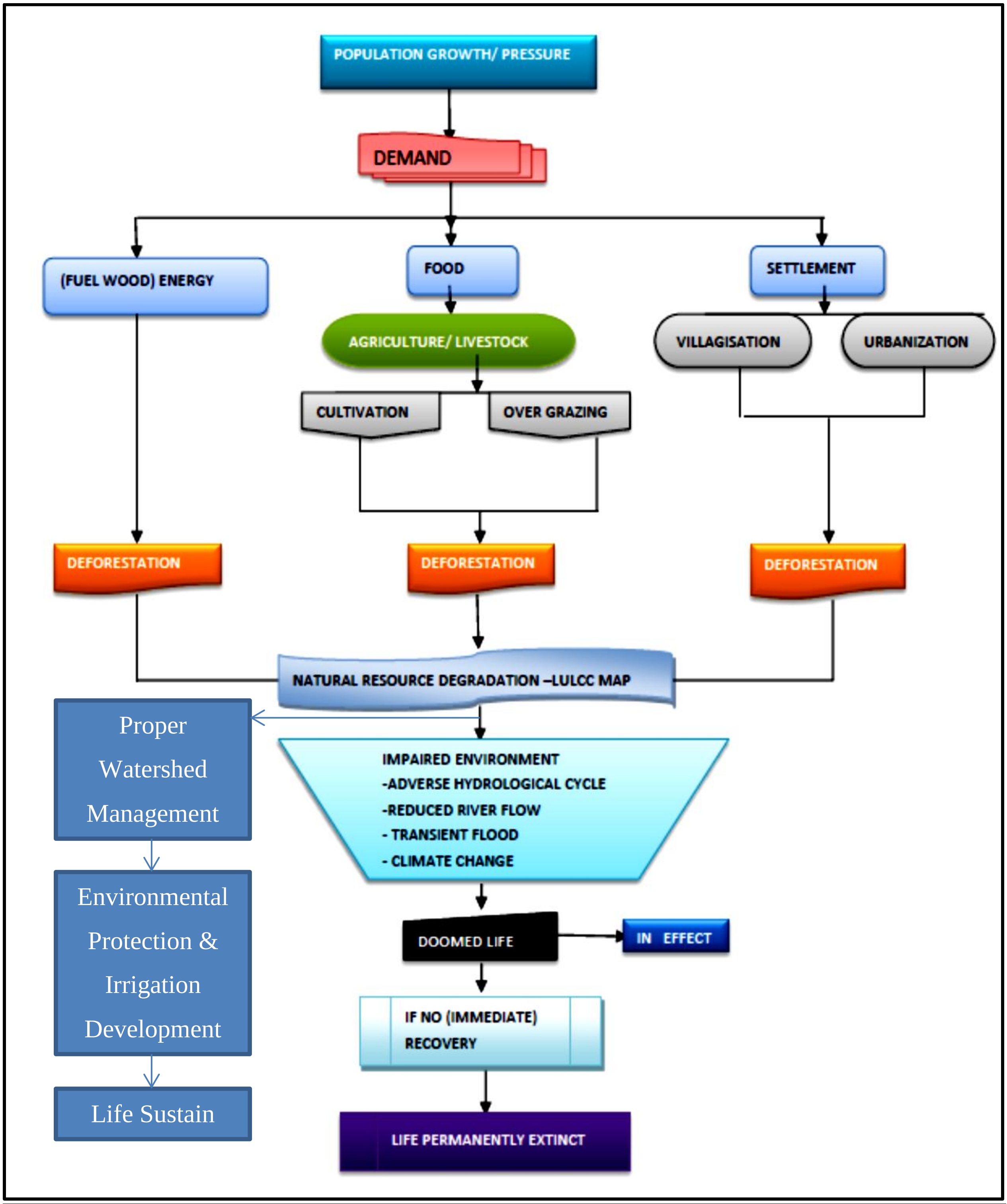


Figure 1-14: CFM Model: Conceptual Framework Model of the Study

2 Review of Related Literature

2.1 Introduction

Mengistu (2017:36) states the role of literature review as "It helps to clarify what is already known to avoid unintentional replications of the same research."

In addition, Chris (1998: 13) defines Literature Review as:

> *The selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed.*

Jesson et al. (2008) mention two styles of literature review, traditional literature review and systematic literature review. Traditional literature review is "a written appraisal of what is already known – existing knowledge on a topic – with no prescribed methodology" (Jesson et al., 2008:10). In addition, systematic literature review is defined as "A method of making sense of large bodies of information, and a means to contributing to the answers to questions about what works and what does not." It is argued, "Unfortunately, it is difficult to find any written support for the traditional review against the powerful surge of the proponents of systematic review" (Petticrew & Roberts, 2006:2). Nonetheless, both approaches can be used to answer a research question or problem. This study follows the systematic approach to literature review. Jesson et al. (2008) states that possible information sources for a literature review may combine those such as library catalogues, digital / electronic libraries, individual full-text journal databases, official websites, online repositories, and bibliographic databases.

This literature review section mainly covers watershed and their roles/importance, the nature, causes and effects of watershed degradation and its linkages with human poverty, as well as emerging responses to watershed degradation. It provides a background to the watershed management, how the watershed functions and factors affecting the watershed contexts. The concept of sustainability of the watershed ecosystem is introduced further as one of the key tasks with a view to satisfying both current and future generational requirements.

The chapter also discusses the concept of watershed degradation relating to vegetation, soil, and water caused by humanity. The effects of Land Use Land Cover (LULC) changes due to disturbances encountered include global warming, deforestation / degradation, biodiversity loss, and the increase of natural disaster-flooding (Dwivedi et al., 2005; Mas et al., 2004; Zaho et al., 2004 cited in Selcuk, 2008). Evidence also shows that greenhouse effects are enhanced because of greenhouse gas emissions including burning of forests, resulting in climate change. Watershed degradation has contributed to adverse environmental consequences resulting in adverse environmental, economic, and social effects.

The chapter also deals with various issues pertaining to sustainable watershed management. Finally this chapter tries to look into policy matters as affecting the subject under caption particularly relating to the participation of communities whether or not due consideration was given to support the implementation activities of natural resources conservation and economic developmental works targeting to benefit sound ecosystem and sustained irrigation agriculture operations on a sustainable basis.

2.1.1 Background to the Watershed Management

Lal (2000: 2) states that, "Watershed is defined as a delineated area with a well-defined topographic boundary and water outlet." Lal (2000: 2) also explains, "The terms watershed, catchment, and basin are often used interchangeably"

Sheng (1994: 1) states, "The concept of watershed management probably originated from the "Torrent Control" work in the European Alps". "Torrent" means swift and violent streams in mountainous terrain. The "Control" includes both horizontal and vertical control of streams and their tributary (watershed) areas" (Sheng, 1994: 1). However, watershed importance has been recognized since the earliest civilizations. Ancient Chinese proverbs state that “Whoever rules the mountain also rules the river” and “green mountains yield clean and steady water” (Ali, 2010:195). Liu et al. (2007) state, that the system of watershed management involves social, economic, resource, and environment components. Watershed management activities can be considered at various levels including individual watershed level or at a regional scale. This study is based on

an individual watershed level, targeting causes of watershed degradation and the exploration of participatory approach towards the restoration of the degraded ecosystem with a view towards effecting sound environment management and sustainable irrigation agriculture operations for benefiting better community livelihoods.
The watershed management objectives, according to Lao (2002), include improved conservation, protection and management of natural resources as forest areas that are important for the maintenance of biodiversity and water resources. According to Ushie (2013:4) “-----natural resource management deals with the interactions between humans and the natural environment while natural resource governance addresses the systems and institutions that determine these interactions."

The proposed Belbela-Wadecha research will focus on the nature and causes of watershed degradation as well as possible intervention towards conservation and protection of the vegetation, soils and water resources. The resources can be used for economically productive purposes, on a sustainable basis, thereby enhancing and maintaining the social and environmental service functions of the watershed to the surrounding community.

Various potential areas of intervention and measures to achieve the objectives include effective utilization of natural resources to mitigate adverse effects, maintaining healthy environment whereby water yield and biomass production shall increase (DSE, 2001; Wiesmann, 1999). The current researcher concurs with that the increased water resource, because of good watershed management, can be used for irrigated agriculture development to support and enhance the livelihoods of the community of the area through generating additional income and restore sound ecosystem where forests are protected and can bring benefit, as a source of goods and services.

According to IWSM's Policy Brief (2015: 2), "Effective watershed management critically depends on good land and water governance". The definition of land governance as presented by FAO and UN–HABITAT (2009 cited in IWSM, 2015: 2) states as;

> *Land governance concerns the rules, process and structures through which decisions are made about access to land and its use, the manner in which the decisions are implemented and enforced, and the way that competing interests in land are managed.*

The Environmental Protection Authority (EPA, 2005) states that sound decision-making has to be based on good science and information available. The EPA (2005) also mentions that fostering collaborative problem solving should be followed as an environmental management approach which involves "creating a shared vision and joint strategies to address concerns that go beyond any particular interest or stakeholder" (EPA, 2005: 4).

Establishing good governance in watershed resource management is critical, especially through the formulation and enforcement of bylaws and other relevant rules and regulations. Moreover, for managing and improving watershed protection and restoration, it is important to know the impact of agricultural operations on soil and water resources. It is also necessary to identify and address land use practices and other human activities that pollute local water resources and / or alter watershed functions.

To develop sustainable programs, management of land and water together in an interdisciplinary approach is a prerequisite. In this regard, Ali (2011) notes the challenges of watersheds as follows:

- High population growth
- Increasing land use intensity
- Highly degraded or threatened river systems
- No legal protection for in-stream flow needs
- Significant allocation to irrigation
- An extensive plumbing systems of canal and dams
- A highly uncertain water supply and
- Emerging water conflicts

The Canadian Council of Ministers of the Environment (CCME) (CCME, 2016) states that an appropriate scale for integrated water management (IWM) is also important and depends on, among others, the capacity, leadership and jurisdiction of the proponents for IWM. Table 2-1 shows steps for integrating socio-economic factors into the planning process of natural resource management.

<u>Table 2-1: Steps for Integrating Social and Economic Factors into NRM Planning</u>

Source: Byron et al. 2004

Action	How?
Understand the socio-economic trends in the target area.	By means of both primary and secondary sources of data.
Select the most important social, environmental and economic issues.	Identifying the issues that are a high priority in the community and taking this into consideration NRM strategies. Benchmarking can be used to evaluate future changes in attitudes following an activity such as a public awareness campaign.
Assess likely impacts of NRM targets and estimate the potential impacts of the proposal.	Using social and economic data determine the likely positive and negative impacts of change.
Conduct detailed planning and analysis.	Analyse a range of regional NRM issues through input/output analysis, cost/benefit analysis, and multi-criteria analysis, or social impact assessment.
Recommend the best action.	Weighing of all the impacts, benefits, and alternatives and using these to recommend an appropriate management action the social context. Once actions are underway, an effective monitoring program should be maintained.
Overcome barriers and build bridges.	By conducting solid social and economic research to understand local constraints and tailoring NRM programs to fit area and region.

2.1.2 Concept of Sustainability of Watershed Natural Resources

This sub-section brings various authors' ideas together and discusses their views relating to the concept of sustainability of watershed natural resources. The ideas raised by each of authors are related in content terms, reflecting more or less similar arguments and thus appear to characterize repetitive concepts. However, the researcher of this study reflected his views on the ideas raised and drew conclusions relating to his subject study accordingly. Hence, the following discussions were noted.

The concept of sustainable Watershed management is defined as:

> *a system of managing watershed resources that yield adequate and continuous flow of goods and services to meet the needs of the present and future generations (Cruz, 1999: 32).*

The sustainability of watershed resources mainly depends on the utilization approach that seeks to maintain a dynamic balance between economic and environmental uses of the watershed.

Therefore, to manage the watershed area sustainably, its components - physical, biological and social- need to be treated all with equal importance.

Independent Evaluation Group (IEG et al., 2013) states balancing competing demands on forest resources and managing them for sustainable development can put poverty alleviation and economic development on equal footing with conservation.

In addition,

> *Sustainable development can occur only when the needs of people and the capacity of the natural resource base to meet those needs are balanced over time (Working Group on Watershed Management and Development, 1988: 11).*

The Working Group on Watershed Management and Development (1988) further states that watershed management offers a suitable tool to use in making this balance happens. Therefore, it is important to integrate watershed management concepts and practices in a way that it is mainstreamed in development work. Furthermore, Tuyll (2006:3) [unpublished] defines watershed management as "is the process of people guiding and organizing water, land and forest resource use on a watershed in order to provide desired goods and services without adversely affecting water, soil, and vegetation resources". Some of the driving forces of successful watershed management include a demand driven approach and committed community participation (IWMI, 2016).

The protection of watershed resources shall benefit the ecology, environment, and the economy in a sustainable way. Accordingly, to induce a sustainable watershed functions requires due attention to be given to some of the more critical elements, including equitability and participatory management, efficiency and effectiveness, adequate and coherent policies and integrated land use planning (Cruz, 1999). The Storm water Harbors and Watersheds Program (SHWP, 2010: 1) states Integrated Watershed Management, as developed at the 2008 meetings with the inter-municipal and community IWM groups, as follows:

> *Integrated Watershed Management (IWM) is the coordinated, sustainable management of land and water resources within a watershed to ensure the sustainability of vital ecosystems where local governments and stakeholders work together to control and*

conserve hydrology, ensure biodiversity, minimize land degradation and maximize economic, social and environmental objectives.

Integrated Watershed Management (IWSM, 2015) states that integrated watershed management is a crucial approach to reduce disaster risk and improve productivity through sustainable land management, and thereby contribute to better living patterns. Alemu et al. (2014) state that an integrated watershed management approaches is the only possible solution for the rehabilitation of degraded lands. The above literature underscores the use of physical, biological, and agronomic soil and water conservation measures through public investments.

In order for integrated watershed management to become effective, the issues argued above need to be supported critically with rules and regulations binding upon all stakeholders who are willing to participate and invest in the management of the resources of the watershed. The management approach should ensure that the resources are used more effectively with a view towards advocating equitable use of benefits derived from the watershed environment. This management practice includes goods and services resulting from effective and efficient utilization of the resources and that participation of all stakeholders is maintained.

Community–led watershed planning and management tasks should be done in conjunction with local governments, where the local authorities must provide the community with the assistance of related experts and the required information as and when necessary (Teather et al., undated).

In addition, consideration of land use planning is a key item in promoting optimal use of scarce land resources so that protection of environmental resources can come to the fore. It is also instrumental in harmonizing and satisfying the usually competing watershed resource needs, reflecting on the biophysical and socio-economic impacts of the land use options, whereby screening out alternative scenarios can be effected towards benefiting the sustainability of the watershed environment.

Sustainability is based on the principle that development must meet the needs of the present generations without compromising the ability of the future generations (Ali, 2011). Therefore from the researcher's commonsense point of view, sound watershed natural resources management and sustained development in the Belbela-Wadecha watershed ecosystem can be referred to as a set of actions needed to secure sustainability functions of the area to meet the present needs without jeopardizing the interests of future generations. This is because this study is about making watershed ecosystem management and irrigation functions operate on a sustainable basis where incomes can be generated better while subsequently preventing over exploitation of the natural resources.

Sustainability, in this regard, as defined in the World Commission on Environment and Development (WCED)'s our common future (1987) focuses on meeting the needs of both current and future generations.

The Brundtland Commission identified seven strategic issues (Hackett, 1960) relating to sustainable development:

- Reviving growth
- Changing the quality of growth
- Meeting essential needs for jobs, energy, water, and sanitation
- Ensuring a sustainable level of population
- Conserving and enhancing the resource base
- Reorienting technology and managing risk
- Merging environment and economics in decision making

Bartelmus (1997) argues that, if sustainable development is to be achieved the economic approach, the social concept and the ecological view need to be reconciled and operationalized. Bartelmus (1997: 53) also states, "Sustainable development implies a set of measures or actions adopted to achieve certain desirable objectives, defined in terms of improvements to human well-being".

Guerin (2001) argues that, for sustainable development to be achieved, sustainable technologies need to be developed. These technologies include, but are not limited to, vegetation conservation measure such as grass contours, alternative tillage techniques and physical structures like terraces, stone bunds and gabion boxes (Tesfaye, 2011). As these technologies are homegrown ones, they can be put in place and maintained using the community’s own capacity; as a result, sustainability should not be a problem.

The World Bank, having attached more importance to vegetation measures in watershed management, favors technologies that are low cost and more farmer friendly. The Bank further states that successful adaptation would be achieved through involving farmers in the choice of technologies and associated implementing strategies commensurate with the farmers' local circumstances, helping them produce more harvest and meet their needs (World Bank, 2001). Nehemia et al. (2015: 6) states:

> *The rural poor together with vulnerable farmers in developing countries are in dire need of science-based solutions to accelerate successful adaptation of agricultural systems to climate change.*

Nehemia et al. (2015) further argued technological and policy solutions can make significant contributions towards enhancing the capacity of famers to manage better their resources, environment and food security.

Rosegrant (2002) argues that sustaining refers to the conditions where ecosystems provide goods and services to sustain and fulfill the livelihoods of a society. Thomas et al (2003) identify Non-Wood Forest Products as *Food Products:* Nuts, fruits, vegetables*; Spices and condiments:* Nutmeg, cinnamon, cardamom; and *Industrial plant oils waxes, plant gums (Frankincense, gum, Myrrh),* natural honey and beeswax, medicinal plants and food products. These products, which can be derived from watershed ecosystems, contribute to a varied uses by the community, including food, spiritual purposes, medicinal purposes, flavoring, soil and water conservation, shade, aesthetic, among others. The communities therefore tend to protect and nurture these resources to ensure continued benefit from the watershed ecosystem. However, competing interests for the watershed resource usually result in environmental degradation of the watershed environment.

The forestry sector in Ethiopia is administered under the Department of Natural Resources and the Regulatory Department of the Ministry of Agriculture. However, other institutions are involved directly or indirectly in the conservation of forest resources, including the following:

- The Environmental Protection Authority in charge of environmental matters, including monitoring, protection and environmental information linked to forests, woodlands, bush-lands and all forestry-related resources and assets;
- The Water Resources Development Ministry that is responsible for sustainable development of water resources;
- The Ministry of Education involved in environmental education;
- The Ministry of Mines and Energy involved in energy resources development;
- The Ethiopia Agricultural Research Organization responsible for conducting research related to agriculture and forestry;
- The Institute of Biodiversity Conservation and Research (IBCR) in charge of conservation and development of biological resources, including forest biological resources.

In order for conservation activities to be successful, co-ordination mechanisms remain a critical area of concern. This requires calling upon all affected parties to come together and design ways on how the stakeholders can discharge their institutional and joint responsibilities in line with the consensus reached collectively and ensuring that functions are monitored and evaluated on a regular basis.

Jean Bonnal (undated) states development programs and projects have gradually evolved to cover the many aspects of the problems to be dealt with. They only not have accounted for the problems encountered but also covered the complexity of the situations and solutions proposed. Focus has to be given to designing projects and programs with a participatory and decentralized approach so that the need of the communities concerned can be satisfied. In watershed development processes, priority is given usually to the regions of high production potential (e.g. irrigated plains) and consequently less attention was given to the large parts of watershed.

Obviously, this approach does not take into full account of the potential of the watershed system (limited in scope); and that the large part of the watershed should be considered besides economic benefits. This study considers watershed as a resource base for income generating activities and also the need maintain a sound ecosystem that in turn can be a potential source for sustainable water flow to the dam and irrigation development as well as for ecological, social and cultural purposes. This study will also embrace the less advantaged farmers, not only "the rich farmers in the plain". In addition, this study also tries to bring the upstream and downstream communities together towards making both communities benefit in their respective areas in an equitable way, which also advocates for the conservation and revitalization of the watershed ecosystem.

Adrian et al. (2001) argues that the Conservation Strategy of Ethiopia (CSE), is a potential way ahead, reflecting on two elements or groups of activities, the government and civil society elements' particular characteristics and their contributions support the enhancement of watershed development and management. However, this researcher argues that they ought to have primarily accounted for the beneficiary communities residing in the upland and lowland of the watershed system. No compromise should be allowed relating to involving the main and immediate (the owners) stakeholders in the natural conservation implementation process. The inclusion of this last element (the watershed community), as a main actor undoubtedly ensures effective watershed management and sustainability of operations more than anyone else in the stakeholder system, as their livelihood is directly and / or indirectly influenced by the natural resources in the watershed environment as opposed to the former two elements.

In addition, according to National Conservation Strategy (NCS, 1994), if environmental management has to bring sustainable development to the fore, three necessary and complementary elements, environmental sustainability, social sustainability and economic sustainability need to be integrated and put on an equal footing into a framework for sustainable development. However, the experience today reveals that these three elements are not on the same footing. In this regard, the CSE (1997) has outlined cross-sectoral and sectoral guiding principles and strategies to guide sustainable development. However, there appears to remain a practical enforcement gap of legislative provisions and implementation strategies and tactics to prove it on the ground, thereby winning the farmers' perceptions and enabling the three elements operate simultaneously in harmony and sustainably.

This study tries to look into the possible missing link in policy and legal framework options and seeks to propose ways to translate these sustainability functions (sustainable environment and sustainable development) into practical ventures.

2.1.3 How the Watershed Functions

According to MERILARK et al. (2002), the three processes within watershed that can protect water quality if the vegetation cover is preserved are water capture, water storage, and water release. MERILARK et al. (2002: 2) state, "Water capture is the process of water transfer from the atmosphere into the soil". Land managers through making it easier for water to infiltrate the soil surface and percolate to greater depths can enhance the extent of water capture. MERILARK et al. (2002) also further stated that good infiltration rates are influenced beneficially by:

- Plant cover that reduces the physical impact of raindrops upon the soil surface, and thereby minimizes soil crusting
- Plant cover that increases the roughness of the soil surface, thus decreasing the velocity of runoff water
- Root systems that provide channels in the soil for water
- Plant litter and organic matter on and incorporated into the soil surface to absorb moisture and help maintain soil structure
- Plant cover that traps snow at or very near the soil surface (this will also make the soil freeze more slowly and enhance the water's chance to enter soil during winter months*)*

Black (undated) argues that ecologically the watershed functions in two additional ways that consist of (i) providing diverse sites and pathways along which vital chemical reactions take place; and (ii) providing habitat for the flora and fauna that constitute the biological elements for ecosystems. He also further states that in the release/discharge functions of watersheds, resistance is inherent in and intricately involves (a) characteristics of drainage network; (b) proximity of the storage site thereto, and ultimately, (c) interactions between the two.

Ali (2011) states that watersheds convey the water that runs over the land and into the ground. Watersheds provide many vital ecological and hydrological functions. However, human activities, both in the water and on the land, can have a great impact on the watershed functions.

The hydrological function of the watershed relates to collecting water from rainfall and snowmelt and storing some of the precipitation in wetlands, soils, trees and other vegetation, underground in aquifers, and the floodplain alongside the river banks as illustrated in Figure 2-1.Some of this storage quantity eventually flows into streams, rivers and lakes as runoff (Ali, 2010:195).

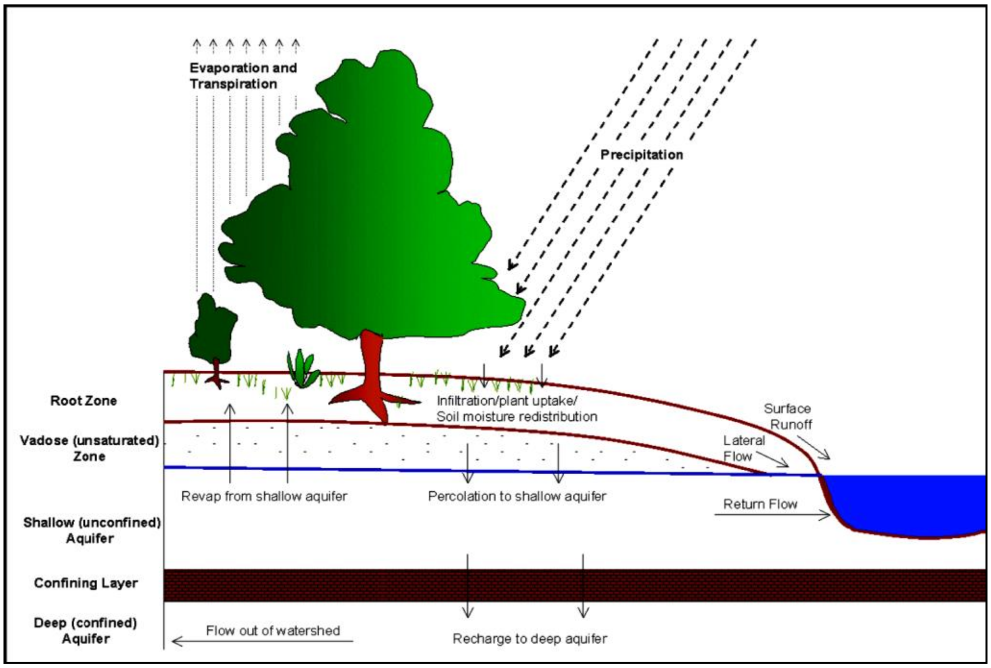


Figure 2-1: Schematic Representation of the Hydrologic Cycle
(Source: Neitsch et al. (b) 2000)

Moreover, watershed systems offer transport paths for sediments, nutrient, minerals and chemicals; and water to human communities for drinking, cleaning, recreation, navigation, hydroelectric power, and manufacturing.

However, the natural setting of the watershed environment is changed overtime as a result of adverse effects due to human interference in search of goods and services for life sustenance. In this regard, according to Taylor (1999), Figure 2-2 illustrates a simplified schematic of the flow of impacts on human activity on watershed products). Hence, conserving the watershed ecosystem should be a mandatory task if the natural resources system has to be maintained and kept intact for sustainable life sustenance on this earth.

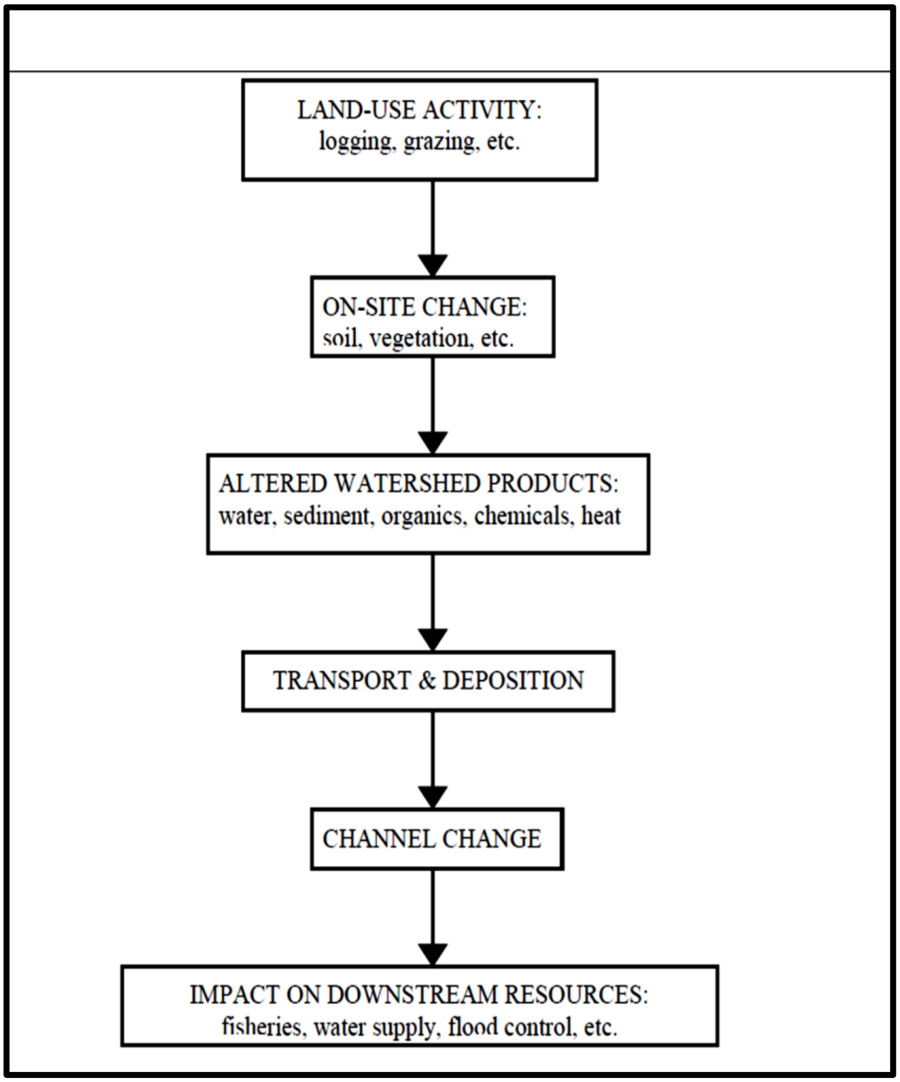


Figure 2-2: Simplified Schematic of the Flow of Watershed Products
Source: Ross N. Taylor, M.S. 1999

2.2 Watersheds and their Roles/Importance

2.2.1 Importance of Watershed Natural Resources

Ali (2011: 195) state that, "watersheds have been viewed as useful systems for planning and implementing natural resources management and agricultural development for many centuries". He also states that several factors that influence natural resources management include innovative decision-making tools, research and development, property rights, pricing resources, well-regulated markets, strong institutions and information dissemination and / or sharing. Sound natural resource management seeks to promote the concept of sustainable development.

However, unless communities are made party to every step of the way and involved in the decision making process on natural resources management, the watershed that is being studied is likely to get degraded. Therefore, in order to manage properly natural resources, more participatory approaches need to be considered, for instance, involvement of the community in water, agriculture and forests management and into a broader context with a web of related outcomes (World Development Report, 2010). This research intends to involve the community in the identification of environmental problems in the watershed and their causes as well as in making decisions to respond to these environmental problems.

Watershed as an important land unit, and if it is well managed through investment of knowledge and other related resources to make the area as productive as possible, multiple benefits can be harvested including provision for drinking water, irrigation, fishing, and recreation. According to Burton (2010: 8) "Those involved with water resources and irrigation development will need to think more broadly, they will need to understand and consider the multiple uses of water and integrate the management and uses of the resources."

Other goods and services provided by watersheds include selective logging, climate mitigation and regulation, groundwater recharge, maintenance of biodiversity, healthy habitat creation and sound ecological formation. Taru (1998, cited in Wani et.al, 2011: 15) states, "Groundwater should be regarded as a common property resource". Therefore, the watershed communities and those involved with water resources developmental activities need to take account of this while engaging in developmental activities.

When a watershed is managed properly, reduction of sediment laden water flow will take place, which in turn increases the amount of useful water storage in the reservoir and consequently increase the useful lifespan of a dam. Because of these management interventions, irrigation operators will enjoy more required water for longer seasons and farmers will harvest the designed beneficial uses so that the livelihoods of the community will be improved and sustained. Therefore, avoiding or minimizing the amount of sediment inflow to the reservoirs through watershed environment protection is an important way forward.

Ali (2011) argues that citizen participation is required at various stages in the watershed development and management processes, including, planning, design and operation and management. This community engagement process also benefits in changing attitudes and behaviors of the community towards reducing contamination and degradation of the watershed so that water quality can be improved as a result.

2.2.2 Role and Benefits of Watershed

Forests / vegetation have multiple functions in constituting sustainable watershed management. The Ministerial Conference on the Protection of Forests held in Europe from 12-14 May 2009, in Antalya, Turkey, highlighted the benefits of forests and water. These include stabilizing soils, minimizing soil erosion, trapping sediments and pollutants from up-land and protection of water bodies and watercourses and contribution to the supply of water where in turn water plays significant role in growth and sustenance of forest resources.

The forest and water interaction is crucial in terms of landscape and natural resource management. Forest, according to Santra (2016: 1501), is defined as "Biome with enough average annual precipitation (at least 76 centimeters, or 30 inches) to support growth of various species of trees and smaller forms of vegetation". Forest resources contribute towards water resources generation, which in turn serves in different beneficial areas including ecology, agriculture, domestic and industry. Forest and water as a new entity " will focus on improved national awareness and policy environment in support of sustainable management of mountain forest and upland areas with regard to water resources" (Moujahed, 2002: 8). Therefore, watershed management advocates the interrelationships between economic gains and natural resources conservation through promoting upstream and downstream linkages.

According to Moujahed (2002), keeping and using a system of improved land, water and vegetation management intact will ensure sustainable use of land resources. Hence, maintaining upstream and downstream harmonious functions of forest and water resources will further strengthen simultaneous operation of environment and agricultural functions in watersheds. In this regard, Moujahed (2002:3) states: "Upstream management of forests strongly affects downstream uses of water resources". Therefore, ensuring strong upstream-downstream linkages will in turn ensure sound environment and sustainable agricultural development through the wise management of forest and water resources as one entity.

In addition, forests make significant contribution in improving the operation of ecological systems that makes the environment suitable for living for all forms of lives. The Forest Stewardship Council (FSC, 2013:1) states that:

> *Provide food, building materials, shelter, medicines and fuel. They keep soils in place and act as giant sponges, globally providing estimated 75 percent usable water. They are the home of most plants and animals; they provide genetic diversity; they play an important role in climate regulation.*

A statement by participants of the Kunming Expert Meeting on forests and water (2014) proposed a five-year action plan that emphasizes the importance of forest-water interactions has received objective attention since 2002 and has gained considerable momentum. This included having 20 partners comprised of international organizations, academia, civil society, non-governmental organization and the private sector. The five-year action plan called for the mobilization of knowledge and efforts involving international stakeholders toward formulating policies and scientific approaches where forest and water interactions have clearly demonstrated a success.

In this connection, the meeting had put forward its vision, mission, and objectives, supported with related activities. In addition, policies, science, economic, capacity building and corresponding strategies have been set for the planning period. It now appears as though it is high time, as it is the end of the planning period, 2019, to assess and evaluate the impact of the activities of the plan to help design future directions.

Furthermore, the role of forests has received much greater attention than ever before since the Shiga Declaration of 2002, relating to the Third World Forum (Statement by participants of the Kunming Expert Meeting on forests and water, 2014). However, a lot still need to be done in involving more countries (only 20 partners until 2014) as members to the group to move together to furthering discourse process of forest-water agenda.

According to David (2016), forests and trees are essential instruments to improve rainfall, prevent erosion and flooding and recharge ground water. On the other hand, it was pointed out that deforestation can lead to reduced evapotranspiration and enhanced surface temperatures. Deforestation disturbs the hydrological cycle and affects moisture circulation resulting in reduced moisture availability for crop consumption and that further leads to a reduced production affecting poverty.

The Ministerial Conference on the Protection of Forest in Europe (MCPFE) (MCPFE, 2009) further indicated challenges of coordination to maximize the wide range of multi sectoral forest benefits while maintaining the healthy functioning of water resources and ecosystems. The conference argued that there must be an understanding made of the need to appreciate the interface between forest / trees and water. It was argued also further that institutional mechanisms have to be developed to enhance synergies in dealing with forests and water issues including implementation and enforcement of action plans at the local and national levels.

The Government of Ethiopia (GoE) has launched a Proclamation NO. 542/2007 on "Forest Development, Conservation and Utilization" (GoE, 2007) that clearly states functions, mandates, rights of uses and obligations in the event of flagrant offences where any affected implementing entities, including Government (both Federal and Regional), Associations, Privates and NGOs, can take part in the process. The Proclamation is a well thought out piece of account that would address a varied range of critical matters that need to be attended to by all parties involved. However, the response level is not promising as forest resources continue to be in a state of decreasing trends, and people resulting in serious damage to forest resources and disturbance of animals from their rightful territories are persistently invading game parks.

The watershed community seeks to draw on forest products, goods and services, to sustain life; without adversely affecting the ecosystem functionality. The first and foremost task should be to recognize the close interrelations between forest and water. Unfortunately, these two scarce resources are managed, in most cases, through different state entities. Therefore, the potential benefits of those resources are not tapped effectively as organizations responsible for water and forest administration are charged with technically interdependent mandates influencing social, economic, environmental, cultural, aesthetic and spiritual functions are not coordinated for abstracting optimal benefits. In addition, the fact and the reality is that it is not how clever the policy you put in that matters, rather, it is how you ensure the practical delivery of the policy in its appropriate sense of concern.

The natural resources must be managed and administered through the hands-on experience of the community that is supported naturally by the inherent feeling of sympathy they have towards nurturing the natural resources. This is because the communities are the immediate user and has the real feel of what is meant by a sustained environment - that feel emanates from the direct and practical reflection on their day to day life style as affecting their livelihoods.

Therefore, it appears that enforcement levels of the provisions stipulated in the Proclamation on Forest Development such as Conservation and Utilization (GoE, 2007) procedures and other Government working documents, including the bylaws, needs to be accounted for critically without exceptions as it supports a meaningful delivery of the outcomes required. Drafting management plans and active enactment procedures and schedules including monitoring and evaluation mechanisms at all levels are still quite a grey area that needs to be looked at seriously while not forgetting the priority agenda, community participation.

2.3 Nature and Causes of Watershed Degradation

2.3.1 Population Pressure

According to Yisraw et al (2017), Land Use Land Cover Change (LULCC) is one of the fundamental concerns that threaten global environmental functions and sustainable development. LULC change relates to human activity on land in a quest of goods and services to secure livelihood that is evident through the expansion of agricultural activities, fuel wood production, resettlements, overgrazing, mining and other construction activities. This shows that human population pressure affects the environment because of LULCC.

Malthus (1798) states that, human population grows geometrically whereas food production grows only arithmetically. In addition, Malthus (1978, cited in Abdissa, 2010) states that the limited natural resources impact on human population growth in a way that population growth is restricted (UN, 1994). Hence, from this one may argue that food production needs to be increased to cater for the population growth, which requires expansion of agricultural land by clearing forest, bush, woodland areas and occupancy of uncultivated land, which shall naturally be followed by LULC changes. Malthus further argues that control on population growth will provide certain level of reduction in environmental consequences (UN, 1994). This view of population-environment relations has been shared in the work of Brown (1976); Ehrlich and Holdren (1971 and 1974) and Boserup (1965), cited in Abdissa, 2010. In addition, "Population expansion over the next century is expected to occur primarily in less-developed regions placing more pressure on forest ecosystems to provide essential ecosystem services" (Ge et al., 2016: 3). The UN (2015: 3) states, "More than half of global population growth between now and 2050 are expected to occur in Africa". Wilson (1992, cited in Tilahun, 2010:13), states, "the raging monster upon the land is population growth".

However, Boserup (1981), argues that population growth might induce technological changes to account for the increased food production to keep pace with the population increase. This was counter-argued by Lemessa (2009) who states that the agricultural technology in Ethiopia is at low level of development. It is also worth noting that none of the authors has specifically addressed population-environment relations as such, rather they argued in relation to land use and food production. Moreover, Abdissa (2010) states that both perspectives characterize a linear relationship between populations and their environment.

Furthermore, the World Bank Policy Document (1993, cited in Tilahun, 2010: 13) states: "the causes of environmental degradation are as varied as its manifestations. But, the heart of the problem is the rapid rate of population growth in many developing countries". Catherine (1997) also states that in developing countries, the natural science perspective explains more pertinently the current environment-population relationship. According to Jolly (1994, cited in Abdissa, 2010) poverty and unequal distribution of resources are responsible for environmental degradation and population growth.

In this regard, the researcher argues that environmental sustainability can be achieved through promoting sustainable ecosystem functioning. Competing demands also need to be addressed in such a way that the environment is kept healthy while at the same time incomes and other benefits necessary for living, goods and services, are derived from the watershed environment on a sustainable basis. Resource utilization, among other benefits, of the watershed area must be shared among the community in a manner of equitable use. This relates to creating a sustainable means of income for the population of the study area to keep the community away from unplanned/ incidental use of the resources (cutting trees, overgrazing) of the watershed environment for livelihood sustenance. Einar (2010) argues that attention should be paid to alternative measures that would reduce the dependence on the resources of headwater areas, where wastages are reduced and efficiency of resource utilization is increased. This can be supported by constituting a diverse means of livelihood sustenance through planned, designed, well operated, monitored, and evaluated use of agriculture, irrigation, logging and animal husbandry using irrigated pasture. This can be achieved through watershed ecosystem restoration whereby the biophysical landscape is restored through vegetative growth, reforestation, leading to water resource conservation and soil cover stabilization.

Ethiopia has experienced slow population growth for many years (Arowolo, 2010). However, it is worth noting the increasing trend in population growth in Ethiopia after 1984. From the census of the population, there has been an increase in population size from 41.2 million in 1985 to 63.5 million in 2000 (CSA, 2004).The projected figures for the year 2015 were 94,000,000, Figure 2-3. The high rate of population growth has declined only marginally over the years, from a peak of 3.0 percent per annum in 1990 to 2.7 percent in 2005, and is projected to decline further to 2.6% (2005-2010) and an average of 2.4% during the period 2010-2015, (Arowolo,2010). In addition, according to UN (2002, cited in Assefa, 2003) population growth rate will decline to 2% by 2020 and reduces further to 1.3% by 2050. However, Nani (2020) states that Ethiopia's population; one of the fastest growing in the world, with a growth rate of 3.02% per annum will double in the next 30 years. Nani (2020) also indicated that the current population of Ethiopia is 114.96 million. In this regard, the researcher concurs with this last figure as the Government of Ethiopia claims, through its broadcast services, that the current population figure of the country is over 110 million.

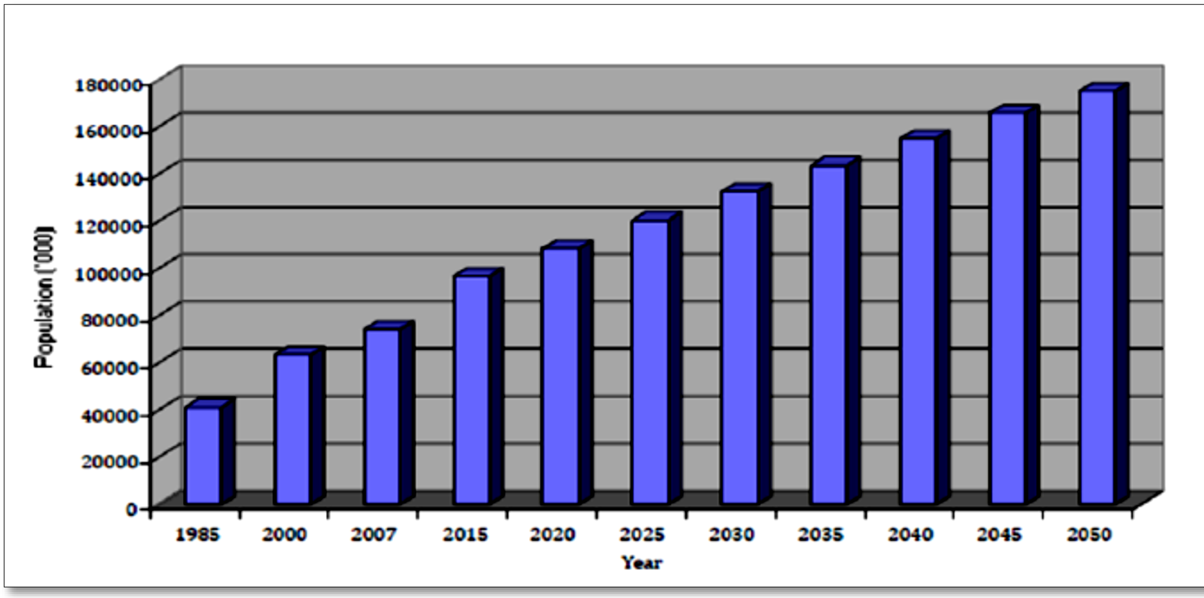


Figure 2-3: Estimated Projected Population of Ethiopia
Source: UN, Population Division, 2009

The controversy on the population and environmental interrelationships has been between those who consider rapid population growth results in increased demand for resources and environmental degradation, and those who emphasize opportunities rather than problems (Markos & Dilnesaw, 1998). In this regard, UNDESA (2019) states that "While the relationships between population size, consumption, technology and the environment are far from simple, demographic trends highlight the importance of integrating population dynamics into development planning (SDGs 6, 7, 9, 12, 13, 14 and 15)". During pre-historic times, population distribution was sparse and man-to-land ratio was very low. However, as human population growth increased over the centuries, the human settlements expanded and the population density increased. With rapid population growth, the availability of land gradually became less, (Markos & Dilnesaw, 1998).

To satisfy the resource need of a growing population land is the center of agricultural production; basic land-use change is required, expanding food production through forest clearing, to intensify production on already cultivated land and developing infrastructure needed to support increased population (Hunter, 2000).

Nonetheless, the researcher argues, population growth needs to be supported by sustainable economic development if life is to be sustained. On the other hand, if population growth, especially in non-industrialized countries, cannot be sufficiently supported by income generating activities the communities will go out to the nearby areas where there are natural resources such as trees, grasses, to cut them down and take them to the market for sell to support their economic needs. In this regard, Rob and Arjan (2008) argue that poor communities may lack financial capacity to mobilize for the protection of soil degradation, resulting in lower harvests. Subsequently, the communities may clear natural resources (forests, trees) to maintain their desired level of economic gains. As it stands today, United Nations Department of Social and Economic Affairs (UNDESA) rated Ethiopia as one of the highest projected population increase countries in the world (UNDESA, 2019).

Therefore, Ethiopia being one of the developing, low income and populous countries in the world, needs to strive to balance and harmonize population growth and environmental wellbeing to secure sustainable livelihoods. In this regard, agricultural expansion through land clearing with a view to accounting for population growth cannot be an option for sustainable development. Therefore, in order for both environment and agricultural development function simultaneously and in harmony, the community needs to be provided with on various income generating activities that keep them away from the natural resources and damage to the existing ecosystem.

Land use / cover change, which is caused by human population pressure, climate change effects, socio-economic and political factors, will cause land degradation. Soil erosion is a serious problem related to LULC change.

2.3.2 Global Deforestation

Deforestation in developed temperate countries is no more an issue today and in fact increases are recorded in forest area today (Anon 1990a, 2010). Although the definition of what is forest and what is not forest remains controversial, 60 per cent of the deforestation was recorded in tropical forests during 1990-2010 (Anon 1990a, 2010).

Tropical deforestation gained momentum during the last half of the 20th century (Sumit et al., undated). Table 2-2 and Table 2-3 Table 2-3show the summary of deforestation by region, sub-region, and countries during 1990-2010.

Table 2-2: Annual Change in Forest Area by Region and Sub-Region, 1990-2010

Source: Anon, 2010

In the period 2000 -2010

Region/sub-region	1990-2000		2000-2010	
	1,000 ha/year	%	1,000 ha/year	%
Eastern and Southern Africa	-1841	-0.62	-1839	-0.66
Northern Africa	-590	-0.72	-41	-0.05
Western and Central Africa	-1637	-0.46	-1535	-0.46
Total Africa	**-4067**	**-0.56**	**-3414**	**-0.49**
East Asia	1762	0.81	2781	1.16
South and Southwest Asia	-2428	-0.77	-677	-0.23
Western and Central Asia	72	0.17	131	0.31
Total Asia	**-595**	**-0.10**	**2235**	**0.39**
Russian Federation (RF)	32	n.s.	-18	n.s.
Europe excluding RF	845	0.46	694	0.36
Total Europe	**877**	**0.09**	**676**	**0.07**
Caribbean	53	0.87	50	0.75
Central America	-374	-1.56	-248	-1.19
North America	32	n.s.	188	0.03
Total North and Central America	**-289**	**-0.04**	**-10**	**0.00**
Total Oceania	**-41**	**-0.02**	**-700**	**-0.36**
Total South America	**-4213**	**-0.45**	**-3997**	**-0.45**
World	**-8327**	**-0.20**	**-5211**	**-0.13**

During the period 2000-2010 South America and Africa have lost approximately four million and 3.4 million in hectares annually respectively while Oceania lost 700,000 hectares mainly due to severe drought and forest fires in Australia that exacerbated the forest loss from 2000 AD (Sumit et al., undated).

Furthermore, Brazil and Indonesia accounted for 40% of the net forest loss over the decade of 1990s and during the past decade, the forest area in North and Central America remained stable, but the rest still need to make effort in fighting against deforestation and stabilization of ecosystem, particularly the developing countries. On the other hand, the current forest situation in Europe records a state of reduced deforestation due to a focus on sustenance.

Table 2-3: Countries with Largest Annual Net Loss of Forest Area, 1990-2010
Source: Anon, 2010

Country	Annual change 1990-2000		Country	Annual change 1990-2000	
	1,000 ha/year	%		1,000 ha/year	%
Brazil	-2890	-0.51	Brazil	-2642	-0.49
Indonesia	-1914	-1.75	Australia	-562	-0.37
Sudan	-589	-0.80	Indonesia	-498	-0.51
Myanmar	-435	-1.17	Nigeria	-410	-3.67
Nigeria	-410	-2.68	Tanzania	-403	-1.13
Tanzania	-403	-1.02	Zimbabwe	-327	-1.88
Mexico	-354	-0.52	The Congo	-311	-0.20
Zimbabwe	-327	-1.58	Myanmar	-310	-0.93
Congo	-311	-0.20	Bolivia	-290	-0.49
Argentina	-293	-0.88	Venezuela	-288	-0.60
Total	**-7926**	**-0.71**	**Total**	**-6040**	**-0.53**

2.3.3 Watershed Ecosystem Degradation

The Millennium Ecosystem Assessment (MA, 2005) argues that the term 'land' recognizes renewable natural resources, including soils, water, vegetation and wildlife, relating to their terrestrial ecosystems. Land degradation, in turn, relates to all processes that weaken the capacity of land resources to deliver on substantive functions and services in these ecosystems, including deforestation, biodiversity loss, degradation of soils and adverse effect on hydrologic cycles (MA, 2005). In response to the ongoing serious land degradation phenomenon, as a result of population expansion and associated demand for ecosystem goods and services, the Government of Ethiopia launched related national programs during 1970s and 1980s. The Government of Ethiopia launched a Guideline on Community Based Participatory Watershed Development in 2005 (MoARD, 2005) to support sustainable land management, reflecting on the following principles of watershed development:

- Participatory
- Gender sensitive
- Building upon local experience, strength and what works
- Realistic, integrated, productive and manageable
- Watershed logic and potential respected

- The need for flexibility at different levels
- Cost sharing and employment/ ownership building
- Complementary to food security and rural development

Although the Government, through its Ministry of Natural Resources, supported rural land rehabilitation programs and institutional capacity building run by FAO, attached to the Ministry of Agriculture, it did not account for those real life actors, the communities, but only those technical experts in the field (MoARD, 2005).

Pilot tests were done through the assistance of FAO, involving field technicians but not the community, which was considered the evolution of participatory planning approach in watershed management (Tesfaye, 2011). Subsequently, NGOs and bilateral organizations, in collaboration with the Government, adopted the program and attached it to their operational plan as one of the programs activities.

To this end, although, the exercise contributed to technological benefits, it did not satisfy the intended purpose as it missed the most important stakeholder, the local communities in its functions. Consequently, the exclusion of the community would pose a potential threat to sustainability of these programs.

Obviously therefore, to reverse the threat, involvement of the user communities from start to finish would be necessary in order to work together, identify problems and priorities, constraints, suggest possible solutions and recommendations including policy options where monitoring plans and impact evaluation procedures are considered (Johnson et al., 2001).

According to Pretty and Ward (2001), Governments and NGOs have recognized that protection of watersheds cannot be achieved without the willing participation of the affected communities. The main point that makes the farmers' participation most important is that they are the closest entity in the area and the owners of the programs. Hence, they are aware and close to the real problems and possible solutions, which the experts would likely miss.

2.3.4 Forest Degradation in Ethiopia

Although during the early 1980s Ethiopia's land mass was covered by about 35% of forest resource, currently it has alarmingly and unbelievably dropped down to 2.3% coverage Demel (2000, cited in Elias et al., 2008). Parry (2003) also indicated that trees covered 42 million hectares (35%) of Ethiopia's land at the beginning of 20th Century. The researcher hopes that this figure today would have changed to some level higher than that as massive tree planting activities are undertaken each year during the rainy season. Reasons for deforestation, as cited in Ethiopian Policy and Strategy for the Development, Conservation and Utilization of Forests, is the increasing demand for goods and services (fuel wood, unlawful settlement in forest areas and unlawful logging, farmland) resulting from population growth. The document also indicates the adverse effects of deforestation, including depletion of biodiversity, land degradation, soil erosion, runoffs, desertification, droughts and recurrent famine (MoA, 2007).

UNEP (2000) states that forest ecosystems play various roles globally and locally in terms of providing environmental services and economic benefits. The Stockholm Conference of 1972 highlighted the need for sound land and forest use policies and emphasized the need for the introduction of forest management practices. The importance of effecting basic and applied research on improved forest planning and management emphasizing on environmental functions of forest has also been given due recognition.

Tilahun (2010:10) argues, "The historic loss of forests is closely related to demographic expansion and the conversion of forest land to other uses". He further indicated that assessments of changes in forest cover in Ethiopia have been carried out over the past 30 years by a number of organizations, where the assessment results, although approaches vary, concur with each other that forest resource potential is declining and forest ecosystems are threatened.

Moreover, Gebru (2016) also argues that the total annual change of forest cover of the country keeps reducing. Accordingly, Table 2-4 shows annual changes of the forest cover.

Table 2-4: Annual Change of Forest Cover
Source: Ethiopian Ministry of Water Resources, 1999

Total Forest Cover (1000 ha)			
1990	2000	2005	2010
15114	13705	13000	12296
Annual Change Rate (1000 ha), Negative number represents deforestation			
	1990-2000	2000-2005	2005-2010
	-141	-141	-141
Annual Change Rate (percent), Negative number represents deforestation			
	1990-2000	2000-2005	2005-2010
	-0.93	-1.03	-1.08

Studies suggest that policy reformulation, where community participation is given due focuses, should be implemented and that enforcement issues and procedures of related policy/laws/regulations should not be compromised. This study also concurs with this approach.

2.3.5 Watershed Degradation in Ethiopia

Watershed degradation features, according to Ethiopia's Ministry of Agriculture and Rural Development's guideline document on Community Based Participatory Watershed Development, (MoARD, 2005), consists of the depletion of water resources, soil erosion and land degradation, impoverishment of the vegetative cover, and damage to infrastructure.

The document further states that Ethiopia suffers from "recurrent wastage of most of its rainwater" (MoARD, 2005: 15). Soil is eroded due to loss of water through surface runoff, triggering adverse socio-ecological consequences, including chronic food security. This is because, the topography of the land, coupled with poor farming practices and inappropriate use of technologies and mechanisms, are the underlying issues that subsequently resulted in resource degradation and threatened the natural function of the biophysical resources, whereby biotic operation is hampered and the lives of all living things are jeopardized.

The Ethiopian Ministry of Agriculture and Rural Development guideline document (MoARD, 2005) also describes reduction in soil depth and fertility that is attributed to soil erosion and degradation which can take place in the form of physical, biological and chemical erosion. This has also reduced soil water holding capacity. Watershed degradation is also due to exploitative use of the land covering, cultivation of steep slopes, shallow soils, tillage, overgrazing, and encroachment of forests/closed areas.

The reduction of the vegetative cover and biomass is attributed to climatic factors, overutilization of vegetation, erosion and reduced soil fertility, cutting down of trees, overuse of crop residues for animal feed and fuel wood, overgrazing and burning (Lakew D. et al., 2005). The reduction of vegetative cover due to land degradation, results in the depletion of water resources, which could lead to desertification or disappearance of the potential of the land to sustain life and livelihoods.

Soil erosion and lack of vegetative cover has adverse impact on sedimentation rates in water reservoirs, and damages irrigation schemes and road networks. Other than socio-economic and environmental adverse consequences of watershed degradation, the cost of rehabilitation and properly re-operationalizing the infrastructure could be huge. Hence, to account for such environmental and sustainability issues, investing in participatory watershed planning, implementation and management may help reverse the effect and sustain environment for better living and livelihoods at a reasonable cost.

2.3.6 Soil Degradation as Lack of Vegetation Cover

According to Verheye (2011), the land surface of the Earth covers 13340 million hectares. One third to one half of the total land surface change is attributed to human activities including logging, deforestation, agricultural activities, overgrazing and multiple construction functions, (Briassoulis, 2011). The EPA report (1999, cited in Morie, 2007) states that anthropogenic (human induced) activities on LULC change are grouped as direct (proximate causes) and indirect effects (underlying causes). Proximate causes include agricultural expansion, wood extraction and infrastructure construction while underlying causes refer to policy and institutional structures, technological, economic, demographic and cultural factors (Geist & Lambin, 2002). Nearly a third of the earth's land surface is currently being used for agriculture or grazing cattle (FAO, 2004a), which are created at the cost of natural forests, grasslands, and wetlands that provide valuable habitats for species and services for humankind (Millennium Ecosystem Assessment, 2003).

In addition, Oldman et al. (1991 cited in Wirtu, 2014:17) state that overgrazing in dryland areas accounts for 49%, poor land farming practice for 24%, and deforestation for 27% of land degradation. According to Sharma et al. (1995, cited in Wirtu, 2014), the causal factors relate to policy and institutional matters, inadequate technologies, population pressure poverty, cultural values and behavior of individuals and farming practices. Therefore, it is worth revisiting the rules and regulations and the need for critical enforcement procedures cannot be overemphasized.

2.3.7 Land Use / Land Cover Change in Ethiopia

Land cover “refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and / or artificial structures" (Ellis, 2016: 1). Land use is defined as "in terms of syndromes of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity" (Ellis, 2016: 1). In addition, relating to social scientists and land managers, land use is defined as "more broadly to include the social and economic purposes and contexts for and within which lands are managed (or left unmanaged), such as subsistence versus commercial agriculture, rented vs. owned, or private vs. public land" (Ellis, 2016: 1).

Land cover has also been defined by the attributes of the Earth’s land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human (mainly built-up) structures and land use as the purposes for which humans exploit the land cover (Lambin *et al.*, 2003; Baulies & Szejwach, 1997). It involves both the manner in which biophysical attributes of the land are manipulated and the intent underlying that manipulation, i.e., the purpose for which the land is used (Turner *et al*., 1995; Lambin *et al*., 2003).

Conversion and modification are the two forms of land cover changes described by Meyer and Turner(1992) where the former refers to a change from one class of land cover to another (e.g., from grassland to cultivated land). The latter refers, however, to a change within a land cover category (e.g. thinning of a forest or a change in composition).

Four aspects of change detection, which are important when monitoring natural resources, Macleod and Cognation (1998, cited in Zabair, 2006), are indicated as follows:

i Detecting the changes that have occurred
ii. Identifying the nature of the change
iii. Measuring the area extent of the change
iv. Assessing the spatial pattern of the change

Table 2-5 also presents LULC detection techniques. Most of the studies on land use / land cover changes are focused on deforestation, expansion of cultivated land on watershed natural setting, urban growth (Bireda, 2015). LULC change impacts on forest and vegetation due to human activities that were undertaken at the cost of natural vegetation, (including forest, woodland and shrubbery). Tekle and Hedlund (2000) indicated that "Within 28 years (1958-1986), open area, urban and natural lands showed an expansion by 33.3%, 19.5% and 75% respectively at the expense of shrub land and forest" (Bireda, 2015: 8) in Kallu District, Southern Wello Region, Ethiopia. Tekle and Hedlund (2000) further allege that LULC changes impact on the hydrological flow regime of watershed by altering the balance consisting of rainfall, evaporation and runoff response. Mesfin (2009) argues that a significant increase of urban growth area from 34% in 1986 to 51% in 2000 was observed in Addis Ababa, the capital of Ethiopia, taking over what was once either agricultural land or vegetated areas or both, because of population expansion. In addition, Keno et al. (2019) states that the growth area for Addis Ababa for the periods of 1995-2005 and 2005-2017 shows 39.5% and 36.1% respectively and 186.7% for a period of 1987-2017.

Table 2-5: LULC Change Detection Techniques

Source: Sing, 1989

Techniques	Characteristics	Advantages	Disadvantages	Examples
Image differencing	Subtracts the first date image from a second date image, pixel by pixel.	Simple and straight forward, Easy to interpret the results.	Cannot provide a detailed change matrix, requires	Forest defoliation, land-cover change and

			selection of thresholds.	irrigated crops monitoring.
Image regression	Establishes relationships between bitemporal images, then estimates pixel values of the second-date image by use of regression function, subtracts the regressed image from the first-date image	Reduces impacts of the atmospheric, sensor and environmental differences between n two-date images.	Requires developing accurate regression functions for the selected bands before implementing change detection.	Tropical forest change and forest conversion.
Image rationing	Calculate the ration of registered images of two dates, band by band.	Reduces impacts of Sun angle, shadow and topography.	Non-normal distribution of the result is often criticized.	Land-use mapping.
Post classification comparison	Separately classifies multitemporal images into thematic maps, and then implements comparison of the classified images, pixel by pixel.	Minimizes impacts of atmospheric, sensor and environmental differences between multitemporal images; provides a complete matrix of change information.	Requires a great amount of time and expertise to create classification products. The final accuracy depends on the quality of the classified image of each date	LULC change, wetland change and urban classification.
Spectral-temporal combined analysis	Puts multi-temporal data into a single file, then classifies the combined dataset and identifies and labels the changes.	Simple and timesaving in classification.	Difficult to identify and label the change classes; cannot provide a complete matrix of change information.	Changes in coastal zone environments and forest change.

2.3.8 Factors Causing Watershed Degradation

According to Lambin et al. (2006), identification of causative factors of LULC changes requires an understanding of how people make land-use decisions and how various factors interact in specific localities covering local, regional, or global scale to influence land-use decision-making processes.

The relationships between human activities and land-use / cover change have been conceptualized by Turner et al. (1993a) and Ojima et al. (1994), among others and that is illustrated in Figure 2-4.

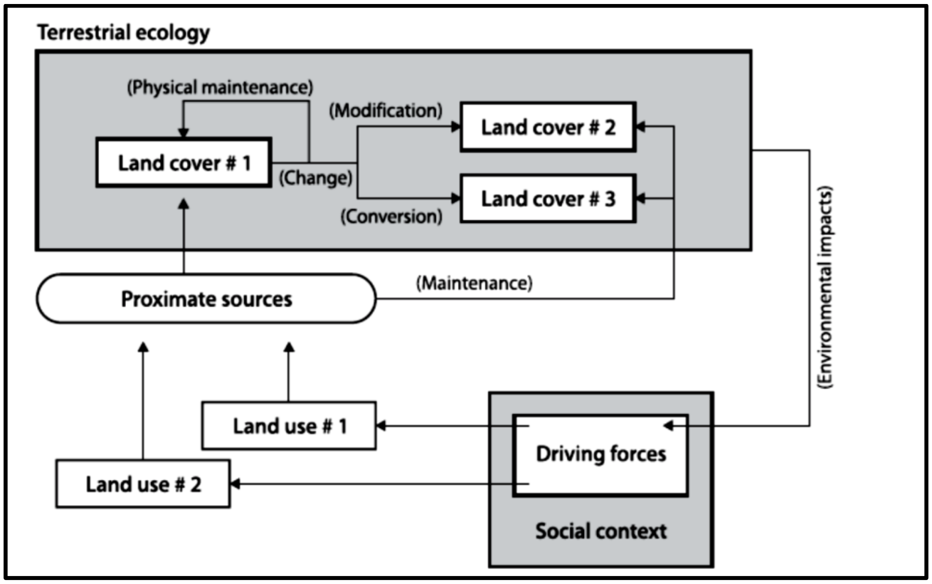


Figure 2-4: Links Between Human Activities and Land Use and Land Cover Change

Source: Ojima, et al, 1994

The Figure depicts an important distinction between proximate and underlying causes of land–use change (Turner et al., 1993a, 1996; Lambin et al., 2001). The framework has been widely applied (for example by Nielsen and Zobisch, 2001; Xu and Wilkes, 2004; Geist, 2005; Misselhorn, 2005). The proximate causes of land cover change relate to human activities that concern the intended manipulation of land cover as reflected on the recurrent set of activities involving agriculture, forestry, and infrastructure construction.

The proximate causes operate at local level, including, individual farms, households or communities (Lambin et al., 2003; Mather, 2006a). Underlying causes are forces that operate from a distance by altering certain proximate causes, which are formed by social, political, economic, demographic, technological, cultural and biophysical variables that constitute structural conditions in human-environment relations (Brookfield, 1999). The underlying driving forces, in contrast to proximate causes, originate from the regional or global levels with interactions among various levels of organizations (Mather, 2006b). Figure 2-5 shows Proximate causes and their underlying driving forces.

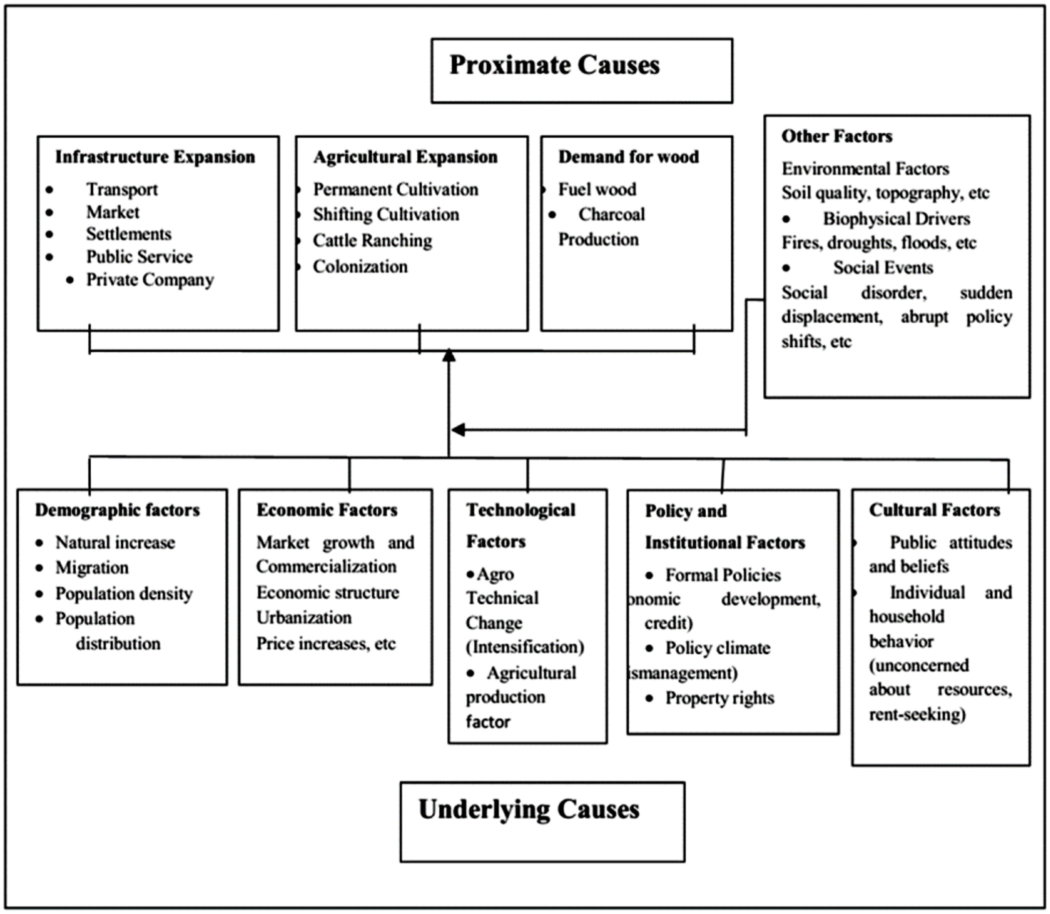


Figure 2-5: Proximate and Underlying Causes of LULC Changes

Source: Geist, H.J. and Lambin, E.F., 2002

Moreover, land degradation, according to Ali (2011), is a process in which the value of biophysical environment is affected by a combination of human-induced, physical, biological and chemical processes acting upon the land. It is viewed as any change or disturbance to the land perceived to be deleterious or undesirable.

Human activity also eliminates critical natural habitat sites, thereby limiting biodiversity in the watershed. Land degradation has implications upon agronomic productivity, the environment and food security.

In this study of the Belbela-Wadecha watershed, the Belbela-Wadecha cascaded micro-earth dams had significant deposits of sediment transported from upper catchments, which in the researcher's view were the result of degradation of natural resources of the watershed caused by human interference from communities residing in the upland watershed environment. Such human activities adversely affected the watershed ecosystem and agronomic productivity, which then further affected food security and the livelihood patterns of the community. This can be viewed as the result of both proximate and underlying causes of deforestation.

2.3.9 **Reservoir Sedimentation**

Worldwide, useful storage volumes of waters behind the dams are displaced by sediments mobilized from upper catchments originating from both point sources and non-point sources (Table 2-6). Sedimentation phenomenon is attributed largely to physical soil degradation, which is constituted from various forms of soil erosion. Soil erosion is mainly of two types; natural geologic erosion and human accelerated erosion (Rajesh, 2018). The former consists of removal of top soil by natural processes and the latter takes place because of human activities like overgrazing, deforestation and mining (also known as biotic agents), In the latter type the rate of erosion is faster than the renewal. The two types of agents that cause soil erosion are biotic and climatic agents. Biotic agents, as referred to above, are those caused by human intervention and climatic ones occur due to wind and water. Soil erosion through water includes, stream bank erosion, rill erosion, gulley erosion, and sheet erosion; and wind erosion relate to saltation, suspension, and surface creep.

The two types of soil erosion agents may also further induce desertification. Desertification is a process where a number of ecological changes destroy the ability of land to be used for growing crops or grazing takes place. Rajesh (2018) states that human activities that degrade soil and water resources can lead to the creation of desert like land. A number of attributes including deforestation, overgrazing, mining, drought and hot temperatures, improper soil and water resource management, salinization and water logging causes desertification. UNEP indicates that one-fifth of the world land area may become desertified over the next 20 years (Rajesh, 2018). It has also further stated that the most desert-affected areas would include Africa, Asia, Australia, South Western United States, and Central and South America.

Therefore, soil erosion, as a movement of soil components from one place to another, washes and blows soil particles into the rivers, lakes and oceans, resulting in sediment accumulation in the reservoirs behind the dams. Sedimentation of water reservoirs has adverse environmental consequences and poses a diminishing effect on the socio-economic characteristics of both upstream and downstream communities.

According to Basson (2009), the installed water storage capacity of reservoirs worldwide is about 7000 km^3, of which 4000 km^3 is used for energy production, irrigation, and water supply. Basson (2009) also argues that the highest sedimentation rates occur in arid regions of the Middle East, Australia and Oceania, and Africa (Table 2-6).

Table 2-6: Sedimentation Rate
Source: Basson, 2009

Region	Average Sedimentation Rate % Year	Hydropower Dams: 80%	Other Uses Dams: 70%
Africa	0.85	2100	2090
Asia	0.79	2035	2025
Australia & Oceania	0.94	2070	2080
Central America	0.74	2060	2040
Europe	0.73	2080[a]	2060[a]
Middle East	1.02	2060	2030
North America	0.68	2060	2070
South America	0.75	2080	2060

[a]Including Russia

Basson (2009) predicts that 80% of the useful storage volume for hydropower production will be lost due to sedimentation by 2035 in these regions, whereas 70% of the storage capacity used for irrigation will also be lost to sedimentation in Asia by 2025. This also applies to the Middle East by 2030 and Central America by 2040. These Figures underscore that reservoir sedimentation endangers sustainable food and energy production in various regions in the Globe.

In addition, some characteristic features of some specific reservoirs' sedimentation can be cited, including Shah (2005) and Seddeqy (2007), which state Nepal loses approximately 240 million m^3 of sediment per year and Afghanistan loses 150 million m^3 per year respectively. According to Chanson and James (1998), four major Australian dams (Moore Creek, Gap, Korrumbyn Creek, Quipolly) that were built to supply water for domestic, agriculture, and mining uses were fully silted-up in less than 25 years of operation.

The Ethiopian Highland Reclamation Study (FAO, 1986) states 80% of the population resides in the highland areas of the central part of the country where almost all Ethiopian rivers originate. The highland of Ethiopia is characterized by high population density, with the communities engaged in extensive and intensive cultivation patterns to sustain the large human population. However, at the same time, these human activities have a high potential for physical soil degradation to take place due to the physiographic nature of the land formation, thereby endangering the useful storage capacity behind the dams and inducing negative environmental consequences. This further adversely affects the productive capacity of the land and thus the socio-economic status of the agricultural farming community.

Ethiopia has constructed small, medium and large-scale dams for irrigation, drinking water supply and hydroelectric power generation, including flood control, all over the country and many are under construction with many pending dam projects on the drawing board. According to the researcher's view, those dams in operation are almost all either performing under capacity or nearing complete stoppage of functioning due to quick reservoir sedimentation resulting from soil erosion.

In addition, in Ethiopia, most reservoirs have either partially been silted-up in far less than their design life or have become fully silted-up even while still under construction. Gilgel Gibe I Dam, having storage capacity of 917 million m^3 of water, was expected to serve at least 70 years. However, studies reveal that it will be filled-up completely with sediment discharge within 24 years (Hathaway, 2008; Devi et al., 2007). Borkena dams in Wollo area, which were meant for irrigation water supply, were silted-up while under construction (Amare, 2005). Legedadi reservoir was constructed provide Addis Ababa's drinking water supply. However, a bathymetric survey of 20 years (1978-1998) reveals an average sediment accumulation of 26000 m^3 per year, indicating that water shortage for the rapidly growing city population would take place (Gessese, 2008). Haregeweny et al. (2006), indicate that 50% of the studied micro-earth dams used for irrigation in Tigray region have siltation problems that would shorten their economic life by half of the designed period. Further, in Tigray region, although Filiglig and Grashito reservoirs' design life were 30 and 21 years respectively, they were later on estimated to only serve 6 and 4 years respectively based on their annual sedimentation rate of 6928 and 11987 m^3 respectively (Aynekulu et al., 2006).

The Koka reservoir supplied by Awash and Modjo rivers was constructed in 1959, impounding 1650 million m^3 storage capacities, for hydroelectric power supply (Musa et al., 2005; Shahin, 1993). However, Addis Ababa city faced power shortages in 2000, even during the rainy season, as the turbines were not properly functioning due to sedimentation / siltation (Hathaway, 2008).

According to Elias (2003), as a result of sheet and gulley erosion from agricultural sites in the watershed ecosystem, an earth dam in the headwaters of Modjo Rivers was completely filled-up with 96000 m^3 of silt within two years of operational time. Table 2-7 shows a summary of effects of sedimentation on some of reservoirs of Ethiopia.

Table 2-7: Summary of Effects of Sedimentation on Some of the Reservoirs of Ethiopia

Source: Kebede, 2012

Reservoir	Capacity reduce/expected to reduce	Source
Koka	2302 t/km^2/year 17Mm^3/year	Amare (2005)
Aba-Samuel	50% lost 664,980 t/year accumulate	Devi *et al*. (2007) Amare (2005)
Gilgel Gibe I	Designed for 70 years but will function for 24 years	Devi *et al*. (2007)
Melka Wakena	Greatly reduced	Hathway (2008)
Angereb	Annual siltation 1200 t/km^2/year; 50% will be lost by end of 2010	Musa *et al.* (2006)
Borkena and Adrako	Silted up before the construction ended.	Haregeweny *et al.* (2006)
Legedadi	26,000m^3/year	Gessese (2008)
Gilgel Gibe III	1/3 reserved for sediment	Hathway (2008)
Tekeze	30 Mm^3/year is expected, not threatening	http:/www.eepco.gov.et/files
More than 50 micro-dams in Tigray	50% of the studied reservoirs will lose their economic life before half of the design period.	Haregeweny *et al.* (2006)
Filiglig	Economic life time reduced 5 times	Aynekulu *et al.* (2006)
Grashito	Economic life time reduced 5 times	Aynekulu *et al.* (2006)

Extending the useful life of water reservoirs supports the economy of the surrounding communities as their economic source. Hence, the pressure exerted on forest resources should be redistributed to other livelihood sources, through the provision of diversified income generating activities, thus protecting and reviving the watershed ecosystem. The researcher argues that various records elicit that, among the approaches and techniques proposed and put in place for the implementation of a watershed ecosystem, integrated participatory watershed management is a clever mechanism opted for to reduce sedimentation influx on a sustainable basis and in an affordable way. OV1 (2010: 2) states that, "IWRM places much more emphasis on social equity, ecological sustainability and economic efficiency than has been the case in the past".

2.3.10 **Global Warming and Greenhouse Gases**

2.3.10.1 **Introduction**

This section will look into some of the global climate change events and its impacts with particular emphasis on the developing countries. For brief understanding of what the global climate, system is like and its functions in general and Ethiopia in particular will be reflected upon.

Given the topic of this study, it was felt necessary to shed more light on human induced land use / land cover changes (LULCC) which resulted in the deforestation / degradation of Belbela-Wadecha watershed natural resources. The researcher believes that this phenomenon has contributed to the global warming functions. Therefore, some global warming related events will be discussed briefly below.

According to Ellis (2016), globally, LULCC are important drivers of global warming because of releasing greenhouse gases to the atmosphere. Ellis (2016: 1) states, "Biodiversity is often reduced dramatically by LULCC. When land is transformed from a primary forest to a farm, the loss of forest species within deforested areas is immediate and complete". Ellis (2016) further mentioned that changes in the LULC are important drivers of water, soil and air pollution. Land use / land cover (LULC) changes due to human / natural disturbance have resulted in deforestation / degradation, biodiversity loss, the increase of natural disaster-flooding, and global warming, (Dwivedi et al., 2005; Mas et al., 2004; Zaho et al, 2004).

Global Warming is an increase in the temperature of earth due to greenhouse effect. Greenhouse Effect, according to Santra (2016: 1503), is:

> *a natural effect that traps heat in the atmosphere (troposphere) near the earth's surface. Some of the heat flowing back toward space from the earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the lower atmosphere (troposphere) and then radiated back toward the earth's surface. If the atmospheric concentrations of these greenhouse gases rise and are not removed by other natural processes, the average temperature of the lower atmosphere will gradually increase.*

Greenhouse gas is:

> *any of the atmospheric gases that cause climate change by trapping heat from the sun in the earth's atmosphere - producing the greenhouse effect. The most common greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Ozone (O_3), and water vapor (H_2O), (World Bank, 2010).*

Global warming and anthropogenic and climate changing is now widely recognized as a reality, and responding to climate change is widely acknowledged as one of the greatest challenges facing society (UNFCCC, 1992; World Bank, 2012a; IPCC, 2001).

High rate of human population growth and rapid industrialization has resulted in fast greenhouse gas (GHG) emissions that adversely affect the environment, thereby threatening the Earth's life support system consisting of flora and fauna, water, air and soil. The resulting climate change over the years has attracted a wide attention of the scientific community and now is considered an imminent global threat. Conservation of the natural resources, including forests and water, is a primary concern to humanity. Enacting developmental policies is necessary to provide scientific and sustainable development approaches in the area of natural resources, agriculture, pollution, law and education.

To help deal with this climate change phenomenon, the international community established the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) Sahoo (2011). The protocol outlined emission-reduction targets for the developed countries (so called annex-1 countries) and devised policy mechanisms to help them meet the targets set through carbon sequestration in various sectors. The protocol also allows industrialized countries to invest in forestry in developing countries to offset their carbon emissions. The clean development mechanism (CDM) is one such mechanism of Kyoto Protocol that allows different kinds of emission reduction projects where afforestation and reforestation (A/R) projects are important to note in the forest sector.

According to Santra (2016), one-third of the shortwave radiation (including the visible part of the spectrum) received by the earth from the sun is reflected, while the rest is absorbed by the atmosphere, land, ocean, ice and biota. The outgoing radiation from the earth and atmosphere balances the energy absorbed from solar radiation. Shortwave radiation can easily pass through the atmosphere, whereas that emitted by the warm surface of the earth as long wave terrestrial radiation is partially absorbed by a number of trace gases in the atmosphere known as greenhouse gases (GHGs). The greenhouse effect, Figure 2-6, is one of the most important factors in global climate change and is one which humankind has the capacity to alter. The greenhouse effect comes into the view because of the atmosphere being largely transparent to the incoming solar radiation while being quite heavily absorbing to outgoing thermal radiation from the planetary surface and the atmosphere.

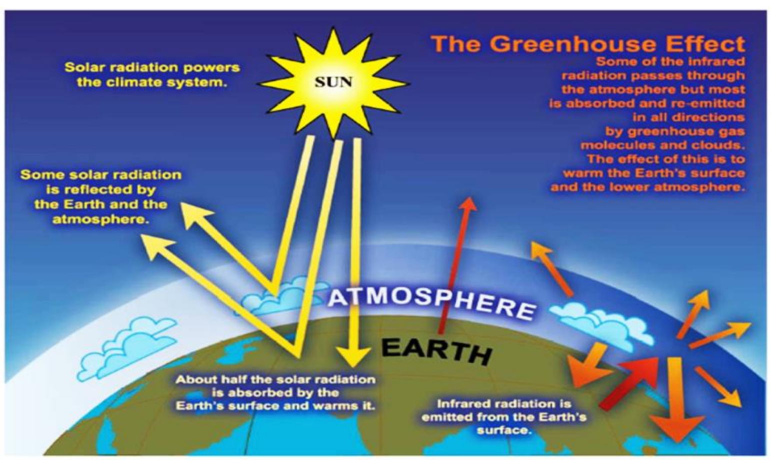
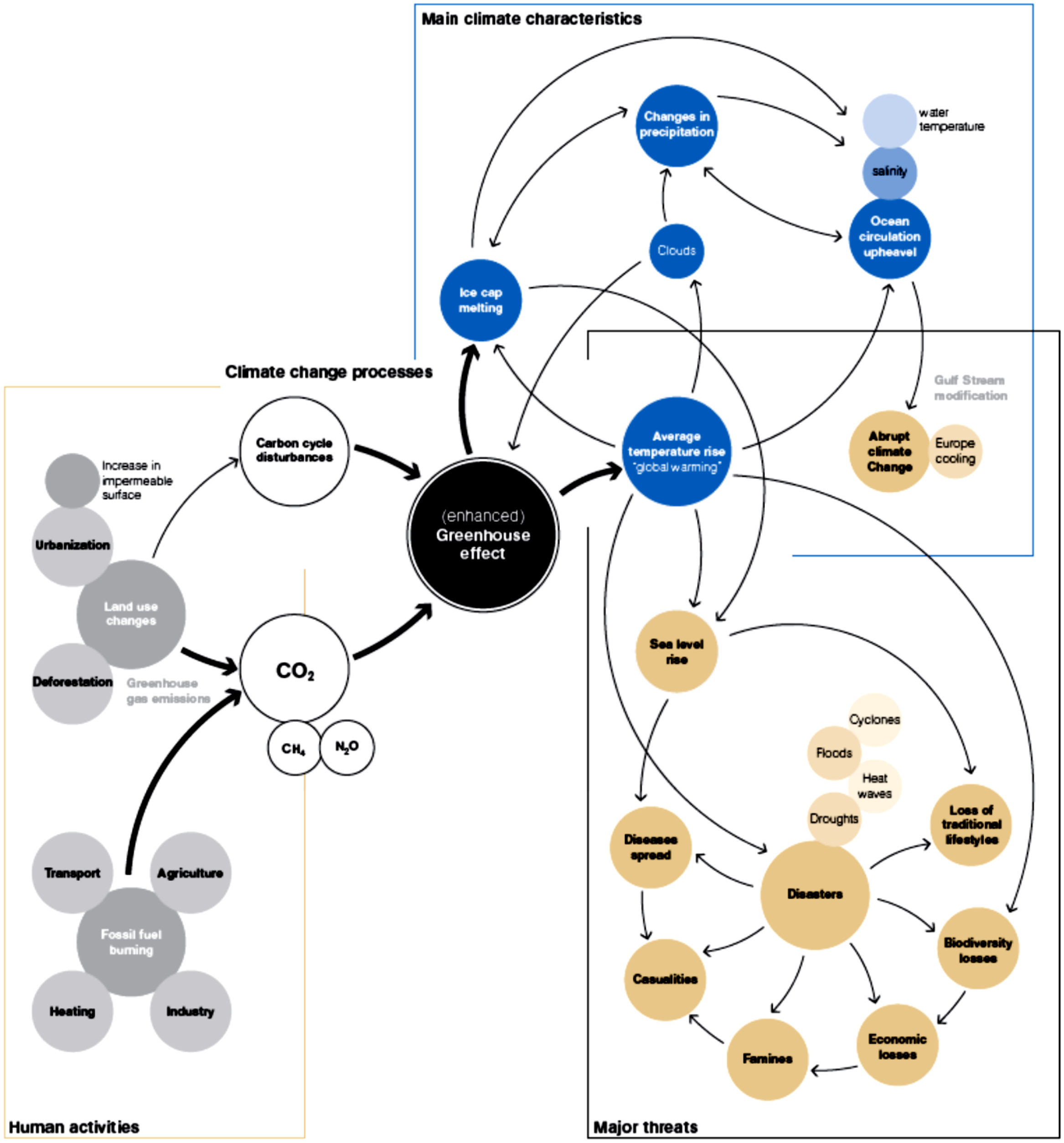


Figure 2-6: The Greenhouse Effect

Source: Yadav Prasad Joshi (2015)

The most common GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and water vapor (H_2O). Figure 2-7 illustrates the process, characteristics, and threats these gases play in effecting climate change phenomenon.



Source: UNEP/GRID-Arendal, 'Climate change: processes, characteristics and threats', designed by Philippe Rekacewicz, UNEP/GRID-Arendal Maps and Graphics Library, 2005, <http://maps.grida.no/go/graphic/climate_change_processes_characteristics_and_threats> (Last accessed 10 October 2007)

Figure 2-7: Climate Change: Processes, Characteristics and Threats

2.3.10.2 Global Climate System

Climate, according to Santra (2016: 1494), is defined as "General pattern of atmospheric or weather conditions, seasonal variations, and weather extremes in a region over a long period – at least 30 years; average weather of an area", and weather, according to FMoH (2018: iv), is "The fluctuation of temperature, humidity and wind within short period of time".

IPCC (2007:96) illustrates the complexity of the global climate system and the greenhouse gas effects as in Figure 2-8.

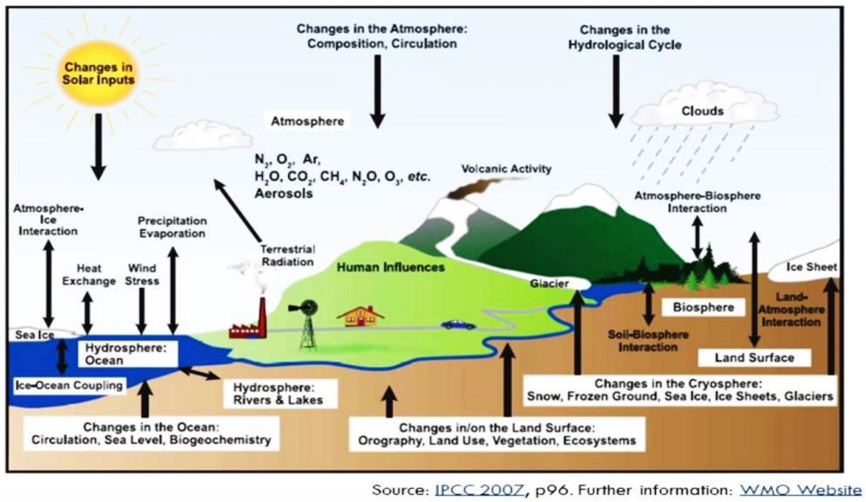


Figure 2-8: Complexity of the Global Climate System

2.3.10.3 **Possible Impacts of Global Warming**

Generally, global warming resulting from greenhouse gases effects has a number of effects on earth climate, ecosystems, and biospheric processes. The major consequences include sea level rise, crop yield change, uncertainty on water resources, and human health (spread of tropical diseases). The major driving factors of climate change of 21st century will be enhancement of GHGs in the global climate system.

2.3.10.4 **El-Nino and La-Nina**

According to Abhijit (2015), El-Nino is termed as an internal fluctuation in the ocean atmospheric system that disrupts normal weather around the Pacific Ocean, resulting in heavy flood and rain in countries like Peru and droughts in Australia. Usually, wind blows westwards and nutrient rich bottom water moves on to the surface. The water portion near the surface is warmer than that at the bottom causing sufficient temperature difference between surface water and bottom water. This local phenomenon of warming ocean water near South America is called El-Nino (Abhijit, 2015).

This warm water is then streaming to the western pacific region bringing about intense storm that hits Australia and part of Western Asia causing droughts in North America and floods in Bangladesh and Sudan, this phenomenon known as La-Nina. Figure 2-9 depicts natural climate fluctuations, example of El Nino and La Nina.

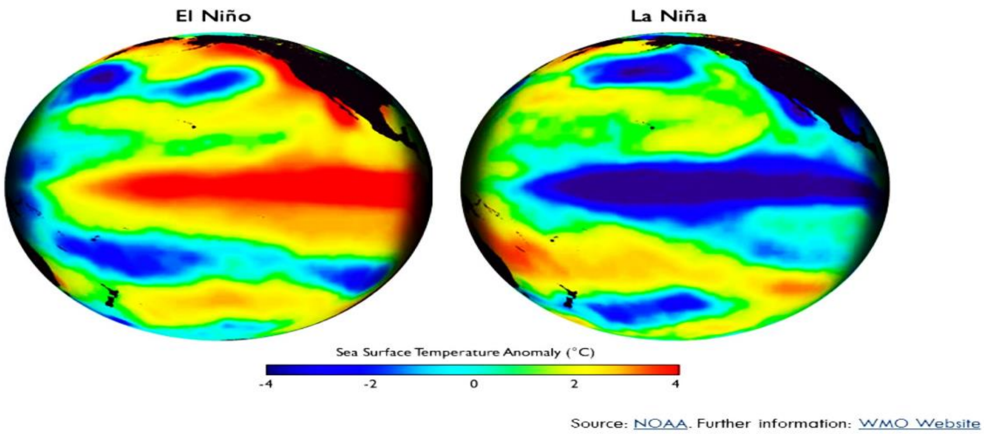


Figure 2-9: Natural Climate Fluctuations, Example of El Nino and La-nina

2.3.10.5 **Ozone**

Ellis (2016), state that environmental impacts of LULCC also cause the destruction of stratospheric ozone through release of nitrous oxide from agricultural land and altered regional and local hydrology. "Ozone is colorless, highly reactive gas with distinctive odor" Abhijit (2015: 78). Ozone layer is defined as "Layer of gaseous ozone (O_3) in the stratosphere that protects life on the earth by filtering out harmful ultraviolet radiation from the sun" (Santra, 2016: 1510).

Although, ozone is available in both troposphere and stratosphere, most of the ozone is concentrated in stratosphere (Abhijit, 2015). The ozone layer in stratosphere is known for its essential use for survival of life on earth. However, pollutants, common ozone depleting substances, available in the troposphere, move into stratosphere and destroy the ozone layer through different photochemical reactions. These reactions are human induced origins as depicted in Table 2-8:.

Effects of ozone depletion include, in general terms, effects on eyes, skins, human immunity, DNA damage and lung diseases, effects of hydrogen peroxide on human health, and effects of food shortage on human population (Fakhra et al., 2016).

A number of agreement protocols on ozone layer protection are in operation before and after Montreal Protocol involving many countries at various venues in the world.

Table 2-8: Common Ozone-Depleting Substance and Some Alternatives

Substance	Uses	Ozone-Depleting Potential*	Global Warming Potential**
Chlorofluorocarbons (CFCs)	Refrigerants, cleaning solvents, aerosol propellants, and blowing agents for plastic foam manufacture.	0.6 – 1.0	4,680 – 10,720
Halons	Fire extinguishers/fire suppression systems, explosion protection.	3 – 10	1,620 – 7,030
Carbon tetrachloride (CCl_4)	Production of CFCs (feedstock), solvent/diluents, fire extinguishers.	1.1	1,380
Methyl chloroform ($CHCl_3$)	Industrial solvent for cleaning, inks, correction fluid.	0.1	144
Methyl bromide (CH_3Br)	Fumigant used to control soil-borne pests and diseases in crops prior to planting and in commodities such as stored grains. Fumigants are substances that give off fumes; they are often used as disinfectants or to kill pests.	0.6	5
Hydrochlorofluorocarbons (HCFCs)	Transitional CFC replacements used as refrigerants, solvents, blowing agents for plastic foam manufacture, and fire extinguishers. HCFCs deplete stratospheric ozone, but to a much lesser extent than CFCs; however, they are greenhouse gases.	0.01 – 0.5	76 – 2,270
Hydrofluorocarbons (HFCs)	CFC replacements used as refrigerants, aerosol propellants, solvents, and fire extinguishers. HFCs do not deplete stratospheric ozone, but they are greenhouse gases.	0	122 – 14,130

‡ This is a limited list and does not represent all of the alternatives approved by EPA's Significant New Alternatives Policy (SNAP) program. For a complete list, see: www.epa.gov/ozone/snap/lists/index.html.

* Ozone-depleting potential (ODP) is the ratio of the impact on ozone caused by a chemical compared to the impact of a similar mass of CFC-11. The ODP of CFC-11 is 1.0.

** Global warming potential (GWP) is the ratio of the warming caused by a substance compared to the warming caused by a similar mass of carbon dioxide. The GWP of carbon dioxide is 1.0.

Although the international community has recorded encouraging results, healing the ozone layer is found still to be an un-done homework. It requires a concerted worldwide effort where the focuses would include the complete phase out of ozone depleting substances. The public has to be educated continuously, especially the children, on how to protect themselves from excess exposure to UV radiation; continuing to foster domestic and international partnerships to protect ozone layer; and encourage the development of products, technologies that are energy efficient (United States Environment Protection Authority (US EPA) (US EPA 2007).

2.4 The Effects of Watershed Degradation

2.4.1 Climate Change Effects

Climate change is a change perceived / observed in climate characteristics, including temperature, humidity, rainfall, wind and severe weather events over long term time periods. The average global surface temperature has increased by 0.6^{o}C during the last 100 years because of human activities including deforestation and burning of fossil fuels (Sahoo, 2012). It is stated that the effects of climate change are manifested in various ways; increase in precipitation is one that results in the global mean sea level rise. This phenomenon will further result in geographic shifts that of the occurrence of different species and or the extinction of species. Changes in rainfall patterns will affect water resources, which, will in turn, hamper both irrigation and drinking water supply.

Incident of heat waves and flooding will be more frequent. This affects human suffering including loss of river deltas which was once under cultivated agriculture, and estuaries that are important wildlife habitat will be flooded and that will further be resulting in salinization making the area unsuitable for productive uses. According to WHO (2015), the impact of climate change is becoming more serious that it could overwhelm the capacity of most countries, especially the developing nations, to cope with. The WHO (2015) further stated that coordinated and networked action across sectors, countries must occur, and that shall be directed to the most vulnerable section of the society.

Furthermore, the Intergovernmental Panel on Climate Change (IPCC, 2001: 700) states in its Third Assessment Report “that the globally averaged surface temperature is projected to increase by 1.4^{o}C to 5.8^{o}C from 1990 - 2100 under business-as-usual, and sea levels by 9cm to 88cm over the same period". The Assessment Report further states that if nothing is done to this phenomenon to prevent or limit, there will be major consequences on the ecosystem.

Ellis (2016) argues that LULCC's role is significant in climate change, globally, regionally, and locally. Ellis (2016) further states that, globally, LULCC is responsible for releasing greenhouse gases to the atmosphere, driving global warming. According to Santra (2016), the major driving factors of climate changes are natural and human. Some of the natural factors include changes in topography, earth's orbit, solar luminosity, earth's volcanic activity, composition of the earth's atmosphere and changes in internal variability of atmosphere-ocean system.

On the other hand, from societal point of view, the six most important bio-geophysical (or natural system) effects according to Klevin and Nicholls (1999) are: increasing flood frequency probabilities; erosion; inundation; rising water tables; saltwater intrusion; and biological effects. However, as the study of the natural cause of climate change is beyond the scope of this work it is not pursued any further.

Today, human-induced greenhouse gases are contributing to major climate change, Table 2-9, and the risks as a result are widely acknowledged by the world community to be a reality and that global security is under threat resulting from global warming. Global warming relates to the overall warming of the climate, based on the average temperature over the entire surface of the earth. The impacts of rising global temperature are manifested in, changing precipitation patterns, flooding, droughts, rising sea levels, pandemic disease, disputes over refugees and resources, destruction of natural resources, hunger, poverty and conflict, among others.

Agricultural production and food security can be compromised severely by climate change in many African countries, as their source of livelihoods is largely dependent on the areas that are susceptible to climate shocks such as agricultural field of productions. According to the International Panel on Climate Change (IPCC)'s Forth Assessment Report (AR4), developing countries will bear the brunt of climate change (IPCC, 2007). IPCC (2007) further indicates that, in some countries, yields from rain fed agriculture could fall by up to 50 percent by 2020.

The poor rural people are "in the front line of climate impacts; the ecosystems and biodiversity on which they rely are increasingly degraded; their access to suitable agricultural land is declining in both quantity and quality; their forest resources are increasingly restricted and degraded; they produce on typically marginal rain fed land, with increased water scarcity; energy and agriculture input prices are on a rising long-term trend; and declining fish and marine resources threaten essential sources of income and nutrition" (IFAD, 2011: III). According to IFAD's Governing Council Discussion Paper (2009), the agricultural producing smallholder farmers of the developing countries are facing unprecedented challenges in the 21st century. It is estimated that agriculture will feed 9.2 billion people of the globe, of who 8 billion will be in developing nations (IFAD, 2009). This attracts focus towards addressing demand for food and other agricultural products.

According to the researcher's observation, fostering a climate resilient economy is not just important but a bottom line task appealing for practical intervention focusing on two approaches. One is a short-term scenario on the climate-change- adaptation mechanisms, including the implementation of sustainable and parallel operations of environmental management and irrigation functions. The second is to engage seriously in thematic research activities on delivering pro-poor climate-change-investment options. The criticality of full participation of beneficiaries in all stages of the process of community project making cannot be overemphasized.

Table 2-9: Major Greenhouse Gases Contributing to Climate

Source: Reproduced from IPSS 2007, UNEP 2012, and FERN

Greenhouse Gas	Human Source (Examples)	% of Total Global GHG Emissions (2020)
Carbon dioxide (CO_2)	Fossil fuel combustion, land use changes, cement production, …	76%
Methane (CH_4)	Fossil fuel mining / distribution, livestock, rice agriculture, landfills, …	16%
Nitrous oxide (N_2O)	Agriculture (fertilizers), and associated land use changes, …	6%
Hydrfluorocarbons (e.g. HFCs)	Liquid coolants, …	< 2%
Perfluorocarbons (e.g. PFCs)	Refrigerant, electronics industry and aluminium industry, …	< 2%
Sulphur hexafluoride (SF_6)	Insulator in electronics and magnesium industry, …	< 2%
Nitrogen trifluoride (NF_3)	Electronics and photovoltaic industries, …	< 2%

As the earth continues to warm, perceptibly these challenges are likely to escalate unless scientific community, the public, NGOs, government and political arena, more strongly, devises against collaborative measures. Efforts in this regard are underway in multiple fronts. Focus has been placed on adaptation and mitigation mechanisms supported with formulating measures including policy provisions, programs, and identifying projects following many international conventions, conferences, workshops that deliberated on spectrum of climate related issues.

This being quite a step forward, the question of practical response between developed and developing nations sadly remains varied. It is sad because developing countries, seek practical response, bear the brunt of the climate change impacts when their contribution to global warming phenomenon is quite small, as compared with those industrialized countries, who are not keeping their promises anyway. For example, in 1994, the GHG emissions per capita for Ethiopia totaled 0.9 tone CO_2 equivalent when U.S emissions totaled 23.7 tones CO_2 equivalents the same year (Keller, 2009). In addition, Crippa M. et al. (2020) states that in 2019 the GHG emissions per capita for Ethiopia totaled 0.17 tone CO_2 equivalent when U.S emissions totaled 15.52 tones CO_2 equivalent the same year. So what is next?

Do the international agreements bind upon the developed countries when defaulting, before the court of rulings, or does the international rule of law only apply preferentially? However, leaving this question unanswered (you wouldn't force them anyway), we, the developing countries, need to adapt to this changing environment with a view to reducing or avoiding any adverse consequences and seize any positive gains. The developed nations on the other hand would invest in irrigation facilities, funding support, technology transfer, training opportunities, and awareness making campaign; and support the developing societies to deliver carbon sequestration in a meaningful way to stand practically against the ravaging climatic shocks, if they obey the dictates of their conscience.

In this regard, as one of the support mechanisms, restoration and wise management of watershed ecosystems are necessary, including through afforestation and agroforestry implementation approaches, contribution to the climate balance, maintaining soil productivity level, and sustaining biodiversity and ecosystem services. According to UNFCC (2008), significant carbon sequestration takes place through grasslands and agroforestry plantations which effects carbon reduction from the agriculture sector at non-prohibitive costs.

2.4.2 **Effects of Land Use and Land Cover Changes - General**

Changes in land use and land cover can be characterized by either degradation or regeneration depending on the pattern of agricultural and / or environmental operations that we adopt or adapt for socio-economic and environmental purposes. LULCC therefore mainly relates to how we utilize and manage soils and biodiversity resources. Excessive and unwise use of the watershed natural resources, including the natural vegetation, can lead to environmental damage, whereby most of such resources are severely threatened, putting the resources on the verge of extinction.

The degradation of natural resources further impacts on socio-economic level of the community in a way that the livelihoods of the watershed residents are adversely affected as a result of losing their socio-economic resource base and environmental wellness.

Therefore, it is perceived that loss of soil fertility and depletion of biodiversity can lead to irreversible deterioration of natural resources, as observed in empirical studies done by Mulugeta (2004); and Woldeamlak and Stroonsijder (2003).

2.4.3 Impacts of LULC Changes on the Rural Livelihoods

Livelihood is defined as "the assets (natural, physical, human, financial & social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household", (Ellis, 2000: 1-273 cited in Belay 2018). The Livelihood Resources (Capital) can be divided into the following, (Belay, 2018: 10).

- Human capital − skills, knowledge, ability to work and good health;
- Social capital – networks and connectedness, trust, collaboration, attitudes, values and norms.
- Financial capital – savings, access to credit and loans, labor income, pensions, remittances, livestock, etc.
- Physical capital – infrastructure, tools and
- Natural capital – natural resources and their goods and services, for example land, water, forests, and air quality

Through wise coordination of these assets and corresponding activities dedicated to sustainable development can contribute to enhancing the livelihoods of rural communities.

On the contrary, unwise management and utilization of resources can be detrimental to both the biosphere and geosphere (particularly the soil). The consequences can be witnessed from, inter alia, vulnerability to climate vagaries, including lack or shortage of biomass energy supply (unmet demands), failure to access quality water, use of marginal lands. It also relates to deprivation of livestock rearing amenities related to land degradation and lack of grazing plots owing to the expansion of agricultural operations resulting from population increase and subsequent occupation of new areas, grasslands and fragile / marginal lands.

ILRI (2000), states human population is increasing at about three per cent per annum. In addition, Nani (2020) argues that the population will grow at a rate of 3.02% per annum. Accordingly, one would argue that the capacity of ecosystems to deliver goods and services to human society can be adversely affected as a result of the increase in unwise practices of human activities on land uses, resulting in land cover changes.

2.4.4 Impacts of Forest Management on Water Resources

Assessing the conditions of the watershed characteristics including size, slope, soils, land use and local climate, especially the temporal distribution of annual precipitation and temperatures, are of great importance in judging the impact of forest on water resources.

Forest clearing reduces water yield and may have detrimental effects on local and national hydrologic cycles. Deforestation and soil degradation create water quality problems unless addressed through reforestation processes in the affected areas thereby improving water quality, but reduced yield may happen unless rainfall occurs for recharge purposes. This causes conflicts between forests and water uses.

In certain areas where land cover (natural grassland, shrub lands, and trees) or land previously cleared for agriculture is replaced with fast growing exotic plantations, stream flows and groundwater recharge are often substantially reduced, creating local conflicts between plantations and other water users.

2.4.5 Poverty and Natural Resources Linkages in the Watershed Area

The link between environment and poverty is strong. It is futile to attempt to deal with environmental problems without tackling the factors underlying world poverty (World Commission on Environment and Development, 1987). Poverty is a major cause and effect of global environment problems.

In addition, according to Dellink and Ruijs (2008), those concerned with the environment need to recognize the effects of poverty on land use and evidence shows that more areas of rapid clearance were there in poorer communities than areas in richer communities as illustrated in Figure 2-10.

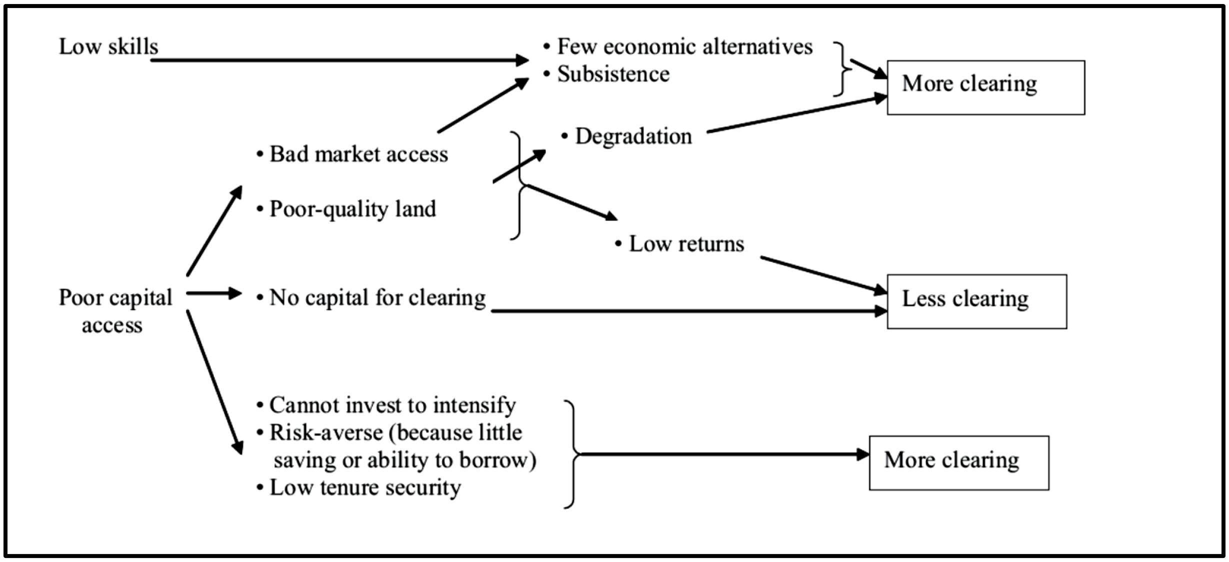


Figure 2-10: Poverty and Deforestation

Source: Dellink and Ruijs, 2008

Accordingly, Rudel and Roper (1997), poor households may clear a given unit of land due to lower skills and lower off-farm economic opportunities; a need to insure given commodity and other shocks; and less preference on the margin for some environmental services. In addition, Rob and Arjan (2008) argue that poor households may not have the financial capacity to invest in the prevention of soil degradation and lower harvests. Thus, they may clear more land to maintain their level of output or also for seeking greater capital benefits.

Deforestation and forest degradation have direct consequences on the local population in terms of reduced fuel supply, shortage of fodder and leaf-litter manure (Jean-Marie B., undated). Spending more time (eight hours per day on the average) on collecting fuel wood, water, grass and leaf fodder affects agricultural operations and other farming activities. As children are involved in collecting firewood, lower levels of schooling are experienced as a result of forest degradation and also child health is affected (Kumar & Hotchkiss, 1988; and Das-Gupta, 1995, cited in Jean-Marie, undated).

Incidence of disease may increase and affect family members resulting from reduced heating in cold weather (Amacher et al., 2001). Evidence reveals that deforestation aggravates the ravaging effects of regular earthquakes resulting in a more landslides and floods, which further affect downstream siltation (Jean-Marie, undated). In addition, deforestation, on a global scale, hastens the depletion of ozone layer that induces greater climate change. It is argued that poor households rely on forest for obtaining goods and services, including fodder and fuel needs. It is argued also that higher income households switch away from traditional fuels to higher quality (more expensive) substitutes such as kerosene and gas (Arnold et al., 2003).

On the other hand, some researchers argue that environmental problems will be worsened by reducing poverty, a contrasting view to poverty-environment hypothesis and energy-ladder theories (Jean- Marie, undated). However, the researcher concludes that provisioning of substitutability through alternative energy sources is of crucial policy importance, with a view toward reducing firewood collection significantly to counter its negative environmental impacts.

Modernization of agriculture and sustainable irrigation development through using various technological in puts would help enhance and diversify incomes, which may assist in reducing deforestation. Irrigation increases the agricultural productivity of a unit of land thus reduces the ever-increasing pressure on land (SMIS, 2016).

In Belbela-Wadecha watershed area, most of the forest resources are cut down, sold on the markets by the communities to satisfy their basic needs, and are used as an economic source to earn a living. In this regard, implementing sound ecosystem management and sustainable irrigation agriculture development in the area would be a viable option to help the poor watershed community enjoy more socio-economic benefits from irrigation agriculture and watershed natural resources.

2.4.6 **Land – Use Transitions**

Aziz (2001, cited in Seeme and Ghan, 2005) argues that poverty in developing countries is the major factor that distorts population transition. Population transition, according to Lambin and Geist (2006: 68), is defined as “a process of societal change in which the structural character of society (or a complex subsystem of society) transforms". Rural-urban flux was induced, beginning in the 19th century, by the creation of industrial jobs and amenities in the urban sector.

The abandoned rural marginal agricultural areas, because of migration to the cities, reverted to forests and as the abandoned area grew further, a transition in forest cover took place, characterizing reforestation in the industrialized nations (Mather, 2006b).

Considering just two aspects of natural land-cover types, forest and grassland, and two aspects of land-use types, cropland and pasture, a considerable amount of land change processes are possible (Figure 2-11). Among these, four aspects give a minimum of twelve possible transitions, as stated below, (only some shown for simplicity) that could take place (Lambin et al., 2006):

- Urbanization (or the increase of built-up areas),
- Conversion of forest to cropland (classic expansion, but virtually always intensification),
- Conversion of grassland to cropland (classic expansion, but virtually always intensification),
- Change of crop on existing cropland (will always entail change in intensity),
- More intensive use of croplands (decreased fallow – up to and beyond double cropping - , change of cultivar, terracing, irrigation, use of chemical and mechanical technology),
- Incorporation of trees into cropland (usually considered intensification, when it is an economic species such as coffee, tea, cocoa, or vanilla),
- Conversion of cropland to forest (considered disintensification, if abandonment; or intensification if for economic gain),
- Conversion of forest to pasture (often cropland as an intermediate step),
- Conversion of cropland to pasture (may appear less intensive, but yield higher rewards),
- More intensive use of pasture (usually through increased inputs),
- Incorporation of livestock into cropland, and, finally,
- Conversion of pasture to cropland.

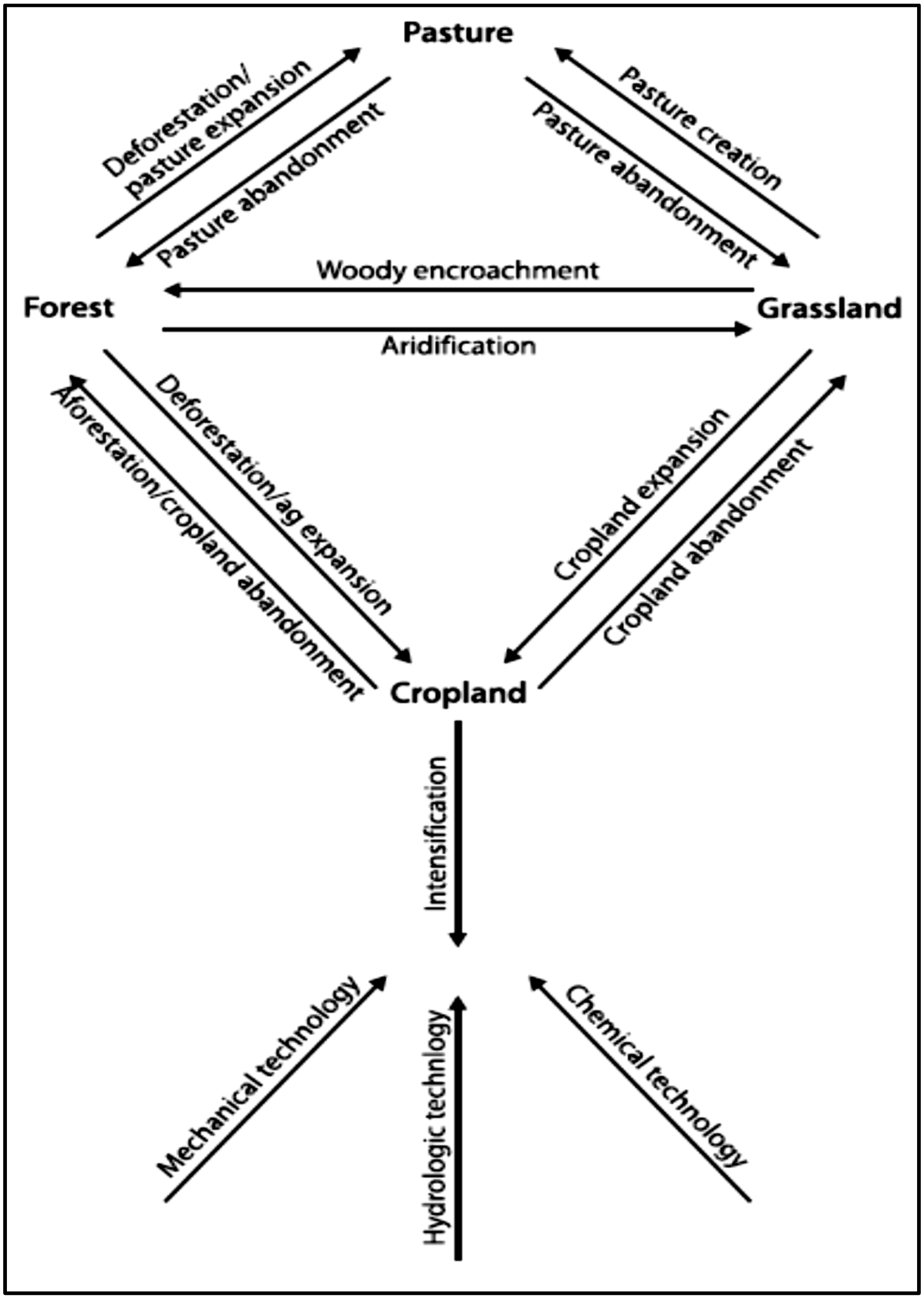


Figure 2-11: Potential Transition Between two Land-Use/Cover States (pasture/cropland, forest/grassland)

Source: Lambin et al., 2006

One can conclude that the transition between the two Land Use/ Cover states (pasture/cropland, forest/grassland) is due to population increase and subsequent search for food response because of poverty.

Land degradation in developing countries like Ethiopia is one of the greatest environmental challenges. Available literature (Markos, 1997; Abiy, 2002, cited in Abdissa, 2010) reveals that the effect is so acute that millions of people have fallen into poverty. Accordingly, rapid population growth in Oromia Regional State is a major threat affecting land cover (BOLEP, 2008, cited in Abdissa, 2010). Ways through which soils are degraded include physical, chemical, and biological processes (Wirtu, 2014). This study refers to degradation of soils related to human causes that include overgrazing, deforestation, bad farming, fire management, and construction for residential purposes for both urban and rural.

Therefore, according to the researcher's view, as a result of loss of vegetation / forest cover in the study area due to human causes, soil is lost through erosion action that remove topsoil which would otherwise have been used for plant / crop growth. People clear vegetation, burn forests, overgrazes lands, practice bad farming activities and others activities that cause deforestation, which goes faster than the forest, can recover.

According to Wirtu (2004), 66% of soil erosion is attributed to deforestation. Therefore, human cause represents the lion's share in contributing to environmental watershed degradation that further affects downstream development endeavors through reduction of the volume of irrigation water storage due to sedimentation that would be transported from uphill and makes less water available in the reservoir for irrigation. Thus, unproductivity effect comes into play as a result, which in turn affects the living patterns of the affected communities.

In this regard, the researcher argues, infiltration of running water in the Belbela-Wadecha watershed system is hampered due to lack of physical or biological obstructions (vegetation) that would retard the overland flow to increase infiltration capacity. This process would benefit recharging groundwater storage, which would otherwise subsequently result in flows as springs from foothills that would join other streams, flow to the reservoirs, and be stored in dams for subsequent developmental purposes.

Therefore, maintenance of vegetation / forest and soil cover in a watershed area is symbolic of sound management of watershed ecosystem and guarantees sustainable supply of irrigation water for crops, thus securing food and economic benefits to watershed communities. Hence, this study looks at ways in which environmental and socio-economic harmony of the watershed can be achieved for the benefit of all.

2.4.7 Effects of Agriculture and Overgrazing on Watershed Ecosystems

Unless a sustainable and eco-friendly approach is employed in food production processes, production of food will have adverse effects on soil, water and air such that environmental degradation, including loss of genetic diversity, deforestation, soil infertility, water logging, and overgrazing take place. Dhankhar (2018: 26) states that:

> *Africa in 1970 was self-sufficient in food but since 1985 due to population growth, flat topography, dry climate, less rainfall, overgrazing, deforestation, soil erosion, desertification, shortage of fuel wood has caused millions of premature deaths each year.*

In addition, Dhankhar (2018) states the effects of agriculture and overgrazing as:

- **Agriculture**

- Soil Erosion: Deforestation exposes soil to wind storms and rain resulting in loss of the top fertile layer.
- Deforestation: Loss of forest cover takes place because of burning trees in forests following shifting cultivation.
- Loss of nutrient: Burning forests destroy the organic matter of the soil and the crops making the soil nutrient poor take up most of the nutrient.
- Loss of genetic diversity: Deforestation causes loss of genetic diversity since forests are the home of many wild animals.
- Endangered wildlife from loss of habitat: Loss of forest area endangers wildlife due to commercial hunting and poaching of animals.

- **Overgrazing**

- Soil Erosion: Overgrazing exposes top soil and induces erosion by wind and rainfall.
- Loss of species: Loss of useful species of plants takes place due to overgrazing.

- Loss of regeneration capacity: Regeneration capacity of the plants is lost due to overgrazing that species are not as regenerated in the ecosystem, that secondary species, in nature, are less nutritive as compared to the primary species.
- Land Degradation: Overgrazing leads to various actions resulting in loss of soil structure, hydraulic conductivity and soil fertility. Infiltration capacity of the soil is lost due to trampling by cattle which reduces percolation of water into the soil

2.5 Response to Watershed Degradation

2.5.1 Instruments and Institutional Matters

Institutions are defined as written and unwritten rules or principles that govern and constrain behavior, thus help assess what others will do and giving individual's orientation and security in their social dealings (Fuest et al., 2005).

Institutional issues (legal, political, economic) and their interaction with individual decision-making process are important in defining land use changes. Appropriate land use policies support the realization of restoration of land use activities through decision-making, protecting, and sustaining the decisions made in a way that the restoration processes come to the fore.

Formulations of appropriate policies that respond to institutions' basic needs such as economic outcomes, political, and social organization of society, are the bottom-line task to have a (workable) sustainable institution in place. According to Daron et al. (2008: 3), Institutions can be an advantage and a curse. "It is a curse because unless we can follow it up with a better understanding of the role of specific institutions, we have learned only little".

The researcher argues that, to be able to design a good intervention mechanism to make poor societies prosperous we need to understand the determinants of political equilibriums. To do this, capacity building of the community should be given due focus so that the community would be able to make informed decisions in undertaking the necessary intervention measures related to project making endeavors.

UNEP (2002:11) defines capacity building as: "It is a holistic enterprise, encompassing a multitude of activities. It means building abilities, relationships and values that will enable organizations, groups and individuals to improve their performance and achieve their development objectives". It further states capacity building, as a means, is central to the quest for sustainable development, a goal where three inextricably linked pillars are focused on, namely: social progress, economic growth, and environmental protection. In addition, chapter 37 of Agenda 21 notes the nature and importance of capacity building.

Pasquale et al. (2008) argue that significant divergences lie between institutional approaches and the capability approach. The contrast relates to the role assigned to certain institutions that influence human capabilities but not necessarily economic performance and the role entrusted to people's agency where in both cases the values assigned to substantial freedoms do not have any necessary economic justification. In addition, Adam et al. (2012) state that, in order to contextualize and address vulnerability, it is desirable to better understand and better respond to both village preconditions and limits of state and market capacity to provide public goods and ensure security.

Koppen et al. (2007) state that community-based water laws have tended to be overlooked in water resources management reform in developing countries. However, they also highlighted that the collaboration of both disadvantaged groups (poor women and men) and the public sector can strengthen community-based water laws. If community-based water laws are put into action they can also show a surprising ability to endure and adapt, which are both attributes of any successful institution and which can also be the basis for additional change and improvement.

The United Nations sustainable development goals (SDGs), with particular emphasis on Goal number 9, are charged with a task of taking up the emerging post-2015 development agenda towards achieving sustainable development through balancing environment, social and economic aspects. SDGs integrate those three dimensions of sustainable development into a universal arena for global cooperation and action. SDG-9 highlights and affirms the critical importance of Inclusive and Sustainable Industrial Development and its contribution to all 17 proposed goals. Ethiopia's growth policy document, Agricultural Development Led Industrialization ADLI (1993), emphasizes the need to enhance agricultural production and productivity to support raw material supply to industry. Hence balancing environment, social and economic functions are important in contributing towards laying foundation for industrialization.

Therefore, integrating environment management and economic development, including irrigation agriculture development, is an approach that acknowledges the SDGs plan of action. Hence, it is believed to be a way forward that the Government of Ethiopia undertakes agricultural development programs / projects on a nationwide scale, such as taking forward the scaling up of successful projects. Such projects as Belbela-Wadecha watershed ecosystem can be one of the possible areas to engage for it integrates environment and economic projects focusing on livelihood enhancement areas, thus addressing socio-economic matters and supporting environmental protection activities. Policy support is important at national and local levels in that it needs to contextualize and address issues pertaining to local economic institutions in a way that social and environmental particulars are addressed wisely and legitimately. In addition, the bylaws need to focus on, among other things, resuscitation of environmental practices related to customary and traditional laws supported by state government (IIMI, 1990).

2.5.2 Participation and Local Level Institutions

For watershed ecosystem sustainability and continuity of the project, beneficiary level rural watershed institutions / organizations are crucial. Lakew D. et al. (2005) guidelines state that there are no established rules and models for local institutions, thus several ones may be formed based on a variety of interests common to all involved beneficiary communities. However, there is need to make sure that the organization functions well in terms of adequately representing the interests of the members and sufficiently speaking / addressing issues on behalf of the group. These institutions can be formed through building upon traditional work parties, including Wonfel[1] and Debo[1] and traditional structures such as Idir[2], Ikub[3] and others. It is believed also that local institutions can play a significant role in terms of responding to climate change through implementing forestry projects. Chambers (1996) asserts that in development projects the realities, needs and priorities that should count most is that of local people. He further stated "Especially, the disadvantaged – women, the poor, the marginalized, those who are physically and socially weak and deprived" Chambers (1996:13).

[1]*Wonfel and Debo are the same in meaning, but called differently by different localities. Both of them are traditional work parties locally instituted by the communities to support a given household through deploying their collective labor force on certain item of work on a given day. This support can also be offered to any other household through deploying their joint labor force on any items of works as requested by the next household. This can be repeated as needs arise with the community members. The items of works include local house construction, cultivation or other agricultural activities etc.*

[2]*Idir refers to a traditional structure of a group of local community where the community is organized to meet in a given interval of time to contribute an equal amount of money by each member of the group, as determined by the community, for possible use in the event of happening of any unforeseen kind of social engagements, grief/wedding. The money collected regularly would be deposited with a selected individual by the association for this purpose.*

[3]*Ikub refers to a traditional structure of a group of local community where an assorted individuals from a community, could be from different or same localities, contribute an equal amount of money in a given interval of time. The money collected regularly would be deposited with an individual that is selected by the members of the group for this purpose. This collected sum of money is given, on a lottery-based principle, to one of the members of the structure to support his or her economic needs, as a first cycle of the functions. The cycle continues until all the members receive the regularly collected money turn by turn. Once the full cycle is done, it can either continue or discontinue depending on the members' decision.*

Carolyn et al. (2015) argue that local institutions, in the absence of action of a government in responding to climate change, can stand in the gap. They further highlight that community adaptive capacity can be built through fixing linkages between households and local informal institutions that foster local learning. Their study also noted that further linkages between formal local and external institutions could facilitate exchange of knowledge and resources, which can foster resilience.

It is thought in this study that watershed communities (as informal institutions) can contribute their meaningful share to providing goods and other services through maintaining their watershed ecosystem resources. Adam (2012) states that forest communities, in collaboration with other formal institutions, can provide better access to public goods and ensure security. In addition, Katarina et al. (undated) argue that the best results have been realized in economic development in countries with predominantly strong informal institutions, irrespective of the strength of formal institutions.

The contribution of such informal institutions are many, including decision making in various aspects of the project, identification of specific activities requiring particular attention for intervention that may relate to vulnerable ones (too old persons, women headed households), and to efficiently utilize available resources from other sources, if applicable. Specific combination of activities, if required, can be formed as User Groups to deal with particulars of each category of the work type, such as hillside closure groups, community-planting groups, water pond user groups.

Therefore, it is necessary to involve all the groups in planning, implementation, operation and maintenance of their respective development activities, if the management of the watershed environment is to be successful.

2.5.3 Watershed - Community Participation Practices in Ethiopia

In response to the ongoing serious land degradation phenomenon, because of population expansion and associated demand for goods and services, the Government of Ethiopia launched related national programs during 1970s and 1980s. The Government launched a Guideline on Community Based Participatory Watershed Development in 2005 (Lakew D. et al., 2005), reflecting on the following principles of watershed development:

- Participatory
- Gender sensitive
- Building upon local experience, strength and what works
- Realistic, integrated, productive and manageable
- Watershed logic and potential respected
- The need for flexibility at different levels
- Cost sharing and employment/ ownership building

- Complementary to food security and rural development

Although the Government, through its Ministry of Natural Resources, supported rural land rehabilitation programs and institutional capacity building run by FAO, attached to the Ministry of Agriculture, it did not account for those real life actors, the communities, but only those technical experts in the field (Lakew D. et al., 2005).

Pilot tests were done through the assistance of FAO, involving field technicians but not the community, which was considered the evolution of participatory planning approach in watershed management (Tesfaye, 2011). Subsequently, NGOs and bilateral organizations, in collaboration with the Government, adopted the program and attached it to their operational plan as one of the programs activities.

To this end, although, the exercise contributed to technological benefits, it did not satisfy the intended purpose as it missed the most important stakeholder, the local communities in its functions. Consequently, the exclusion of the community would pose a potential threat to sustainability of these programs.

Obviously therefore, to reverse the threat, involvement of the user communities from start to finish would be necessary in order to work together, identify problems and priorities, constraints, suggest possible solutions and recommendations including policy options where monitoring plans and impact evaluation procedures are considered (Johnson et al., 2001).

According to Pretty and Ward (2001), Governments and NGOs have recognized that protection of watersheds cannot be achieved without the willing participation of the affected communities. The main point that makes the community farmers' participation most important is that they are the closet entity in the area and the owners of the programs. Hence, they are aware and close to the real problems and solutions, which the experts would likely miss.

2.5.4 **Community Based Watershed Management**

Community-based watershed management (CBWM) is an approach that involves the collective effort of individuals or institutions to participate in identifying and addressing those issues affecting the watershed functions. Watershed management involving local stakeholders results in more locally relevant solutions that take into account each community's unique social, economic and environmental conditions and values (Ali, 2011). It is thought also that the CBWM approach creates a sense of ownership of the identified problems and solutions to the watershed issues.

Watershed management is a general approach to water-resource protection encompassing physical and biological components of the watershed environment, including human communities. Incorporation of a broad range of values and interests of the watershed community shall not only underpin the scientific approach in both identifying and addressing problems, but also make the process more reliable and practical in terms of avoiding possible social and economic conflicts.

Long-term commitment of the stakeholders is crucial to the success of the watershed management functions in the sense that participants need to learn from their mistakes and adapt to the changing circumstances in the process. It is also important to note that when old issues are resolved, new ones may arise, requiring the intervention of the communities to adjust to the changing conditions of the watershed. In connection with this, the CBWM experiences around the globe, according to Ali (2011), suggest the following characteristics:

- Involve stakeholders in the management planning process in a way that is meaningful to them and that allows them to use their particular skills and knowledge most effectively.
- Do not be discouraged if some stakeholders choose not to participate initially.
- Begin by educating and informing key audiences about the values of the watershed to the community, the watershed management process, and specific actions they can take to get involved.
- Determine the appropriate scale for addressing watershed problems. Actions aimed at changing land-use practices are easiest to implement at the local level and become more difficult to manage on a larger scale.
- View the watershed management plan as a starting point and not the product.
- Be prepared to adapt the plan as conditions change and groups learn from their mistakes.
- Make management decisions, when possible, based on a consensus of a broad range of stakeholders. Efforts to resolve conflicts before management decisions are made may bring dividends in the end.

- Focus on desired outcomes (e.g., clean water), which can often be more helpful and motivating for participants than emphasizing problems and who is causing them.

2.5.5 Agroforestry

Ramachandran (1993: 14) states that:

> *Agroforestry is a collective name of land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangements or temporal sequence.*

In agroforestry, systems there are both ecological and economical interactions between the different components, (Lundgren & Raintree, 1982, cited in Ramachandran, 1993).

Trees in agroforestry systems play a marked ecological service role, including providing windbreaks and economic benefits where intercropping is done with other crops. In addition, the systems also possess three attributes, namely i) productivity, in which economic benefits are realized: ii) sustainability, where conservation of the production potential of resource base and fertility are maintained: and iii) adoptability, where the system has the potential to be in conformity with the local farming practices (ICRAF, 2014). Research on agroforestry to achieve the optimal combination of plants and animals (trees, crops, and livestock) is helping the farmers benefit from the various opportunities that nature provides. These opportunities include, but are not limited to, soil fertility replenishment, environmental renewal, fodder trees and shrubs.

Moreover, research would be required on agricultural intensification through integration of agroforestry technologies including windbreaks, live fences, fodder banks, runoff-induced erosion control. The Great Green Wall for the Sahel and Sahara Institute (GGWSSI) was conceived as a five-year strategic initiative, endorsed in December, 2006, as a pan African program, to help in the fight against desertification, including ecosystem restoration and development of arid and semi-arid zones (GGWSSI, 2012). Accordingly, Ethiopia being one of the pioneering countries, following the ratification of the United Nations Convention for combating desertification, has put in place a National Action Plan (NAP) where the initiative has been incorporated into government plans and programs including Sustainable Land Management, Growth and Transformation Plan, and Climate Resilient Green Economy. As a continent however, little progress has been registered, calling for further mobilization of concerted efforts of all affected stakeholders including other bi-lateral, multilateral, NGOs, and private sector institutions.

According to Robert et al. (2009), agroforestry is practiced by 30 percent of the rural populations, covering 46 percent of agricultural land area globally. This represents more than one billion hectares of land and 558 million of people. Robert et al. (2009) argues that it has been found to be particularly relevant in Southeast Asia, Central America, and South America, with over 80 percent of the area under agroforestry. However, integration of agroforestry aspects into croplands in Ethiopia is a practice worth effecting.

2.5.6 **Integrated Water Resources Management (IWRM)**

2.5.6.1 **Introduction**

The ever-increasing demand for water service delivery in various areas because of population increase has placed pressure on traditional / existing patterns of the limited water resources uses. Therefore, coordinated use of water resources between and among different sectors of the society may be important to secure that this limited resource can be made use of efficiently, harmoniously and sustainably. If water resources development schemes have to be sustained, environmental functions need to be accounted for in the planning process and beyond. Wijayadasa (1997: 42) states, "Sustainable development is the product of harmonizing environmental concerns with developmental imperatives". In addition, effective beneficial uses of water resource can be brought to the fore only through effecting proper planning and implementation of the activities thereby involving mainly the watershed community, while other relevant stakeholders are still strongly kept party to the function.

Thus, it has been believed that the IWRM approach evolves to be an important supportive mechanism in promoting efficient management of the resources in the area of agriculture, industry, domestic water supply, power generation and emerging environmental flows of water because of ecological sustainability. The watershed ecosystem benefits can be reflected further in meeting managed demands sustainably while addressing environmental and socio-economic concerns and ensuring sustained economic development. UN (1992), Agenda 21 of the United Nations covering chapters 8, 27 and 28 deals with integrating environment and development in decision-making, strengthening the role of non-governmental organizations as partners for sustainable development, Local authorities' initiatives in support of Agenda 21 respectively were also consulted. Finally the study recommended possible ways on how the watershed natural resources' management sustainably operates and pertinent responsibilities cited to enable maintain a sound ecosystem and sustain effective irrigation agriculture functions.

IWRM can be implemented in context such as river basins and watersheds. However, Butterworth et al. (2010), advocate focusing at the local level and making integration from within sectors aiming at building upon existing institutions and participation mechanisms. In this regard, Belbela-Wadecha watershed environment can be one of the potential areas to invest in through involving all watershed sectoral entities for common, efficient, and sustainable benefits.

2.5.6.2 Some Characteristic Reflections on the IWRM

According to Global Water Partnership (GWP, 2005 and Cap- Net, 2008), integrated management means "that all the different uses of water resources are considered together (GWP, (2005: 7). Water allocations and management decisions consider the effects of each use on the others".

GWP (2005: 7) describes Management as follows:

> *It emphasizes that we must not only focus on development of water resources but that we must consciously manage water development in a way that ensures long term sustainable use for future generations.*

In addition, Zazu (2015:4) states that

> *Integrated means that all sectors must participate: these are Water Users, Agriculture, Forestry, Fisheries, Environment, Industry, Water Suppliers, Waste Water and other stakeholders.*

These entities are believed to be included in the main categories of water users, in the area of managing IWRM.

IWRM, according to GWP (2009:18) is defined as:

a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

USAID (2006) also defines IWRM, cited in OV1 2010: 1) as follows:

IWRM is a participatory planning and implementation process, based on sound science, which brings together stakeholders to determine how to meet society's long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits.

This study follows the definition used by USAID (2006) as it relates more to the objectives and purpose of this study.

The researcher argues that it is widely recognized that IWRM is a mechanism that ensures availability and sustainability of water resources at the same time. Accordingly, UN WATER (2018: VI)'s, Goal 6, states that need to "Ensure availability and sustainability management of water and sanitation for all" and it reflects on all issues of fresh water resources. In this connection, Patricia et al. (2007:8) argue that:

Viable IWRM models must have the following characteristics: (1) the holistic treatment of water resources, (2) the elevation of environmental protection to parity with consumptive use, (3) the use of inclusive, continuing adaptive planning processes, (4) the restriction of present and future consumptive uses, and (5) the recognition of equity or social justice as constraints on water allocation.

The implementation level of these items varies from country to country. With regard to IWRM implementation, according to UN WATER (2018), SDG 6.5.1 score, Ethiopia is categorized "Medium–Low" level of achievement; this implies it has relatively weak coordination. There are three areas of challenges in Integrated Water Resources Management, namely: lack of local context (for example communication), lack of Technical Capacity and High Staff Turnover, GWP (2009).

Therefore improving the status level of IWRM in the country is important in order to benefit the environment and the socio-economic status of the society in a sustainable manner.
In order for IWRM to function harmoniously and sustainably, water resources and its users including water governance and involved institutions have to be explored to balance particulars in each entity and ensure inclusive participation for peaceful, efficient and sustainable utilization of water resource Savenije & Van der Zaag (2008). "IWRM requires good water governance and effective institutions. Institutions are effective if there are strong links between users and managers, between customers and providers. This essentially promotes accountability." (Zaag & Savanije, 2015: 109).

Moreover, in order for IWRM to be successful in meeting availability and sustainability for all sectoral institutions, joint planning and management of IWRM involving all affected watershed entities from point of view of equity, efficiency, sound environment, and socio-economic development on a sustainable basis is a prerequisite.

Caribbean Environmental Health Institute, EHI (2008) states that IWRM planning seeks to address the scope of the plan (including goals and objectives to be achieved), and how we plan to achieve the aims and objectives. The plan also needs to show how it links with other relevant national development processes consisting of varied institutions' needs and associated resource requirements. It should further describe existing water management experiences and the current water resources situation.

GWP (2015) states that good progress has been achieved in IWRM in East Africa at policy levels, and workable strategies have been set-up; however, it is still very much 'a work in progress'. It also states governance is still a challenge. In addition, in relation to governance UN Water (2015:42) states, "Effective governance requires accountability, transparency, equity and fairness, efficiency and effectiveness, and the rule of law".

Good governance can be ensured if pertinent stakeholders participate in a way that each party delivers on expected outputs as foreseen in the planning process. In order that stakeholders effectively participate, there must be a strong link amongst all involved parties. Institutions need to be put in place to catalyze proper bondage between and amongst the stakeholders to ensure effective participation in the IWRM planning, implementation and monitoring and evaluation including feedback remediation. Such institutions would have been charged with a task entrusted to at the time of the establishment of the institutions to ensuring planning, and implementation consistent with efficient, equitable and sustainable use of the finite resource, precious water. Hence, cross-sectoral coordination is a key to the success of IWRM.

In addition, in terms of lessons learned from IWRM Implementation Project in Ethiopia, Final Project Report, political will and stakeholder participation are still important factors to focus on in the process of IWRM implementation (GWP, 2009 & Jembere, 2009). The report also states that IWRM can be a tool for conflict management if supported with capacity building endeavors. It further highlights that piloting in IWRM is important with subsequent scale-up operations towards supporting the maximization of the IWRM action and enhancing socio-economic and ecological benefits.

To this end, efforts need to be deployed to promote shared power and discharge respective responsibilities between and among all sectors on the formulation and implementation of workable policies reflecting on local contexts, building and enhancing institutional capacity, ensuring inclusive participation, and developing and implementing strategic mechanisms for coordination and mitigation of conflicts. In this regard, Belbela-Wadecha watershed area can be one of the potential areas to implement a pilot scheme and explore scaling-up functions for applying all relevant aspects of IWRM execution processes including planning, implementation, and monitoring and evaluation involving pertinent stakeholders across affected sectoral institutions.

IWRM is believed to be an approach to better address issues pertaining to equitable, efficient, effective, and sustained uses of water resource with a view to addressing socio-economic, environmental, spiritual, and religious beliefs coordinated between and amongst affected sectoral institutions. Weak enforcement of rules and procedures; lack of proper governance, weak management and operation capacity, lack of strong political sectoral coordination, participative planning and implementation, and monitoring and evaluation should be explored.

Therefore, in order for IWRM to be more successful, the researcher argues that, in addition to giving an utmost attention to foster IWRM through undertaking participative operations in each cycle by all involved entities, decentralization of decisive functions to the community level should be made. This includes defined mandates encompassing the rights and obligations that the community should bear in its undertakings of IWRM functions and that this is reflected in the policy provisions. Enforcement of rules and regulations needs to be made binding on all involved stakeholders in the process. The researcher also advocates that bylaws between and among stakeholders need to be put in place to also improve coordination mechanisms where that this bylaws are assessed and evaluated regularly by an appropriate organ and remediation is put in place with a view to satisfying its intended missions and objectives.

2.5.7 Climate Policy Response Overview

Since the imminence of global warming phenomenon got global recognition, international community is striving to make the effect less serious or deter at the level collectively agreed upon during the previous series of international meetings. According to the researcher's view, although developed and developing nations convened a number of times to design strategic directions that would address the cause and effect through two broad mechanisms, adaptation and mitigation functions, delivery on tangible and meaningful benefits still remain an area to be revisited and seriously engaged.

The outcome of these recent past various deliberations conducted in multiple countries culminated in producing comprehensive reports that focus on a wide range of specific issues that need to be looked into by developed, developing countries and developing island states. Some of the characteristic areas the international community would focus on should include (Santra, 2016):

- Implementation of immediate cuts of carbon dioxide in line with the requirements/targets set through different agreement protocols, including the Kyoto one.
- The rich countries have agreed to reduce their emissions of greenhouse gases by an average of 5.2 percent by 2010. On the other hand, developing countries were not set formal emission limits, as this would unfairly inhibit their pursuit of economic growth, although the United States insisted that some developing countries accept emission targets, before it is willing to reduce its own greenhouse gas emissions.

- Drawing up further policies and strategies that would be such that all nations should responsibly discharge their national, local and international obligations in the area of, including the phase-out of fossil fuels as quickly as possible.
- Policy focus should also include buying insurance and policy-makers are made aware of the likely unbearable cost of money and loss of other priceless resources not in too long a time.
- Implementation of the protocols of the use of energy efficiency covering use of renewable resources, halting deforestation, minimizing or stopping use of greenhouse gas-intensive agriculture.
- Unprecedented provision of suitable funding especially by the industrialized nations, usually promises are not kept intact.
- Decrease greenhouse gas emissions and increase carbon capture through afforestation and reforestation and shift to non-fossil energy use.

2.5.8 Climate Adaptation and Mitigation

Adaptation, according to Ethiopian Federal Ministry of Health (FMoH, 2018: IV), is "adjustments in human and natural systems in response to actual or expected climatic variation, with a view to moderating harm or exploiting beneficial opportunities". Adaptation needs vary across geographical scales (local, national, regional, global) and sectoral varieties with temporal scales. Adaptation hence involves adjustments that reduce (or aim to reduce) the vulnerability of communities, regions and nations to climate variability and climate change in promoting sustainable development (IPPC, 2001). Various types of adaptation include anticipatory and reactive ones, Table 2-10, as well as private and public responses. Examples of adaptations may include raising river or coastal dikes, substitution of climate resilient plants. Afforestation and reforestation can be considered an important tool in contributing to balancing the ecosystem functions catalyzing a sound environment for living for all forms of life. It is believed therefore that the Belbela-Wadecha watershed ecosystem can contribute towards climate adaptation processes.

Mitigation, according to the FMoH (2018: IV), is "efforts to reduce or prevent emission of greenhouse gases (GHGs) or to enhance their removal from the atmosphere by sinks". Mitigation cannot stop both climate change and climate change impacts but aims to reduce future climate change by slowing the rate of increase in (or even reducing greenhouse gas concentrations) the atmosphere and involves actions reducing the emissions of greenhouse gases.

Table 2-10: Adaptation Measures Highlighted in National Communications of Developing Countries

Vulnerable sectors	Reactive adaptation	Anticipatory adaptation
Water Resources	- Protection of groundwater resources - Improved management and maintenance of existing water supply systems - Protection of water catchment areas	- Better use of recycled water - Conservation of water catchment areas

	- Improved water supply - Groundwater and rainwater harvesting and desalination	- Improved system of water management - Water policy reform including pricing and irrigation policies - Development of flood controls and drought monitoring
Agriculture and food security	- Erosion control - Dam construction for irrigation - Changes in fertilizer use and application - Introduction of new crops - Soil fertility maintenance - Changes in planting and harvesting times - Switch to different cultivars - Educational and outreach programmes of soil and water	- Development of tolerant/resistant crops (to drought, salt, insect/pests) - Research and Development - Soil-water management - Diversification and intensification of food and plantation crops - Policy measures, tax incentives/subsidies, free market - Development of early warning systems
Human health	- Public health management reform - Improved housing and living conditions - Improved emergency response	- Development of early warning systems - Better and/or improved disease/vector surveillance and monitoring - Improvement of environmental quality - Changes in urban and housing design
Terrestrial ecosystems	- Improvement of management systems including control of deforestation, reforestation and afforestation - Promoting agroforestry to improve forest goods and services - Development/improvement of national forest fire management plans - Improvement of carbon storage in forests	- Creation of parks/reserves, protected areas and bio-diversity corridors - Identification/development of species resistant to climate change - Better assessment of the vulnerability of ecosystems - Monitoring of species - Development and maintenance of seed banks - Including socioeconomic factors in management policy
Coastal zones and marine ecosystems	- Protection of economic infrastructure - Public awareness to enhance protection of coastal and marine ecosystems - Building sea walls and beach reinforcement - Protection and conservation of coral reefs, mangroves, sea grass and littoral vegetation	- Integrated coastal zone management - Better coastal planning and zoning - Research and monitoring of coasts and coastal ecosystem

Source: National communications of non-annex I Parties[24] and UNFCC Sixth compilation and synthesis of initial national communication from Parties not included in Annex I to the Convention. Note by the secretariat. Addendum 5. Climate Change impacts, adaptation measures and response strategies[25]

2.5.9 Climate Change and Response in Ethiopia

Climate change is apparently posing an imminent global threat being manifested in various forms, almost all seemingly different to what it was like before. The mean annual temperature, in Ethiopia, has increased by 1.3^{o}C between 1960 and 2000, an average rate of increase of 0.28^{o}C per decade and projected to increase by 1.1 – 3.1^{o}C by 2060s and 1.5 – 5.1^{o}C by the 2090s Gashaw et al. (2017: 148). World Bank suggests, compared to baseline scenario, Ethiopia's GDP may reduce by

2-6% by 2015, and by up to 10% by 2045 (World Bank, 2010 cited in Gashaw et al., 2017), requiring to take adaptation measures. Keller, (2009) concurs that Ethiopia's temperature has increased over the last decades, at about 0.2^{o}C per decade.

In this connection, the Government of Ethiopia has prepared (prioritized 11 projects) a Climate Change National Adaptation Program of Action (NAPA) and submitted it to UNFCCC as part of implementing the commitments of the UN Framework on Climate Change Convention (NAPA, 2007). The program focuses on decreasing vulnerability in the sectors of agriculture and food security, water resources, forestry, and health. Ethiopia's National Adaptation Plan (NAP-ETH) builds on the efforts of related country's development policy frameworks fighting against climate change including CRGE and the second Growth and Transformation Plan (GTP II) (NAP 2019). In addition, four areas of key impacts of climate change stated are global warming, extreme climate events, undernourishment, and lack of stability in food utilization and access (FAO, 2012).

Moreover, Ethiopia has officially established Climate Resilient Green Economy (CRGE) Facility in 2011 as its climate finance delivery entity and formulated four CRGE plan pillars and meeting its objectives of making Ethiopia a middle income country by 2025 (CRGE, 2011). These pillars are: adoption of agricultural and land use efficiency measures, protecting and re-establishing forests for their economic and ecosystem services including the carbon shocks, deployment of renewable and clean power generation, and use of appropriate and advanced technologies in industry, transport, and buildings. Accordingly, positive implementation progress is recorded in the areas of creating enabling environment for translation of the CRGE into action, economy wide integration of climate change, and mobilization of climate finance.

The Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA, 2016) states in its review of adaptation action in Ethiopia that continued efforts are needed to address social and environmental challenges including gender inequality, and resource degradation that leave the people vulnerable to the impacts of climate change. Accordingly, the Government of Ethiopia is closely attending to the implementation progress through monitoring, evaluation, feedback, and verification process. However, this function still requires capacity enhancement in monitoring, reporting and verification (MRV) of GHG emissions (UNDP, 2011).

Developing nations bearing the brunt of the climate change impacts need to concentrate on aggressive afforestation and reforestation, including extensive agro forestry operations to increase carbon sequestration and carbon trading, while striving to convince the developed nations to offset their emissions through a globally concerted effort, including the implementation of the Kyoto protocol and a global sense of humanity.

2.5.10 Watershed Management Policy Overview

This sub-section deals with various policy matters relating to natural resources management reflecting on the practicality of the policy provisions as to whether or not further intervention would be necessary.

USAID (2006), highlights that it is wise to build resilience to risk, shocks, and vulnerability which are critical components of a poverty reduction strategy. It also discusses that effective policies are critical to effective and beneficial natural resources management in the way of increasing the productivity of the natural resources through helping in investing in appropriate technologies and ensuring access to functioning markets. However, reinforcement mechanisms seem to be an area that needs to be revisited critically.

A conference was held on policy analysis relating to sustainable management and food security in the Ethiopian highlands during which a related simulation model was run (UNECA, 2002). The simulation model showed that combining policy promotion of tree planting and conservation through the use of a 'food for work' program may have the potential contribution towards reducing poverty and attaining more sustainable environment as a win-win solution, in terms of environmental sustainability and economic benefits of the community (UNECA, 2002).

A Seminar on Policies for Sustainable Land Management in Highlands of Ethiopia was held at the International Livestock Research Institute, Addis Ababa, Ethiopia (ILRI, 2000). The Seminar included a paper on development paths and policies for sustainable land management in Andit-Tid area, north Shewa, Ethiopia (ILRI, 2000). The findings of the paper showed that the project was not successful because the approaches in the implementation activities were not participative and a top-down system was followed. In addition, constraints that affect the project function were not addressed as appropriate. In the end, the paper concluded that local participation was central for proper design, implementation, monitoring and enforcement of policies (ILRI, 2000).

NEPAD states that reconciliation of its development needs with the sustainable management of its natural resources is one of the biggest environmental challenges facing Africa. It also identified the environmental challenges that can be addressed regionally and internationally. However, despite the growing recognition of the importance of sustainable management and government commitment to natural resources and environmental protection works, environment continues to deteriorate. This is because, existing national, sub regional and regional environmental laws, plans, policies and institutions have proven to have been inadequately operating. This is attributed to, inter alia, lack of appropriate financial resources, and found to be not in line with the Algiers convention (NEPAD, 2003).

In addition, although, most African countries are parties to many international conventions on environment, including the United Nations Convention to Combat Desertification, the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change (UNFCCC), practical implementation remains a challenge. However, all conventions now favor and insist to implement the recommendations through participatory and integrated processes, which are believed, will benefit from collaborative effort of all the stakeholders involved in the sustainable development activities (NEPAD, 2003).

Moreover, the National Forest Policy of the country is designed to ensure environmental stability and maintenance of ecological balance for sustenance of all life forms. According to National Biodiversity Action Plan (NBAP, 2008), although a number of policy, legal and administrative measures are in place to address various aspects of biodiversity conservation, including Forest (Conservation) Act (1980), Biological Diversity Act (2002), it was identified that there is still a need to promote greater harmony and synergy in these measures and effective enforcement of existing laws.
International Fund for Agricultural Development (IFAD) in its Environment and Natural Resource Management Policy indicates that maximizing synergies within and among landscapes through participatory process involving the community is of major importance (IFAD, 2011). More on this, the National Environment Policy (NEP), "The NEP prescribes that human beings are at the center

of concerns for sustainable development and they are entitled to a healthy and productive life in harmony with nature" (NBAP, 2008: 6). The NEP (2006) also seeks to balance harmony between conservation and development with a view to maintaining environmental concerns in all development activities.

In addition, Schlaepfer (1997) proposed questions that one needs to answer for the implementation of ecosystem-based management as indicated in Box 2-1 below. In addition, the World Resource Institute (2003) indicated seven rules required, for environmental governance, to address in the scheme implementation as shown in Box 2-2 below.

This study therefore goes well in line with the above referred to issues seeking to support devise the way forward in the realization of sound watershed ecosystem and sustained irrigation agriculture operations.

Box 2-1: Questions to be answered for the implementation of ecosystem-based management

- What are the guiding principles and the vision for management?
- What are the goals and general objectives?

- How intense should the planning process be?
- Who should belong to the planning team?
- What are the variables sources of information?
- What is the current situation and what are the key issues in the management unit?
- What are the specific management objectives?
- What alternative courses of action could be used?
- What is the mid-and long term effects on the defined criteria and indicators of each alternative?
- Which management alternatives should we choose and how should they be designed?
- Which are the priorities?
- Plan the implementation
- Plan the monitoring and the assessment
- Inform the concerned organizations and persons
- Execution, monitoring and assessment
- Adapt the management
- Presentation of benefits

(Source: Schlaepfer, 1997)

~~Box 2-2: Sven Rules for Environmental Governance~~

- Institutions and laws: Who makes and enforces the rules for using natural resources? What are the rules and the penalties for breaking them? Who resolves disputes?

- Participation rights and representation: How can the public influence or content the rules over natural resources? Who presents those who use or depend on natural resources when decisions on these resources are made?
- Authority level: At what level or scale - local, regional, national, international –does the authority over resources reside?
- Accountability and transparency: How do those who control and manage natural resources answer for their decisions, and to whom? How open to security is the decision-making process?
- Property rights and tenure: Who owns natural resources or has the legal right to control it?
- Markets and financial flows: How do financial practices, economic policies, and market behavior influence authority over natural resources?
- Science and risk: How are ecological and social science incorporated into decisions on natural resource use to reduce risks to people and ecosystems and identify new opportunities?

  (Source: World Resource Institute, 2003)

The Environmental Policy Group (EPG, 2011), states that there are significant limitations to environmental policy implementation capacity, including enhancement and engaging environmental NGOs such as Forum for Environment and Concern for Environment that play important role in environmental management in Ethiopia, in sectors that promote long-term environmental sustainability (CRDA, 2008). It also highlighted that capacity enhancement is necessary for both government body and NGOs where government is required to adjust or improve existing environmental policies.

Elias (2008), states that there is a wide gap between what Ethiopian laws require on forest protection and the facts on the ground. The gap is attributable to the absence of effective regulations, efficient institutional framework and law enforcement mechanisms.

In addition, the International Watershed Management, (IWSM, 2015) notes that to improve water quality and increase productivity with a view to contributing to better livelihoods, it is important that appropriate reforms are conducted. It further states that the success of the reform depends on participatory and transparent planning and implementation process at various stages of program / project making and administrations.

It was stated also in the Ministry of Finance and Economic Cooperation MoFED (2003), Rural Development Policy and Strategy that the country lacks experience in sustainable management of natural resources, including forest resource and that makes development challenges complicated. However, the country seeks to draw on experiences of other countries and on the indigenous experience in the country.

Ministry of Agriculture, MoA (1998), conducted Monitoring of Forest Recourses in Ethiopia in 1998. The Ministry assessed the status of the Forest Resources and undertook the monitoring activities of the Forest Cover in the country, for nearly 30 years starting from early 1970s. In this regard, to promote more effective and sustainable management of forest resources thereby ensure a close follow-up the Government of Ethiopia (GoE) has put in place a proclamation numbered 542/2007, on "Forest Development, Conservation and Utilization" (GoE, 2007). The Ministry also undertook similar activities in Southwest Ethiopia over about the same time span. The findings of both reports were supported with figures. However, the monitoring report culminated in justifying that "…in most National Forest Priority Areas, NFPAs, of Ethiopia forest stands have been degraded or even completely deforested" MoA (1998: 33). The report also highlighted that the government drafted and launched the development of management plans and started the implementation in National Forest Priority Areas NFPAs (1994) and continued similar functions elsewhere subsequently with a close engagement of local level participation all the way through all the implementation stages.

However, "There is an urgent need to break the so-called cyclical and downward spiral of the poverty-environment nexus" NEPAD (2003:26). Good stewardship of an environment hinges on poverty alleviation. It is understandable that the livelihoods of the rural communities, mainly of the developing countries, directly or indirectly depend on the benefits accruing from the natural resources to satisfy their economic and social needs. Therefore one would argue that the way forward to sustain environment and derive economic returns from would be to reconcile sustainable operation and management of natural resources with the development needs supported with practicable laws / bylaws addressing national priorities and local realities with a view to attacking poverty.

Furthermore, World Bank (1995), in its Policy Research Working Paper 1414, advocates that each country needs to undertake legal reform and in that the countries would receive legal technical assistance related to the review and preparation of the draft national Environmental Action Plans. This shows how policy reform is so critical such that the Bank would assist in to solve possible financial shortages to making policy reformed for designing directions through the recruitment of consultants if needed. However, care needs to be exercised as to not to compromise the national policy directions, as a result.

In most parts of the globe, responsible institutions are put in place and corresponding mandates made clear, but leaving a question “are they delivering?". The Government of Ethiopia established Environmental Protection Authority with a defined list of clear mandates and accountability through a Proclamation NO.295/2002 (Federal Negarit Gazeta, 2002). Nonetheless, question arises with respect to forest management: 'is implementation of the stipulations stated in the Proclamation proceedings of the level it ought to have been or is it at all, one would argue, in practical terms of operations, reflecting on the current forest status in Ethiopia?' The question may also include 'do we have a well-articulated environmental auditing system that can be understood and implemented by all affected parties?', ' Is monitoring of the forest resources (like the one done in 1998) undertaken on a regular basis?

In general, as indicated above, although in many countries, parastatal and NGO institutions more or less have most of the required policies in place, not all policy provisions have either been well-articulated or given due practical implementation focus to participatory part of function from start to finish in any program undertaking. All argued to have failed as a result. Therefore, it is wise to take this gap to the forefront, assess, and analyze issues, constraints and priorities. This will help affect collaborative future design in a way the ecosystem operates keeping sustainable environment usable for all forms of life and meeting economic and social requirements of the current and future communities, if the projects and the environment have to be meaningful and the livelihoods of the communities meet the international quality standards of pattern of living.

2.5.11 Stakeholder Mobilization

According to Deepak (undated), resource mobilization refers to the process that achieves the mission of the organization through the mobilization of human knowledge, use of skills, equipment and services to enable the development, implementation and continuation of works for achieving the organizations' mission. Deepak (undated) also noted that resources denote the human (skills, knowledge, concepts, technical co-operation – consultancy, training, scholarship), physical goods and raw goods machinery, equipment, land), money (grant, loan, assistance), materials, information and energy essentials for attaining the objectives of an organization or individual.

Resource is that which is used, including money, information materials, energy or skills. Therefore, resources, as above, need to be mobilized giving attention to satisfying the particular project features.

2.5.12 Monitoring and Evaluation Process

"Monitoring is the collection of raw data or information for evaluation purposes" (Lakew D. et al., 2005: 55). "Evaluation is a process in which judgments on success and failures are made" (Lakew D. et al., 2005: 56).

Wabekbon Development Consultant PLC (2009) notes that monitoring and evaluation activities can be carried out through various line sectors in the government hierarchy to ensure projects are going in line with its original plan to meet its intended mission. The Ethiopian executive organizational structure, in ascending order, consists of the Kebele (the lowest administration unit in the hierarchy), the Woreda (next administration unit to Kebele), the Zone (an administration structure accountable to the Regional Administration), and then finally Federal System.

Community owned projects are administered by the community itself, with certain obvious and temporary support from the higher government bodies necessary for monitoring and evaluation purposes which relate to financial, logistical, and technical inputs. Technical support includes production and dissemination of manuals, guidelines, follow-up activities and conducting periodic refreshment training. Logistical support covers the provision of vehicles, motor cycles, communication facilities – telephone lines, fax machine, computers, photocopier, radio, among other things. Financial support is budgetary provision for project construction that would help it get started and will be repaid later as revolving money to help replicate projects elsewhere as need arises.

2.6 Summary

This chapter has looked into the characteristic importance of watershed natural resources, roles and benefits reflecting on the global practices and measures. The literature review covered particular reflections on the issues pertaining to the prevailing circumstances of Ethiopia, especially, the Belbela-Wadecha watershed ecosystem.

Nature and causes of watershed degradation has been referenced emphasizing on the human causes relating to population expansion, cultivation, overgrazing, resettlements, urbanization and deforestation particularly for fuelwood, among others.

The effect of these factors largely impinge on adversely affecting climate balance, hydrologic cycle, vegetation growth, unexpected heavy flooding, high heat wave and agricultural production and productivity shocks thereby subjugating the livelihoods of the community.

The literature search also included possible response measures and cited policy intervention issues, community participation, Integrated Water Resources Management, agroforestry management, effective resources mobilization and monitoring and evaluation and remediation processes. The status of operation of policy instruments was focused on particularly to see if the policies were delivering on the ground towards supporting the community at the grass roots level.

In addition, the cross functioning of institutions including the local level ones was given due attention to make sure that the communities are not by passed, but given due attention and respect that their voices are always appropriately heard.

3 Research Design and Methodology

3.1 Introduction

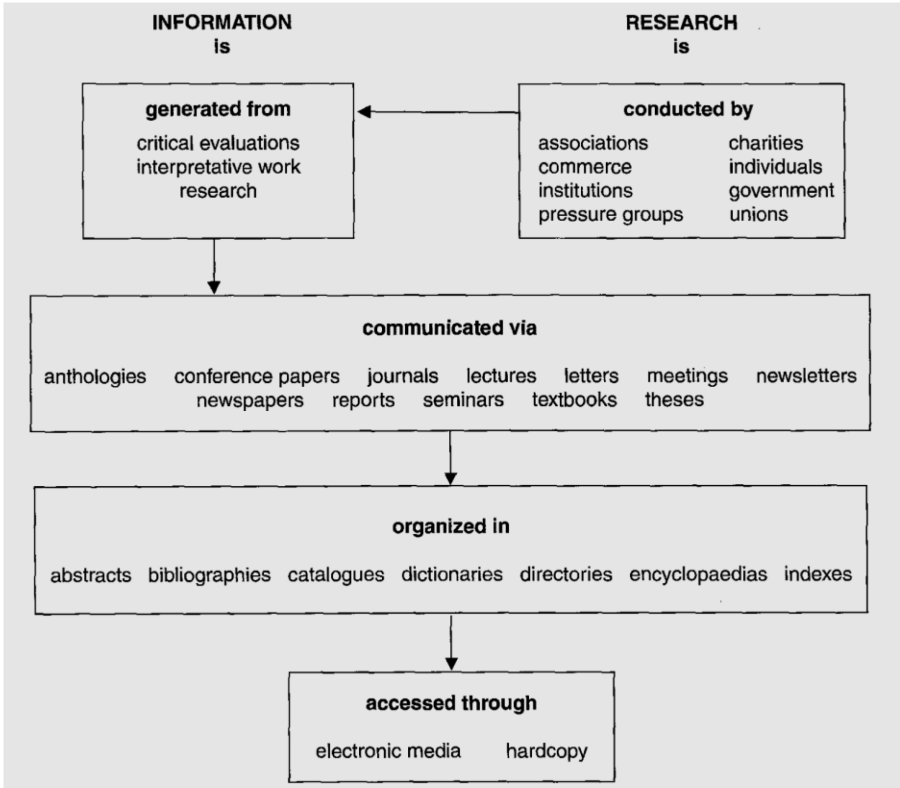
A research design is the logic that links the research purpose and questions to the processes of empirical data collection, data analysis, in order to make conclusions drawn from the data (Bloomberg & Volpe, 2008; Rowley, 2002; Yin, 2009). The research design implies or relies on the chosen research paradigm (Shana, 2015).

Moreover, the research design is the overall plan for collecting and analyzing data (Polit & Hungler, 1997; De Vos, 1998). It is noted further that the research design deals with responding to the research problem of the researcher's overall plan. In addition, it is stated that it avails the guidelines as well as instructions to be used when dealing with research problem (Mouton, 1996; Polit & Hungler, 1993). Research methodology on the other hand refers to the steps, procedures and strategies used for gathering data and analyzing the data in the course of the research investigation (Polit & Hungler, 1997).

Chris (1998: 28) defines methodology as:

> *a system of methods and rules to facilitate the collection and analysis of data. It provides the starting point for choosing an approach made up of theories, ideas, concepts and definitions of the topic; therefore the basis of a critical activity consisting of making choices about the nature and character of the social world (assumptions). This should not be confused with techniques of research, the application of methodology.*

This section deals with the process of generation and communication of research knowledge and information from various sources using different events by organizing in the forms convenient to make plausible, Figure 3-1: shows the process.



<u>Figure 3-1: The Generation and Communication of Research Knowledge and Information</u>

Source: Chris, 1998

In addition, academic skills and knowledge common to related subject areas within similar streams categorized as illustrated in Table 3-1.

Table 3-1: Research Areas for the Application of Skills and Abilities
Source: Chris, 1998

Literature search and evaluation	For example: library searching and use of abstracts and indexes; bibliographic construction; record keeping; use of IT for word processing, databases, online searching and electronic mail; and techniques for the evaluation of research, including refereeing, reviewing and attribution of ideas.
Research design and strategy	For example: formulation of researchable problems and translation into practicable research designs; identifying related work to rationalize the topic and identity a focus; organize time tables; organize data and materials; understand and appreciate the implication of different methodological foundations; and how to deal with ethical and moral considerations which may arise.
Writing and presenting	For example: planning writing; skills for preparing and submitting papers for publication, conferences and journals; use of references, citation practices and knowledge of copyright; construction and defence of arguments; logical, clear and coherent expression; and understanding of the distinction between conclusions and recommendations.

This study follows the Creswell's research design approach and the research methodology stated by Polit and Hungler (1997). The methodological approach followed in this research consists of dealing with both primary and secondary data. This chapter presents the data sources, sample design and size, data collection and analysis methods. The chapter further discusses issues relating to qualitative and quantitative approaches involving GIS and Remote Sensing as well as Participatory Action Research. In addition, the application of test pilot study techniques was used to support the data collection process. All forms of data collection were designed in such a way that it ensures appropriate response to the research questions and objectives. Moreover, measures to ensure validity and reliability as well as issues pertaining to ethical considerations, trustworthiness, scopes and limitations, organization of the Thesis and the output of the study were looked at also.

3.2 Theoretical Framework

The Theoretical Framework that guides this study involves GIS and Remote Sensing techniques used to determine the long-term effects of the land use land cover change on the Belbela-Wadecha watershed landscape. In addition, it was perceived that community participation would be of great importance in watershed management processes. As a result, Participatory Action Research formed part of the theoretical framework guiding the research process and augmenting the LULC mapping. Participatory Action Research was used also in guiding the community participatory restorative action of the watershed ecosystem after the identification of the nature and causes of watershed degradation.

3.2.1 Geographic Information Systems (GIS)

GIS are a powerful set of computer-based tools used to collect, store, manipulate, analyze and display spatially referenced information (Burrough & MacDonnell, 1998). It is noted also that GIS are portrayed as knowledge-based and free from bias. However, as GIS is a socially constructed technology (Warren, 1995), and the process of GIS production, consisting of data creation, analysis, visualization, and GIS output, biases their use, since the process also characterizes political, economic and social motivations.

Nonetheless, the application of GIS functions in this study would be knowledge-based and free from bias so that GIS generated outputs would be reliable, making the research study more beneficial. Figure 3-2 shows a model of communications for GIS illustrating some key locations in the GIS production process.

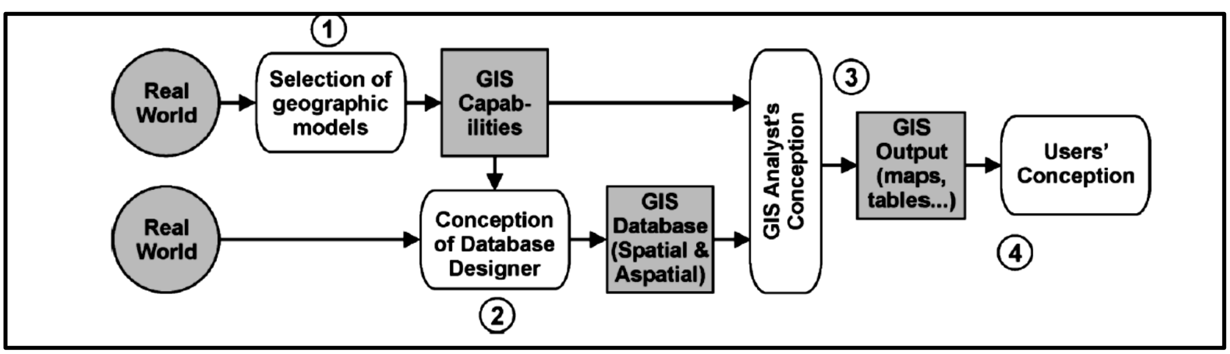


Figure 3-2: A Model of Communication for GIS
Source: Bunch, 2001a

3.2.2 Remote Sensing (RS)

Remote Sensing (RS) is a satellite based observation system that provides spatially and temporally consistent images of the state of land use, land cover mapping and change detection. Figure 3-4 shows remote sensing process, Figure 3-5 illustrates the time frame of Landsat Satellites and Figure 3-6 depicts a General Methodology for Studying LULC and Change Detection (pp 144, 145 and 153 respectively), for Belbela-Wadecha watershed environment study.

3.2.3 Participatory Action Research (PAR)

This sub-chapter reflects on various literatures relating to the Participatory Action Research where each of the literature sources raises quite constructive and practical approaches that all culminate in the issues that promote PAR. This study concurs with the approaches cited, and it accordingly took note of the issues that relate to the Belbela-Wadecha environment, reflecting on particular features of the area as presented below.

"Participatory Action Research (PAR) is a method that has been proposed to overcome the problems inherent in traditional scientific approaches to problems of developments and resource conservation" (Castellanet et al., 2004: XII). Castellanet et al. (2004) state further that PAR neither has been tested adequately in the context of natural resource management nor is it yet clear if it presents a viable alternative to the traditional approaches. It is stated under the same reference that the PAR agenda cannot be planned for it should be renegotiated with the end users periodically. It is stated also further that it is not a legitimate scientific approach but "takes its legitimacy from the fact that it treats problems that normal science does not know how to handle" (Castellanet et al., 2004:33). According to Jacques et al. (2013), PAR "is an expression of science that assumes reflectivity and self-experimentation in history".

Community-based Participatory Action Research (CPAR) begins with a research topic that is important to the community in that their social life changes for the better, for example where the community health is improved and health disparities are eliminated because of combining knowledge gained and actions experienced in the process of participation (Minkler, Blackwell, Thompson & Tamir, 2003). Involving communities in all stages of the research activities is crucial that professionals do not misconstrue or render meaningless information gathered because they are not a member of the socio-cultural group, (ARQH, 2004). In addition, it is also stated that "Despite skepticism from more traditional or conventional scientific communities, community-based participatory research has the necessary rigor and is valid and reliable" (ARQH, 2004; Simpson &House, 2002).

Dayal et al. (undated) state that a critical step in the methodology for participatory assessment is to increase the poor's participation, in particular women's participation, in service development, such as water supply and sanitation. According to Nilanjana et al. (undated), one of the advantages of participatory methods and tools for working with the community's women and men is it enables quick visual picture of local circumstances, which minimizes biases in the discussed representation resulting from their spoken language.

Chambers et al. (2005) state: three aspects characterize participatory approaches and methods. Firstly, there is need for *empowerment goals*, which ensure that the participants are the key beneficiaries from the investigation process relating to the increased understanding of the situation and equitable participation in the analysis and conclusion reached. Secondly, there should be a *participatory process* where investigations are conducted through group discussions consisting of participating members of small groups of three or four to a large number. Thirdly, there is need for *Accessible tools* that can be used to enable participants, including those who are not literate, to understand fully the discussion process and fully participate in the decision making process. The key characteristics and tools for participatory methods (Cambers et al., 2005) are shown in Box 3-1.

Box 3-1: Participatory Methods: Key Characteristics and Tools

Source: Chambers et al, 2005

EMPOWERMENT GOAL

* Increase participants' understanding of their situation.
* Improve understanding between participants.
* Equitable participation in the analysis and conclusions reached.
* Strong networks for future investigations.

PARTICIPATORY PROCESS

* Focus Group discussions
* Participatory workshops
* Community research

ACCESSIBLE TOOLS

* Network Diagrams: trees; flow/causal diagram; Venn/chapatti/circle diagram; Systems diagrams; Pie charts; Histograms; value chain analysis
* Ranking Techniques: preference ranking and scoring; pairwise ranking; direct matrix ranking; ranking by voting; wealth ranking; pile and card sorting; difference diamonds
* Time Trends Analysis: Historical and future (visioning) mapping; Road journeys; Time trends charts, historical matrices; Oral Histories
* Mapping Techniques: resource mapping, mobility mapping; social mapping;
* Calendars: Seasonal calendar; Historical seasonal calendar
* Ethno-Classifications: Proverbs, Stories, Indigenous Categories and Terms, Taxonomies
* Role-play

In addition to the above, William (1991) states that records suggest that practitioners learn better from each other than from researchers. Israel et al. (2003) argue that community defined research is more easily translated into practice as it is relevant to the local conditions, with consumers taking equal role in the project making. Israel et al. (2003) also argue that CPAR's key feature is where by "the community" drives the research agenda. Furthermore, Israel et al. (2003) allege that community engagement establishes a critical link between research and action as community members buy into the process that involves them from the beginning and that places them in a better position to apply findings to real practice and to disseminate those findings.

CPAR enables cross transfer of knowledge and capacity building in the process of participation, thereby imparting communities with tangible and practical benefits resulting from their participation during activities (Springett, 2003). The participatory process considers the legitimacy of local community expertise generated outside of the scientific community, and seeks to build on that expertise (Gaventa, 1993). This approach strengthens co-learning and capacity building among all stakeholders for supporting sustainability issues and for tangible benefits.

However, future challenges remain including how to "provide farmers' organizations and the public sector with the capacity to institutionalize innovations so that they will be able to both organize and implement their jointly developed innovations" (Hagmann et al., 1999:23). Enhancing participatory and interdisciplinary research needs to be given due focus (Probst et. al., 2003; Engel et al., 1997). In addition, newer challenges to agricultural research and development have emerged since the Green Revolution of 1960s and 1970s, among which are included sustained gains on agricultural productivity through improved management of natural resources. IDRC (2012) in this regard states that there is difficulty in harmonizing institutional mandates and accountabilities with demands from communities. As a way to handle such challenges, IDRC (2012: 87) proposes that we "Conduct institutional analysis when selecting partners, and ensure that adequate planning is done among partner organizations to articulate a shared vision, and complementarity in skill base and mandate".

IDRC (2012) also states that the principles of "good partnership" should be observed through clear definition of roles and responsibilities of partnerships of different institutions supported with a constituted memorandum of understanding. It was also added that local expectations need not be raised that may be beyond the delivery capacity of the external partners.

Various authors, as those above, have reflected their views pertaining to Participatory Action Research, which are basically alike and have many aspects in common that largely recognize the community as the running engine of a community project if scheme is to be sustainable, offer meaningful benefits, be replicable, fairly quickly maintainable, system participative, and self-governable.

However, this study seeks, given the low level of development of the country where the farmers need an undeniable support at the start-up phase of activities, to synergize national and local governments and the community resources and mobilize efforts at the outset of the program to develop the upstream and downstream of the Belbela-Wadecha watershed environment. It is important that no key party is left behind to ensure practical benefits are realized. This study proposes an integrated development approach where both upstream sound environmental ecosystem management of the watershed and the downstream irrigation agriculture developments operate sustainably and simultaneously.

In this approach, the government needs to focus especially on capacity enhancement (technical skills, financial mobilization, and enforcement of rules and regulations, among other things). It is critical that the communities' expertise and concerns are given a priority agenda and that the research functions are unequivocally led by the community themselves.

This study may contribute to the examination of the methods of the research process on whether or not it helps the community users to benefit from the scheme through participatory processes. It helps also towards reversing environmental degradation phenomenon in Belbela-Wadecha watershed ecosystem benefiting both sound environment management and sustained irrigation operation functions improving the livelihoods of the watershed community, with the possibility of replicating and up scaling the outcomes.

The PAR approach for the study area was determined jointly with the watershed community. The researcher focused on one selected area, which was environmentally degraded and appropriate to undertake the PAR study process. The approach to the study consisted of four steps, namely: identification of problem areas with the communities; participatory response planning to respond to the problem; participatory action; and participatory reflection (deliberation). Participatory mapping was used to complement the data observed through satellite imageries and was used to triangulate the information towards better coordination of results. Figure 3-3 depicts the conceptual PAR cycle model.

Accordingly, the research on Belbela-Wadecha watershed was planned to engage the local communities from the very beginning with a view to providing locally relevant solutions. This approach was intended to ensure sustainability of the ecosystem of the study area. This is because it uses local resources including knowledge so that if any defective works were encountered in the system, rectification of the part of the system would be locally put right and relatively quicker. It requires no importation of any foreign inputs, which would otherwise be expensive and require much longer time to set the defective item of work right or reinstate the sustainability functions.

The approach is intended to further guarantee replication of similar activities elsewhere as applicable to gain quick benefits in the fields of sound ecosystem management and sustainable irrigation agriculture administration.

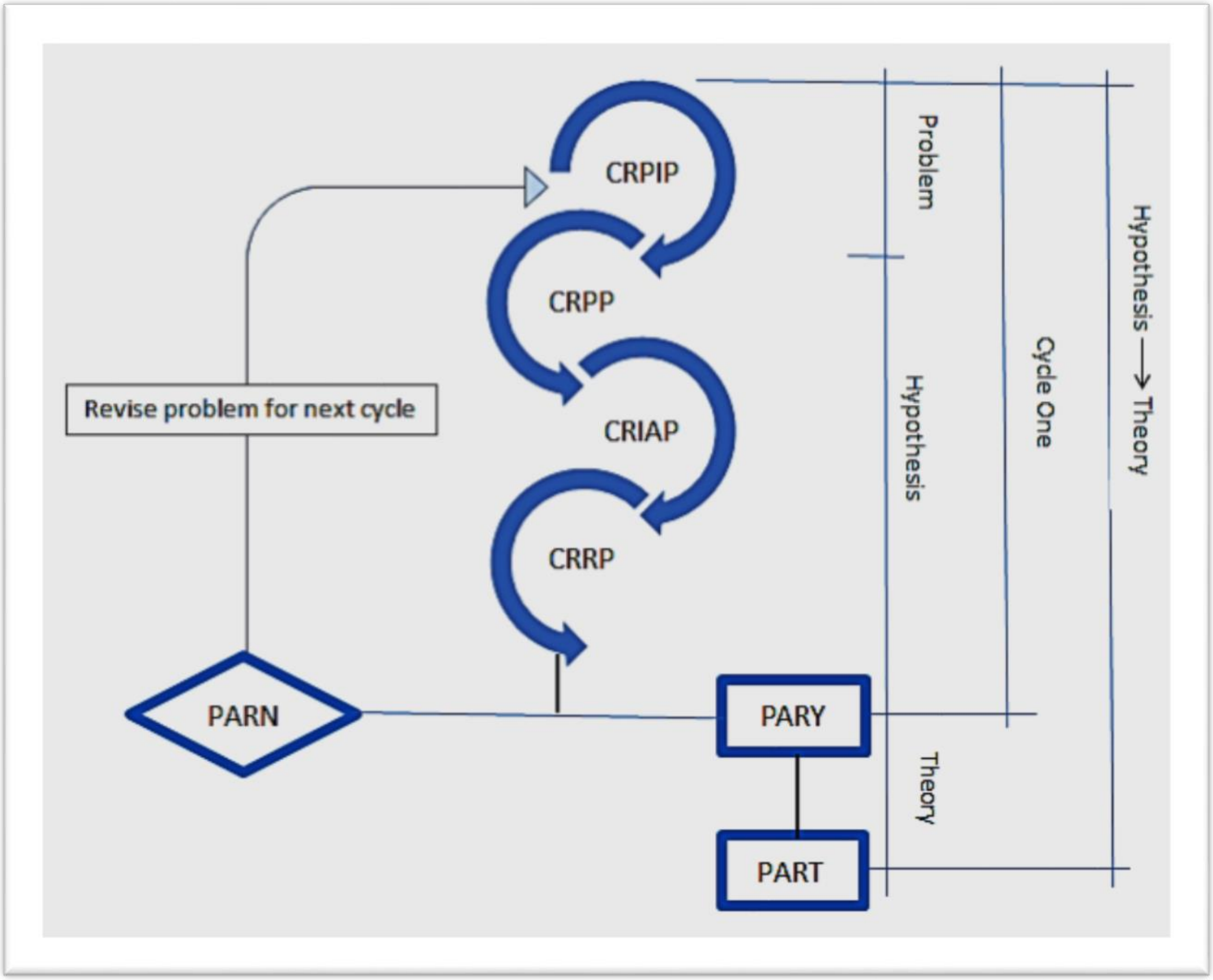


Figure 3-3: Conceptual PAR Cycle Model

Key:

CRPIP – Community – Researcher Problem Identification Phase

CRPP - Community – Researcher Planning Process Phase

CRIAP - Community – Researcher Implementation of Action Phase

CRRP - Community – Researcher Reflection Phase

PARY - Participatory Action Research Yes

PARN - Participatory Action Research No

PART - Participatory Action Research Theory

The PAR Steps

The following steps were taken during the PAR process:

Identification of problems with the communities

- Transect walk: this is a line of path, through which the community and the researcher surveyed the problem area. The transect walk was decided between the two parties based on the prevailing circumstances of the watershed environment relating to the environmental degradation concerning the natural resources (land, water and forest) induced by humanity. Based on the transect walk, assisted with GPS, conducted by the two parties, problem areas, types of problems, extent of the problems and general observations were noted and recorded, which were followed by participatory mapping with the beneficiary community.
- Comparison of community mapping against satellite imageries: With the help of GIS and remote sensing techniques, information on the status of land use and land cover was collected, including aerial photos for the benefit of comparisons and for ground truthing purposes.

Participatory response planning to respond to the problem

- Priorities: Under this section, priority areas were identified considering each problems listed under problem identification section above. The priority list also accounted for the type and degree of environmental degradation to help plan for short, medium, and long-term scenarios interventions.
- Resource requirements: To help identify the resources needed to resolve the problems, considerations shall be made as to how the planning scenarios and the degree of the problems of environmental degradation shall be addressed efficiently and effectively. Consideration will include the period, budgetary provisions, work force, equipment and other machinery requirements as needed.
- Resource availability: Availability of all the required resources will be assessed and provisions made for so that subsequent implementation will not be hampered because of failure to provide the required resources for the project.

Participatory action

- Implementation of the plan shall be undertaken with due care that a close follow- up by the community and the researcher will be very important. The two parties shall ensure that the timeframe, budget, work force, equipment and other resources needed would have been deployed in the implementation process well in line with the resources allocation plan shown under participatory response planning section above without exceptions.

Participatory reflection (deliberation)

- Evaluation of the project: This step will consider whether the project has proven to be a success. If the project is found to be successful, the cycle can be replicated elsewhere where similar problems are the case in point. However, if not successful, the cycle can be repeated all over until the project becomes successful. Under the condition of the successful project, the case can be considered that the hypothesis becomes a 'Theory or a Law' (Prathapan, (2014).
- Transect walk: A joint walk with the community through the agreed upon path in the watershed area will be made again to identify if changes were made because of the implementation of the project. Following the transect walk in the watershed and recorded observations, a participatory mapping will be done.
- Comparison of the maps: This sub section will consider complementing the observations with the satellite imageries and triangulations including aerial photos.

Conceptual Model Validation

The objective of validation is to build confidence in the effectiveness capability of the model through comparison of both the model and experimental data (Reston, 1998). In this regard, the model validation process was undertaken with a view to building confidence in the predictive capacity of the model through comparison against the experimental data and that the data indicates the result may be taken as the representation of the real world experience. Various authors gave definitions to model validation functions of which some are referred to in the following discourse accordingly.

Conceptual model validation is defined as "determining that the theories and assumptions underlying the conceptual model are correct and that the model representation of the problem entity and the model's structure, logic, and mathematical and causal relationships are 'reasonable' for the intended purpose of the model" (Sargent, 2011: 188). In this connection, the intention of developing and validating the model was to check on if the conceptual model concurs with the participatory mapping of the participating community and the satellite imageries output thereby establish confidence for further possible usability as and when required.

The validation process elicited that the comparison of the both model and experimental outputs were reasonably in agreement. Besides, out of a seven approach for conducting a successful simulation study (Law, 2008), Validating the Output from the Overall Simulation Model is taken as “the most definitive test of a simulation model's validity that its output data closely resemble the output data that would be observed from the actual system" (Law, 2008: 44). In this connection, the study discourse again showed the output data of the model goes more or less in line with that of the output data collected by the participating community and the triangulations made with the satellite imageries data.

"If the agreement between experiment and simulation outcomes is unacceptable, the model and / or experiment may need to undergo revisions" (Thacker et al., 2004: 22). In this regard, there was no need to make revisions as the first instance of the model test proved to be in agreement with the experimental data.

Finally, the overall assessments of this model validation process elicited that the assessment was well in line with the expected degree of representation of the study area and the intended uses of the model and that its conceptual description set forth by the researcher was attended to and verified.

3.3 Uses of Geographic Information System and Remote Sensing

3.3.1 Introduction

GIS is defined as “a system, which is designed to collect, store, update, manage, manipulate, analyze and represent graphical and non-graphical spatial data" (Michael, 1996:600). It supports the import of external data, including remote sensing and the selection and transfer of data into application oriented, analytical models (Antenucci et al., 1991, cited in Michael, 1996). GIS constitutes software, hardware and the organizational setup that includes appropriate set-up of computer network and skilled workers.

According to Oswal (2018:165), Remote Sensing is defined "as the science of collecting and interpreting information of an object without being in physical contact with it". James et al. (2011) state that the interpreter must know how images are formed and how sensors portray landscape features, in other words remotely sensed imageries depend on a good understanding of electromagnetic radiation and its interplay with different surfaces and the atmosphere.

Various categories of remote sensing are available, starting from observation by naked eyes, photography by camera, photography from aircraft, and sensing by sensors from space satellite, (Santra, 2012). Santra (2012) further states that, as a result of electromagnetic energy from the sun and active remote sensing, objects on the earth's surface that constitute different physical features and chemical properties reflect, radiate, emit, scatter energies of various wavelengths to the sensor for recording and subsequent use through manipulations by the GIS technology.

Lillesand et al. (1994), state that the atmosphere can have a profound effect on, including, the intensity and spectral condition of radiation available to any sensing system. Lillesand et al. (1994) further argue that the effects are caused mainly through the mechanisms of atmospheric scattering and absorption. Lillesand et al. (2008), also state that the net atmospheric effect depends on the path length and varies with the magnitude of the energy signal being sensed, the atmospheric conditions present, and the wavelengths involved. It was noted also by Lillesand et.al. (2000), that various portions of the energy incident on a water body are reflected, absorbed and / or transmitted. Sabins (1996) states that light, heat and radio waves are included as electromagnetic energy.

According to the orbital type, there are two kinds of satellites, geostationary or earth synchronous and sun synchronous (Punyatoya, undated). It is stated that, "Geostationary satellites are the satellites which revolve round the earth above the equator at the height of about 36,000 to 41,000 km, in the direction of earth's rotation", and "Sun synchronous satellites are the satellites which revolve round the earth in north-south direction (pole to pole) at the height of about 300 to 1000 km" (Punyatoya, undated: 8).

The technique of remote sensing can be divided into active and passive remote sensing. Active remote sensing refers to the illumination of object by artificial radiation and subsequent collection of the reflected energy back to the sensor from the object. Passive remote sensing has a natural source of radiation to capture / detect image of an object/scene. Accordingly, Figure 3-4 (Avinash et al., 2016) depicts the remote sensing process. [A] and [B] characterize passive remote sensing and [C] and [D] denote active remote sensing.

The remote sensing technique is used in the mapping of landscape parameters, namely soil type, land use and vegetation cover (Brodie et al., 2007). There are different types of remote sensing techniques available to remotely sense data depending on the purpose of the study. In this study, optical remote sensing and microwave remote sensing techniques would be used. However, as this largely depends on sun illumination, interception objects like clouds or nighttime observation may influence data capture and image quality. Microwave remote sensing techniques are thought to cater for such limitations in optical sensors for they penetrate clouds depending on sensor's frequencies and vegetation canopy (Knight et al., 2000).

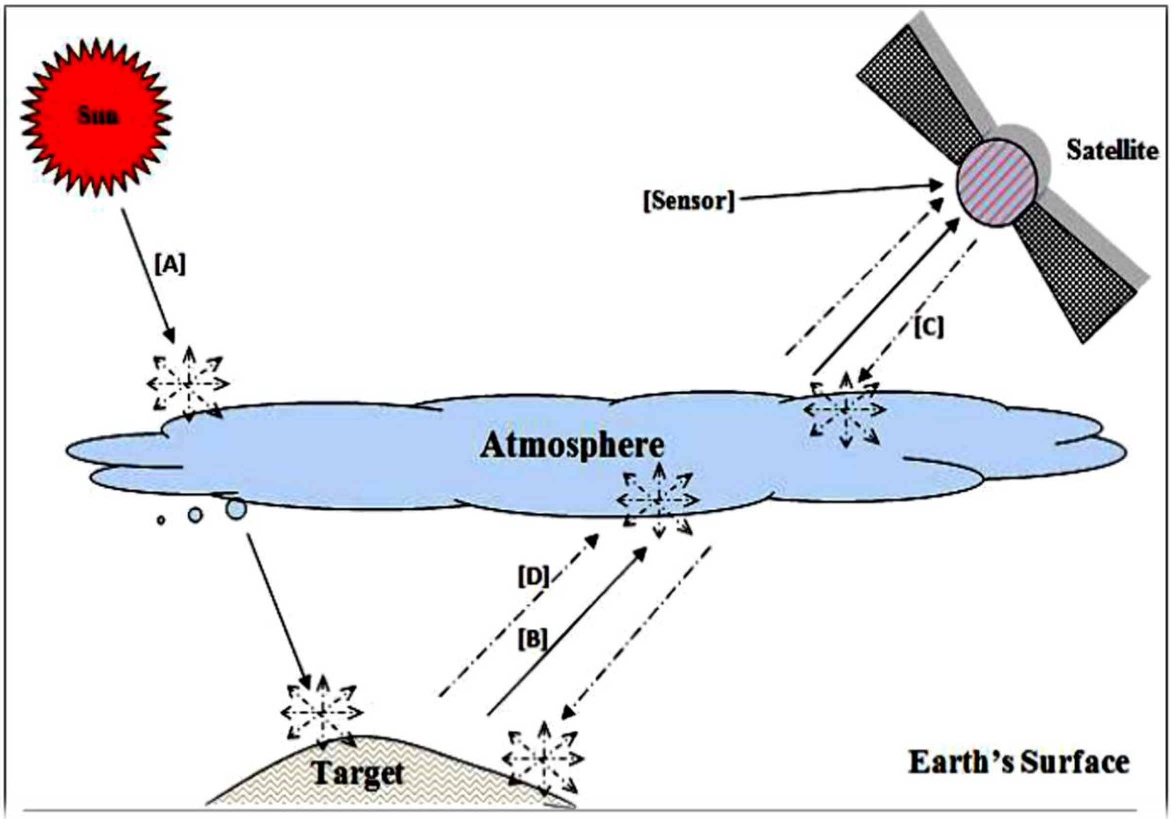


Figure 3-4: Remote Sensing Process

Source: Avinash k. R. et al., 2016

In this study, data sets from multi-lateral Landsat satellite images for the research site will be collected. The imageries, from 1 – 8 Land satellites, shall cover the period from 1985 to 2019 to assess in land use/cover change over the past 34-year period. Each land sat consists of different spectral bands with different spatial resolutions. Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images for instance consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. Among these bands, bands 1, 2, 3, and band 4 from 1-7 Landsat and bands 2, 3, 4, and 5 are from Landsat 8. Therefore, in this research ground truth data would be included regarding land use / cover classes for reference. Geographical Positioning System (GPS) will be used to collect data for the 2019 imagery classification, assessment, verification and analysis.

The methods and approaches in the assessment of the land cover (or land degradation) change of the study area would use a remote sensing and GIS (QGIS with SCP tool) techniques. The assessment LULC change through time would mainly focus on the multi-lateral Landsat satellite imageries with 5 years' period.

In order to assess the land change, remote sensing imageries from the Landsat satellites would be used. Different Landsat satellite imageries (Figure 3-5) from 1972 will be observed from space and provide data that help the public and scientific community to understand the state and condition of Earth's surface through time. The level of detail of spatial resolution is often the most interesting aspect of viewing a satellite image including how different feature surface materials reflect changes in irradiative energy. Different methods would be used for land degradation studies, including field observation, expert judgment (Sonneveld, 2003) and use of remote sensing and GIS approaches (Amissah-Arthur et al., 2000; Sujatha et al., 2000; Haboudane et al., 2002; Thiam, 2003; Wessels et al., 2004).

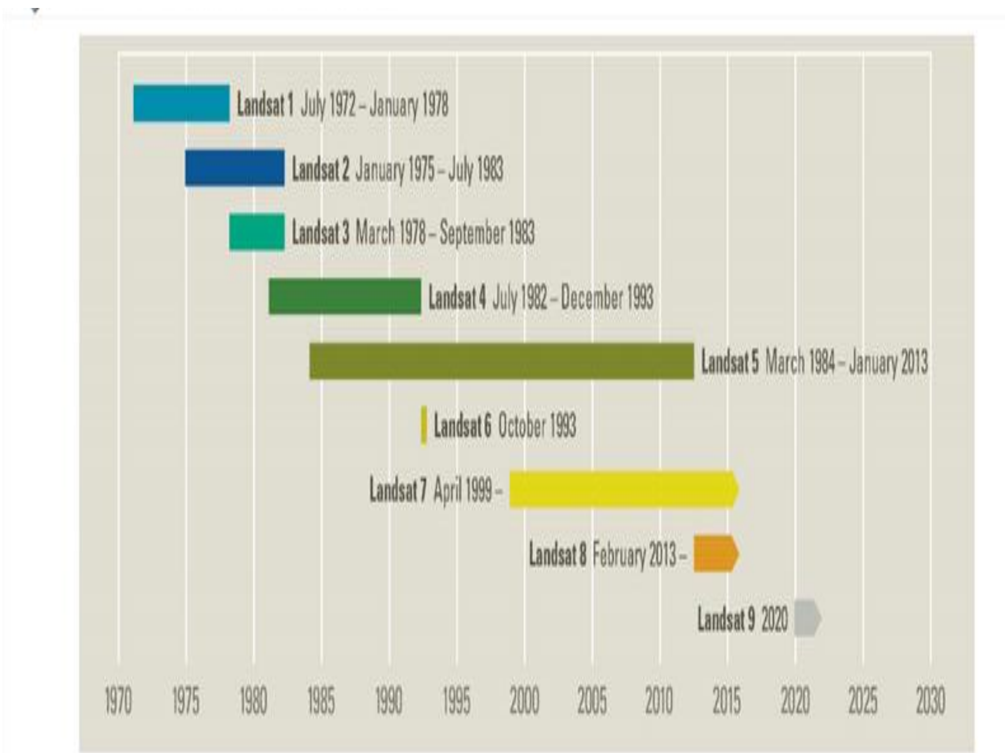


Figure 3-5: The Time Frame of Landsat Satellites
Source: Sonneveld, 2003

Satellite remote sensing can help to enhance largely the capabilities of monitoring, implementation, and actual state of land uses in a comprehensive and timely manner. It fulfills the requirements for monitoring and mapping the status of agricultural land use and land change, because satellites deliver objective and timely information regularly (every 5-6 days). The high spatial detail of satellite images (10-meter pixels) enhances the tracing of these activities at different scales: from the single field level (study area) and even up to country level. In summary, the remotely sensed data are used to visualize the LULC changes of the study area and will be verified using the ground truth for the last 34 years using GIS tools and statistical techniques to analyze the effects of environmental degradation of the study area.

3.3.2 **Spectral Responses of the LandSat**

For the understanding of the remotely sensed data and the spectral responses, the following tables: Table 3-2, Table 3-3:, and Table 3-4: presented (Barsi, 2014; Lee, 2014; Kvaran, 2014; Markham, 2014; Pedelty 2014).

Table 3-2: LandSat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Band	Wavelength	Resolution (meters)	Useful for mapping
Band 1 – Coastal Aerosol	0.43 - 0.45	30	Coastal and aerosol studies
Band 2 – Blue	0.45 - 0.51	30	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from vegetation
Band 3 – Green	0.53 - 0.59	30	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 – Red	0.64 - 0.67	30	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57 - 1.65	30	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11 - 2.29	30	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.50 - 0.68	15	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.36 - 1.38	30	Improved detection of cirrus cloud contamination
Band 10 – Thermal Infrared (TIRS) 1	10.60 – 11.19	100 * (30)	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.5 - 12.51	100 * (30)	100 meter resolution, Improved thermal mapping and estimated soil moisture

* TIRS bands are acquired at 100-meter resolution, but it is resampled to 30 meter.

Source: Barsi, 2014; Lee, 2014; Kvaran, 2014; Markham, 2014; Pedelty, 2014.

Table 3-3: LandSat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 4-5 TM

Band	Wavelength	Resolution (meters)	Useful for mapping
Band 1 – Blue	0.45 - 0.52	30	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 2 – Green	0.52 - 0.60	30	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 3 – Red	0.63 - 0.69	30	Discriminates vegetation slopes
Band 4 - Near Infrared	0.77 - 0.90	30	Emphasizes biomass content and shorelines
Band 5 - Short-wave Infrared (SWIR) 1	1.55 - 1.75	30	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 6 - Thermal Infrared	10.40 - 12.50	120/60 * (30)	Thermal mapping and estimated soil moisture
Band 7 - Short-wave Infrared (SWIR) 2	2.09 - 2.35	30	Hydrothermally altered rocks associated with mineral deposits
Band 8 - Panchromatic (Landsat 7 only)	0.52 - 0.90	15	15 meter resolution, sharper image definition

* TM/ETM+ Band 6 is acquired at 120/60-meter resolution, but it is resampled to 30-meter pixels.

Source: Barsi, 2014; Lee, 2014; Kvaran, 2014; Markham, 2014; Pedelty, 2014.

Table 3-4: LandSats1-5 MSS and Images with 60 Meter Spatial Resolution.

	Landsat 1-3	Landsat 4-5	Wavelength (micrometers)	Resolution (meters)
Landsat 1-5 Multispectral Scanner (MSS)	Band 4 – Green	Band 1 - Green	0.5-0.6	60*
	Band 5 – Red	Band 2 – Red	0.6-0.7	60*
	Band 6 - Near Infrared (NIR)	Band 3 – NIR	0.7-0.8	60*
	Band 7 - Near Infrared (NIR)	Band 4 – NIR	0.8-1.1	60*

* Original MSS pixel size was 79x57 meters; production systems now resampled to 60 meters

Source: Barsi, 2014; Lee, 2014; Kvaran, 2014; Markham, 2014; Pedelty, 2014.

3.3.3 Image Classification and Color Coding

Image Classification

Image classification is the digital image classification procedure that automatically classifies all pixels in an image into land classes or themes (Lillesand et al., 2004). The three types of image classifications are: supervised, unsupervised and hybrid of which the first two are adopted for this study. In addition, image classification refers to the extraction of differentiated classes or themes, usually land cover and land use categories (Weng, 2012).

In unsupervised classification approach, the satellite collected image data is classified as aggregating into natural spectral grouping or clusters present in the scene. This is followed by effecting / determining the land cover type from this spectral grouping of the classified image, which would help as a data for ground referencing (Lillesand & Keifer, 2004). An appropriate method and version would be put in place to assist in producing land use / land cover classification. In addition, true color and false color composites are employed to assessing the visualization of the land use.

In the supervised classification system, supervision is conducted as related to pixel categorization process specifying numerical descriptors (groups of digital numbers (DN) values), of the various land cover types present in the scene and processed through a computer system. A sample site representing the known cover types, called training areas is used to compile a numerical interpretation that describes the spectral attributes for feature type of interest (Lillesand et al., 2004).

In the post classification method, due to the inherent spectral variability encountered by the classifier as applied on a pixel-by-pixel basis, the classified field data often manifest a salt and pepper appearance (Lillesand & Keifer, 2004). In this type of classification, it is possible, that various pixels representing different land cover classes (forest, shrubs) are distributed over a given farmland and that will be classified as a farmland crops or vice-versa. In such circumstances, it is desirable to smooth the classified output that the dominant classification is taken as a classified land cover of the area of interest, through the application of statistical filtering mechanism (Amanuel, 2015).

In accuracy assessment, it is essentially a measure of how many ground truth of pixels were classified correctly which is important function in the classification of accuracy in order to check for errors propagated during the data collection process, analysis and conversion from one form to the other (Edward et al., 1998).

The overall objective of image classification procedures is to categorize image pixels into land use/cover classes. Hence, the most suitable and preferable classification method would be chosen to perform the classification of land use and land cover mapping of the proposed study area according to the standardized classifications. It is also required to classify images after field verification, which includes renaming, combining, and separating of land use and land cover types.

Color Coding

In order to understand the land cover features, a color-coding and combinations of bands are taken into consideration. These are: *Agriculture* (4-3-1), which is useful for monitoring agricultural crops. *Natural color* (3-2-1) is natural visible band, which provides the most water penetration and superior sediment and bathymetric information. It is used also for urban studies. *False colors* (7-5-3) provide a natural-like rendition and vegetation appears in shades of dark and light green during the growing season, urban features are white, gray, cyan or purple, sands, soils and minerals appear in a variety of colors. One particular application for this combination is monitoring forest fires. Flooded areas should look very dark blue or black.

Color infrared (4-3-2) -here vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. Generally, deep red colors indicate broad leaf and / or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue. *Land / water* (4-5-3) is good for picking out land from water. *Vegetation analysis* (5-4-3) is useful for vegetation studies, and is widely used in the areas of timber management and pest infestation. Finally, the Normalized Differential Vegetation Index [NDVI = (4-3)/ (4+3)] is often used to monitor drought, monitor and predict agricultural production, assist in predicting hazardous fire zones, and map desert encroachment. NDVI is a standardized vegetation index applicable in the area of climate change, agricultural production, desertification, land use/cover change, vegetation health and other related project

3.3.4 **Land Use Land Cover Change Detection Analysis**

Change detection as defined by Sing (1989, cited in Atalel, 2014), is the process of identifying differences in the state of object or phenomena by observing them at different times by using remote sensing techniques.

Among various benefits of change detection are crop / vegetation phenology, changes in environmental setting, status of ecosystem management, as related to spacio-temporal effects where comparison between two points of a period is performed. A good change detection analysis should characterize area change and rate of changes, special distribution of changed types, change trajectories of land cover types and accurate assessment of change detection results (Atalel, 2014).

In change detection research, using remotely sensed data techniques, image classification and accuracy assessment functions are important parts of the issues to undertake the change detection analysis. This supports effective utilization in planning and decision making process thereby effect a good result through the corresponding implementation of the planned activities as affecting the social, economic, political and environmental amenities for the betterment of current living pattern and wellbeing of future generations. Integration of the maps of the communities and their other knowledge resources with the digital change detection analysis endeavors would make the analysis process sound better.

As digital change detection can be affected by certain constraints, including spatial, spectral, thematic and temporal properties, it is important to select suitable method or algorithm for change detection.

The current most commonly used methods of change detection covers are: image regression method, image ratio method, image-differencing method, and post classification method (Xu et al., 2009). Some methods such as image differencing and post classification provide change or non-change and complete matrix of change detections respectively.

3.3.5 Flow Chart - General Methodology - LULCC of the Watershed

In satellite image processing and classification, detection of changes has been used in association between the biophysical phenomena on the ground and the acquired imageries (Coppin; Jonckheere; Nackaerts; Muys; Lambin, 2004). In this regard, land use and land cover study is important in land use planning, natural resource assessment and monitoring, and land management. The study benefits further to develop strategies to balance conservation, conflicting uses, and development pressures. Satellite-based observations have provided spatial and temporal consistent images of the state of land use and land cover mapping and change detection. The following flow chart, Figure 3-6, illustrates of the general methodology for studying land-use-land-cover and change detection.

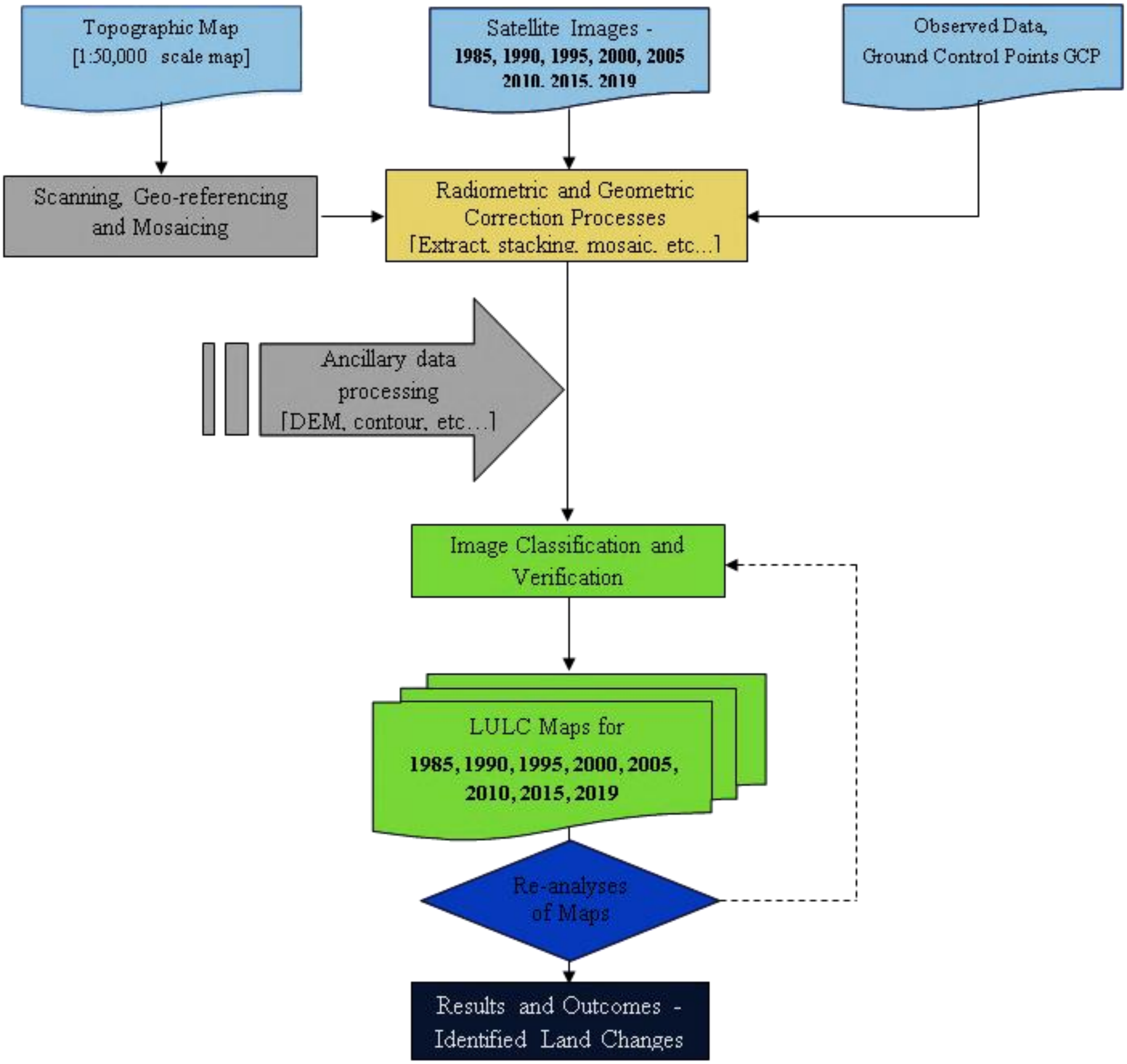


Figure 3-6: Flow Chart of the General Methodology for Studying Land-Use-Land-Cover and Change Detection

3.4 Selection of the Study Area

3.4.1 Introduction

A population of about 400,000, of which, 210,000 male and 190,000 female are living in the Belbela-Wadecha watershed area. About 161,000 hectares of land area of the watershed is administered by the Woreda unit (Wakena, 2008).The land is mainly used for agriculture, with more than 70% of the area cultivated for crop production, and the rest is apportioned among other land uses including livestock grazing area, shrubs, forests, uncultivable formations. As livestock population is high, overgrazing is quite an issue at stake in addition to the vanishing of forests at an alarming rate owing to the diversified uses by the community of the watershed environment.

Therefore, an attempt would be made in this study to map out the status of population pressure and its impact on LULC of Belbela-Wadecha catchment area. The researcher, in this regard, would establish the main causes of land use / land cover change through a household questionnaire and focus group discussions, including the Participatory Action Research process.

GIS and remote sensing techniques can show vegetation changes over time as well as change in the size of water bodies, which can be augmented by vegetation survey information on the ground over the chosen period. There will be a combination of physical evidence from GIS and observations. The effects will be determined from the GIS process and triangulated with participants' observations on the ground, which is drawn from real life experiences.

Reasons for the selection of the study area are as follows:

- It represents much degraded land with the concomitant silted up reservoir for the irrigation scheme.
- It is relatively most accessible to conduct the research.

3.5 Sampling Procedure

According to Tailor (2005), 'Sample' is argued as portion of a given population. "A Sample is a segment of the population selected to represent the population as a whole" (Tadesse, 2014:31). Population, according to Walliman (2011), is noted that population reflects not only a number of people. Ilker E. et al. (2015) state that: although many often relate population to people alone, it also can consider other quantity of inputs necessary for research discourse.

In relation to this, a purposive non-probability sampling technique was used, including a limited use of probability sample design where so required, with a view toward addressing the peculiarities of the particular watershed area (Twenehboah, 2009). Accordingly, a selected community section had been targeted based on the area delineated for the research purpose.

Sampling focused on, two specifically selected areas with irrigation schemes in the watershed area, namely, Godino scheme covering 1396 ha being developed under Wadecha reservoir and, Qoftuu scheme covering 1133 ha being developed under Belbela reservoir, both growing vegetables. The beneficiaries of the schemes are 1770 and 1200 people respectively. Sampling also covered an area upstream of the Belbela reservoir, where there is no irrigated farm, to help assess the living patterns of the communities in each site and their impacts on the watershed environment.

The site selections were confirmed using the opinion of the communities, extension agents and agricultural officers with extensive experience and good knowledge of the study area. A consensus was reached that the selected sites would reflect the characteristics of the other sites in terms of socio-economic spheres and other environmental realities.

Owing to the big number of households (Godino – 636, Male 553 Female 83 and Qoftuu – 533, Male 469 and Female 64, making a total of 1169) in each target area, it would be inconvenient to administer the questionnaire to all households in the two sites. Therefore, the researcher selected twenty percent of the total households size (Godino – 127 and Qooftuu 106, making 233) from each area, which according to Cabal (2000) is adequate to provide policy relevant insights and answers to the main objectives of the study without involving large-scale survey and rigorous statistical analysis. The targeted participants were twenty-two years old or above.

3.6 The Research Method/Approach

The research design selected for the study area is a case study type. Creswell (2007) states that case study research is a qualitative approach in which the investigator explores a bounded system over time through detailed, in–depth data collection involving multiple sources of information (such as observations, audiovisual material and documents and reports). However, because of the nature of the study, a mixed method approach involving both qualitative and quantitative research methods shall be employed having equal weight, status and applied concurrently. In addition, "Mixed methods research designs are moving across the disciplines" (Sharlene, 2010: 1) Nancy et al. (2007: 270) state that "A partially mixed concurrent equal status design involves conducting a study with two phases that occur concurrently such that quantitative and qualitative phases have approximately equal weight." This is the type of mixed method research design adopted for this study.

For qualitative data collection method Participatory Action Research (PAR), Focus Group Discussion and Questionnaire Survey techniques were employed in this research. In the trial plot of this research, an approach to PAR process extensively involved communities of the study area from the start to finish covering site identification, data collection and analysis.

Quantitative data collection approach involving the application of GIS and Remote Sensing techniques using ArcGIS software was used additionally as one of the instruments to detect land use and land cover change practices, over a long-term period, for more confidence building purposes.

Therefore, considering the mixed method type, as referred to above, is an appropriate choice for this study. Hanson, Creswell, Plano Clark, Petska, and Creswell (2005: 224) state that mixed methods "Involve[s] the collection, analysis, and integration of quantitative and qualitative data in a single or multiphase study." Johnson and Onwuegbuzie (2004:21) further refer to mixed method research design as "words, pictures, and narrative can be used to add meaning to numbers." In other context, qualitative data (words pictures and narrative) can be used in combination with qualitative, numerical data, for studies, examinations and analysis. Greene, Caracelli and Graham (1989) argue that five points: triangulation, complementarity, development, initiation and expansion, provide strong reasons for a researcher to apply a mixed method research design. This will give the researcher an opportunity to follow the mixed method research design and to view the past and current practices and help design future directions to revitalizing the watershed environment.

3.7 Methods of Data Collection

3.7.1 Introduction

Qualitative and Quantitative data collection techniques were used in the study. Primary data collection included questionnaires, field survey including undertaking pilot test / pilot (research) scheme, and focus group discussions. Secondary data collection comprised data captured from existing reports, library research, online, research, journals, and books, proceedings of conferences, public records, and publications of the central and state governments (Prathapan, 2014). GIS, Remote Sensing, and PAR were used also in the data collection process.

3.7.2 Secondary Data Sources

The following institutions were approached and respective documented data were obtained. All their data were available in the public domain.

- Ministry of Forestry and Environmental Protection
- Ministry of Water, Irrigation, and Electricity
- Oromiya Irrigation Development Authority
- Ministry of Agriculture
- Geological Survey of Ethiopia
- Awash River Basin Authority
- International Water Management Institute

3.7.3 Qualitative Data Collection Method

This study largely focused on the use of questionnaires, focus group discussions and observation techniques, to effect the qualitative data collection. The aim of using a qualitative approach is to shed light on the respondents' attitude in order to understand why they behave the way they do and further understand the reasons they attach to certain actions (Twenehboah, 2009).

Focus Group Discussions

Traditionally, focus group research is “a way of collecting qualitative data, which—essentially—involves engaging a small number of people in an informal group discussion (or discussions), ‘focused’ around a particular topic or set of issues” (Wilkinson 2004: 177).

It is an important way of obtaining, in a simple but effective way, respondents' perceptions and understanding. The focus group discussions would include local residents and government representatives in the watershed area. A checklist was prepared to help guide the discussion.

A focus group discussion is an important instrument in obtaining a relatively realistic data on the subject study area through the purposively sampled group of community of the area who are believed to be relevant for the scheduled discussion. The aim of using this method, other than developing broad and deep understanding of the study circumstances, is to have a feel of respondents' background reasoning attached to a particular subject and why that reasoning was attached to the subject. In this regard, focus group approach was used for purposively selected local government officials and farmers who were born and lived in the area for long years of time where each group of participants amounting to 12 household heads would participate from the selected communities, namely from Godino and Qoftuu areas as indicated under sub-article 3.5. Use of questionnaires and Participatory Action Research (PAR) methods were also included

All recordings and discussions were transcribed and included in the results, as necessary. In addition, listening to the recordings over and over again enabled the researcher keep the issues and interaction procedures in mind throughout the length of the study process.

According to Morgan (1997:6), focus group is defined as "a research technique that collects data through group interaction on a topic determined by the researcher". (Vaughan et al., cited in Puchra & Potter, 2004:6) state that focus group discussion covers the goals including to "elicit participants' feelings, attitudes and perceptions about a selected topic". In addition, as the questionnaire was prepared in an open ended format, participants could expand on their statements that they made during their participation. This type of discussion helped to understand the motive behind their responses and the content of their reasoning and helped as to where the argument was driving at or achieving what. Denscombe (2010:115) notes that focus group discussion "consist of small group of people who are brought together to explore attitudes and perceptions, feelings and ideas about a topic".

Accordingly, focus group discussions were held with two key entities, a selected group of farmers and government officials.

Farmers' Focus Group Discussion

A group of selected individuals from the sample area (Godino and Qoftuu) was invited to participate in the Focus Group Discussion totaling 12 participants and all present. Selection of the participants focused on those who were born in the area and still leave there, with a view to benefiting the possessing of a more reliable data that would result from their longer stay of time period in the area. Discussion started at 11:00 AM, on December 17, 2018 and ended at 11: 45AM.

The researcher opened the discussion by welcoming the participants and introducing himself to the discussants and explained the purpose of the meeting that the aim was to gather information on natural resources degradation status in the Belbela-Wadecha watershed area. The researcher further explained that any participant was free to participate or not and free to leave at any one time if not willing to, at any point during the discussion. The discussants were also told that there would be electronic recording and photography, upon their permission and the researcher further went on to say that, the photos that would be taken would be treated technologically in a way that obstructs the clear vision of the faces of the respondents. Accordingly, the participants concurred with that both electronic recording and photography would be possible. However, from anonymity point of view, the captured photograph was edited in such a way that the faces of respondents are made blurred in a manner that no one could notice who the participant was. Figure 3-7 shows focus group discussion. The interview guide for farmers' focus group discussion is shown in Annex – 1.

Figure 3-7: Focus Group Participants

Interviews

(Cunningham, 1993:93) states that: "In depth interviews are open-ended face-to-face interactions, in which an interviewer tries to elicit a respondent's knowledge, opinions, feelings or behavior related to a defined set of topics. Interviews provide the opportunity for the researcher to investigate further, to solve problems and to gather data, which could not have been obtained in other ways". In depth interviews are similar to group discussions, but in depth interview discussions are processes that usually only one person is interviewed at a time as opposed to focus group discussion where any respondents are free to respond to the topic opened up for discussion by the researcher.

Cannell and Kahn (1968) define the interview as a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information. This form of interview, according to those referred to above scholars, focuses on the contents and objectives set by the researcher.

The semi-structured interview is suitable for this study (Tuckman, 1972), it makes it possible to measure what a person knows, what a person likes or dislikes, and what a person thinks. This type of human characteristics elicit human attitudes and beliefs which largely would account for the real life position of the situation and that in turn contribute to a successful conclusion of the study as it would be based on a data collected from a real life scene.

However, it is noted that the difference between the in depth interview and focus group discussion being of no significant amount and can be flexibly accounted for if deemed necessary, the focus group discussion is the selected type of data collection method to be followed in this study. The difference between the two, as referred to above, can be restated as that in the interview type of process, one is interviewed at a time, but, in the focus group technique, everyone else is free to comment without procedural limitations. Hence, it is perceived that no essential data collection benefits would be missed because of dropping the in-depth interview process from this study.

Questions could be generated also from, among others, secondary data source including other reports on the study area and through field observations as stated under research questions sub-article 1.10.2 to elicit responses on environmental issues.

The interview guide, therefore were presented to them and responses were recorded. The participation took place by any individual who was ready and willing to participate without procedural limitations/restrictions.

Government Officials' Focus Group Discussion

A group of assorted individuals from different Government institutions at various operative levels was invited to participate in the focus group discussion. The discussion was scheduled for 17 December 2018 at 3: PM in the office of the Woreda for natural resources, and all were present. The meeting lasted 30 minutes, owing to the participants' busy schedule. The participants of the meeting consisted of the bureau head of the natural resources, Woreda Environmentalist, Irrigation Coordinator of the Woreda and Kebele Administrators for both sampled areas of Godino and Qoftuu.

The Researcher informed the participants of the objectives of that scheduled meeting after having introduced oneself.

Survey Questionnaire

A questionnaire (open ended) was used to collect primary data. The questionnaire was developed reflecting on four major issues, background information of the respondents, formal and informal institutions on environmental management within the study area, the watershed environment, and the local economy. Accordingly, the 233 (sample size) respondents have addressed each issue in accordance with its particular aspects (as captured, Annex 3).

In addition, the community in the pilot study area was consulted informally in order to probe their perception on watershed conservation practices prior to and after the implementation of the restoration project.

Participant Observation

This method would help obtain more information and knowledge on the watershed community that will help build more access into gathering more relevant data with a view to help analyzing it more appropriately. It would also help to modifying the survey questionnaires and focus group discussion guideline where necessary, and to acquire information on the physical setting of the area.

Robson (2002) contends that with observation, a researcher gets the real life experiences in the real world of the participants. Robson (2002) also states that the researcher is not required to ask people, but only listen to what participants say and watch what they do.

Participatory Action Research (PAR)

Qualitative data collection was carried out also through PAR process. Castellanet et al. (2002: 21) state: "PAR is a way of organizing this dialogue with science and helping people become conscious of their limitations as well as their potential strengths". (Parkes & Panelli, 2001) argue that PAR is a tool where researchers and researched population come together to form collaborative relations to identify and address issues jointly perceived through process of research and action. Although techniques associated with PAR are similar to those applied in Participatory Rural Appraisal (PRA), including community mapping and transect walks, PAR is more consistently oriented to community empowerment and capacity building (Martin et al., 2012).

Different routes of transect walks were carried out with the community through a route chosen by the community themselves, as they knew their site where intervention was deemed necessary and also where they could explain problems and discussed concerns and priorities for action with the transect walk team. Information on the transect walk was collected, including photographs, and recorded and stored in a GIS system. The stored data would be incorporated later on also into GIS-supported community maps.

Community mapping could denote areas including those used for cultivation, grazing, road lines, schools, churches, and settlement and wastelands. Information obtained during the transect walk could also have been accordingly incorporated into the maps. Once the maps were produced, they could be used at community meetings to help discuss and elaborate on areas of concern within the community. The maps could also further assist in presenting their issues to potential entities including the Government and NGOs for intervention. Moreover, the maps could have been cross-referenced also with satellite imageries in order to compare and contrast or make verifications (ground truth).

The approach and the steps followed as a qualitative data collection instrument through PAR process are given below.

The PAR Process

Introduction

A few steps that were followed during the research process will be looked at that characterize joint operations of both the researcher and the community starting from problem identification through to the implementation of the scheme, including monitoring and evaluation of the project. The steps followed would include identification of the problems with the affected communities, participatory response planning to respond to the problem, participatory action phase, and deliberations (participatory reflections).

Identification of problems with the communities

- As a first instance, the community and the researcher convened to discuss the problems of the watershed area relating to natural resources degradation of the area. Accordingly, after thorough discussion, consensus was reached that, Godino and Qoftuu areas were selected to be the chosen representative areas of the watershed area by the community. The reasons for selection of the areas mainly hinged on that includes the communities that were selected were in close proximity to the reservoir for irrigation purposes and showed a relatively more degraded environment. The area also featured the availability of wasteland and a characteristic steep slope. In addition, the site gives an opportunity for close and easy accessibility to and from Addis Ababa, enabling the researcher as many trips as possible for undertaking research activities when necessary. Subsequently, a walk through the areas was made by undertaking different lines of walk attempting to identify areas apparently affected by degradation phenomenon relating to land and forest induced by humanity. During the joint transect walk, supported by an Ecologist, the types of ecological sustainability problems, extent of problems and general observations were noted and recorded and this was supported with GPS.
- Following a number of routes that were taken, one route was particularly selected in Qoftuu area on which potential demonstration site was identified and unanimously agreed upon by the team as suitable site that pilot testing and demonstration activities could take place. The chosen site satisfied the pre-set criteria for pilot testing and the provision of a plot of land for demonstration purposes with a view towards effecting revitalization of the

watershed ecosystem through revegetation / re-afforestation efforts. In this respect, participatory mapping was done also with the selected communities.

The beneficiary participants did community mapping at the end of the visit at coordinate point of 506223E, 9766748N as shown in Figure 3-8.

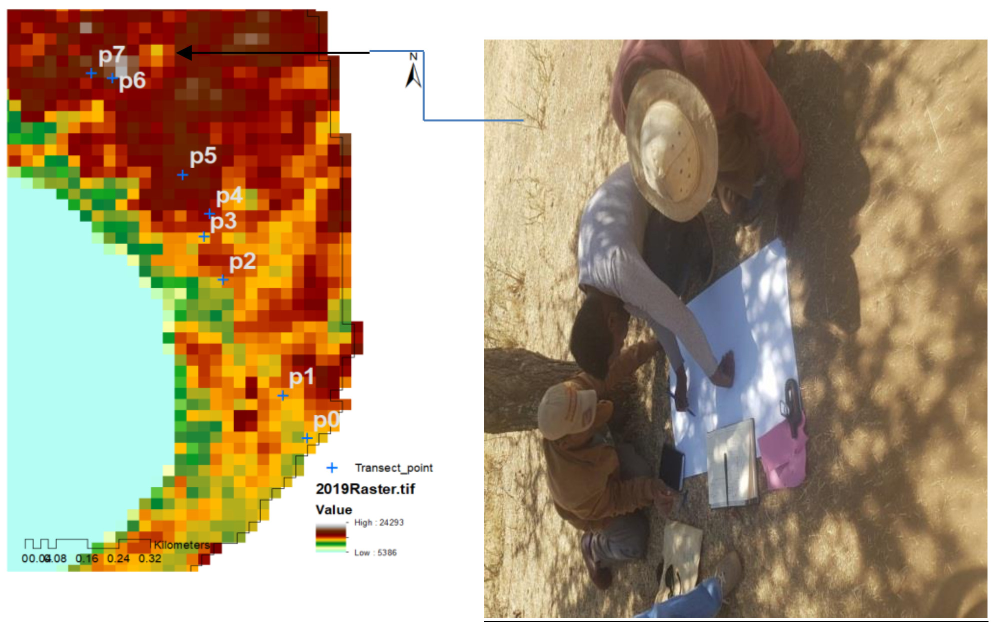


Figure 3-8: Participatory Mapping

Participatory response planning to respond to the problem

- Priorities: Under this section, priority areas were identified collectively considering each problem listed under problem identification section above. The priority list also accounted for the type and degree of environmental degradation to help plan for short, medium, and long-term scenarios. Interventions included one selected plot for demonstration purposes.
- Resource requirements: To help identify the resources needed, to resolve the problems, focus would be given to the degree of the problems of environmental degradation and how this can be addressed efficiently and effectively, taking the pilot scheme as a sample plot. This section would have further considered period, budgetary provision, labor, equipment and other machinery requirements as needed.

- Resource availability: Availability of all the required resources would be assessed and provisions made for so that subsequent implementation would not be hampered because of failure to provide the required resources for the project in light of implementing the project effectively and timely.

Participatory action

- Implementation of the plan and the pilot scheme would be undertaken with due care that a close follow-up by the community and local administration would be very important. The two parties (the researcher and the community) should ensure that the period, budget, labor, equipment and other resources needed would have been deployed in the implementation process well in line with the resources allocation plan shown under participatory response planning section above without exceptions.

Participatory reflection (deliberation)

- Evaluation of the project: The two parties reconvened and reflection was made on the status of the implemented project and consensus was reached on the project's success in meeting the targets set at the planning stage. The deliberation further under scored that the possibility that the project could be replicated elsewhere where similar problems would be the case in point.
- According to Prathapan (2014), this project may be considered in a way that the hypothesis becomes a 'Theory or a Law', thereby no revision of the problem is required for the next cycle.
- Transect walk: A joint transect walk with the community through the agreed upon path in the watershed area was made again to identify if changes had been made because of the implementation of the project. Following the transect walk in the watershed environment and recorded observations, participatory mapping was done. Joint observation was made only on the pilot scheme, as watershed-wide implementation was not done as it involves a large amount of finances, which the researcher did not have at the time of the study.

- Comparison of the maps: Comparison between the participatory mapping last made and satellite imageries was made as means of triangulation. Similarity between the two mapping systems could lead to the findings being considered as a 'Theory or a Law'.

3.7.4 **Secondary Data Sources**

Data collection was done also through use of secondary data sources involving various pre-identified institutions and from primary data sources of interviews, focus group discussions and observations. Although all secondary data sources were obtained from public domain resources, they were all duly acknowledged. Primary data was obtained using different instruments including focus group discussion involving farmers and government officials, participatory action research, and questionnaire surveys. The focus groups used guiding questions where participants replied freely and without coercion. The participants were free to give or not give information, to participate fully or partly or to decline entirely. These procedural rules were made clear to the respondents before any objective session commenced. Electronic recording and photographing possibilities were made also clear to them and they were asked if they had any objections to these propositions. All participants concurred with the propositions. However, for anonymity reasons, the faces of the respondents were obscured in a way that no one would identify them.

3.7.5 **The Pilot Scheme**

It was thought necessary to undertake a pilot test to identify problems and seek possible solutions related to environmental degradation of the watershed area. Accordingly, a site with a size of about 0.3ha (50x60m) was selected, coordinate points are given in Table 3-5 - in partnership with the community and experts in the related field (topographic map, Google earth, Figure 3-9).

Table 3-5: Coordinate Points of the Pilot Scheme

PROJECT AREA

ZONE 37 ,PROJECTION=ADINDAN

EAST	NORTH	ELEVATION	REMARKS
505065	975626	--	1
505070	975661	--	2
505003	975650	--	3
505004	975631		4

Pilot Scheme

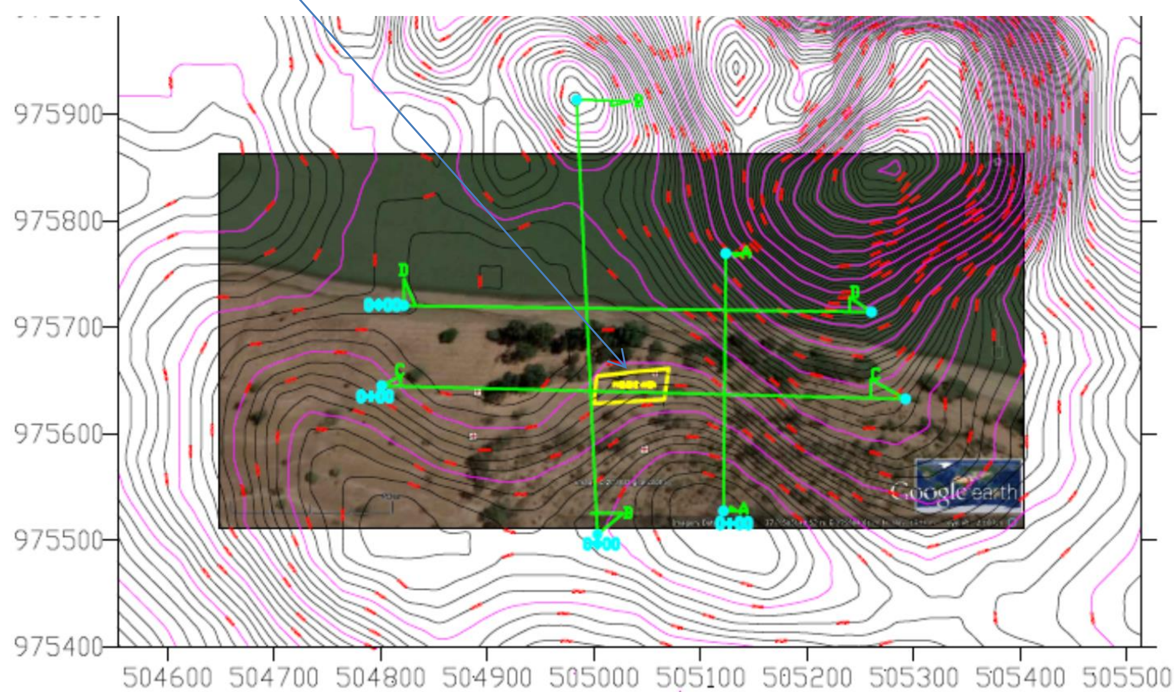


Figure 3-9: Topographic Map of the Pilot Scheme

The selected plot characterized the criteria set early on prior to the start of the transect walk. The characteristic plot features included steep slope, close proximity to the dam inundation and adjoining a cultivated land.

Following the selection of the test plot and having done enclosure fencing, pits were excavated and made ready (Figure 3-10) for planting seedlings on the selected study area. The planting activity was carried out on a planting grid (of 1.5x1.5m spacing), (Figure 3-10) as advised by an ecologist and agronomist, which is more like following the contour line. In addition, a soil scientist advised the researcher to perform a soil test to help scientifically identify the properties of the soils of the pilot area for identifying the possible crop types and determining the most convenient soil conservation methods on the identified soil characteristics.

Six test pits were excavated, each to a depth of 40cm, which were evenly distributed in the pilot plot and all soil samples were uniformly mixed to bringing into one pack of soil sample for laboratory analysis.

The laboratory test was carried out identifying the soil texture and organic matter content as loam and 0.936% respectively. The analysis was carried out through the institution of Laboratory Research and Training Centre of Ethiopian Construction Design and Supervision Works Corporation, Annex-5. The Laboratory Test Analysis also helped in fixing the k value of the soil and related percentage of organic matter content. The test identified the soil as being unstable type of soil character for organic matter content being less than 3.5 percent (Oswal, 2018). Accordingly, a rough soil loss estimate was done, Annex – 6 depicts. The pilot scheme cross section profile was used in the calculations of the soil losses where parameters including slope length were calculated from, Annex- 4. Accordingly, the demonstration plot was planted with related indigenous trees as a vegetation restoration trial.

Figure 3-10 and Figure 3-11 show photographic evidence of the site handing over and planting the seedlings.

Figure 3-10: Site Handing Over and Community Tree Plantation Preparation Process at the Pilot Scheme

Figure 3-11: Planting the Seedlings

3.7.6 Quantitative Data Collection Methods

Two types of quantitative data collections were used in this research study, namely satellite and ancillary. Satellite data covers eight years multi-temporal satellite imageries of 1985, 1990, 1995, 2000, 2005, 2010, 2015, and 2019 for the month of February.

The eight types of data sets from multi-lateral LandSat satellite images were collected and deployed. The eight types of multi-temporal LandSat data of the 1985, 1990, 1995, 2000, 2005, 2010, 2015, and 2019 that are used are imageries from 1 – 8 Land Satellites. Each LandSat consists of different spectral bands with different spatial resolutions. LandSat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9 were employed. Among these bands, bands 1, 2, 3, and band 4 from 1-7 LandSat and bands 2, 3, 4, and 5 are from LandSat 8. These satellite data were acquired from the USGS Login web portal and Earth Explorer and GLOVIS websites.

Ancillary data included ground truth for land use –land cover data classes collected in the form of reference points. Geographical Positioning System (GPS) would have been used also to collect for the 2019 imagery classification and assessment, verification and analysis. GPS collected information could be processed through GIS manipulations for further use in the decision-making procedures.

Moreover, different images showing the current condition of the land use/ cover classes were collected; Figure 3-12, on the ground at specific locations using GPS for verification of the real conditions on the ground.

GIS and Remote Sensing tool based data collection techniques for the years 1985, 1990, 1995, 2000, 2005, 2010, 2015, and 2019, were employed. Remotely sensed data collection techniques were undertaken during clear sky state or minimal cloud. Community mapping and ground truth activities supported this data acquisition approach. Data collection for ground truth activity was performed also, for the year 2019, through the application of GPS device and that the GPS points and corresponding LULC classes were compared against the GIS and Remotely Sensed imageries. Finally, the results of both sources found to comply with each other that it would be used to design future intervention mechanisms.

Figure 3-12: Images Collected from the Study Area

3.8 Data Analysis Methods

3.8.1 Introduction

The data analysis was done both quantitatively and qualitatively. According to Dey (1993: i) state, "The perspective of qualitative data analysis is pragmatic rather than prescriptive, introducing different possibilities without advocating one particular approach". Qualitative research indicates the feelings and perceptions of the respondents in the form of descriptive data. It relates to non-statistical methods and small, purposively sampled populations into a not well researched subject (Polit & Hungler, 1997).This method, in this research, involved use of open-ended interview questions, focus group discussions, questionnaire surveys, observations and included participatory action research reflection. The data was analyzed qualitatively.

According to Natasha et al. (2005), qualitative research produces culturally specific and contextually rich data and the method involves less formal interactions between the researcher and the participant. It is also open-ended and flexible as opposed to quantitative methods that are characterized by closed-ended or fixed and inflexible questions. Qualitative research methods also allow for meaningful comparison of responses of participants in the study area. The qualitative data collected in this study was open ended and flexible.

Field notes are written based on the information gathered from the site of the study and the nature of participation. Patton (2002:305), in this regard state, "When field notes are written will depend on the kind of observations being done and the nature of your participation in the setting being studied". In addition, Sarah (2013:114) states, "The field notes writing process is methodological and systematic, yet also playful and inventive".

Quantitative research involves a systematic gathering of information, which would be translated into numeric data and analyzed using statistical methods (Polit & Hungler, 1995). Quantitative research is: "Explaining phenomenon by collecting numerical data that are analyzed using mathematically based methods (in particular statistics)" (Aliaga & Gunderson, 2000:1). In this study, descriptive statistical method of analysis would be employed to support the image analysis method that would include Tables, graphs and other related statistical parameters. The image analysis would involve Land Use and Land Cover change that would be analyzed using the remotely sensed data from LANDSAT/NASA source.

3.8.2 **Qualitative Data Analysis**

The outcomes of the focus group discussion, PAR, questionnaire survey and interviews were analyzed qualitatively. The purpose of using this approach was to throw light on the respondents' underlying subjective feelings with a view to understanding why they do the way they do and trying to sense the reasons why they attach to certain practical actions. The results obtained are discussed at length under chapters four and six.

3.8.3 **Quantitative Data Analysis, Remote Sensing and GIS**

Descriptive information was presented in tables, including frequency tables, and figures including graphs, that show raw numbers and in terms of percentages of the total derived from factual questions posed during field data collection.

Based on the data collected in line with the study objectives, the land use and land cover changes were assessed and analyzed. Land cover refers to the physical characteristics of the earth's surface, captured in the distribution of vegetation, water, soil and other physical features of land, including those created solely by human activities, settlements, etc. On the other hand, land use refers to the way in which land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities (Ramachandra, 2004). The land use and land cover changes were detected using satellite imageries over time and were verified using ground truthing.

Globally, land use and land cover can be changed through time. In this study, to understand the significance of long-term changes and trends, GIS and remote sensing techniques were adopted to analyze vector change, image analysis, post-classifications and comparisons of remotely sensed imageries. Therefore, the land use and land cover change detection were addressed using post-classification techniques to detect the changes. Post classification analysis is an approach where two or more dates of imagery are independently classified and registered. Then an algorithm is employed to determine which land use and land cover categories (or classes) have been changed and reclassified through time. In addition, statistical methods of analysis were used to support the image analysis. Finally, the LULC changes were identified accordingly for the last 34 years. This would help predict future trends that can help augment decision-making processes during planning and future developments.

3.8.3.1 Image Processing - Introduction

This section is based on Ronald (2001)'s approach and applied in the text as necessary. Largely, four basic operations are involved in digital image processing, namely image restoration, image enhancement, image classification, and image transformation. This process requires having access to image processing software such as IDRISI[4]. After the required earth images are collected through the satellite system, image restoration should be done to make sure that the images collected would be a faithful representation of the earth's surface as much as possible, which is a fundamental approach for all applications.

[4]*TerrSet (formerly IDRISI) is an integrated geographic information system (GIS) and remote sensing software developed by Clark Labs at Clark University for the analysis and display of digital geospatial information. TerrSet is a PC grid-based system that offers tools for researchers and scientists engaged in analyzing earth system dynamic for effective and responsible decision making for environmental management, sustainable resource development and equitable resource allocation. (https://en.m.wikipedia.org>wiki).*

Image Restoration- To collect information, electromagnetic energy must pass through the atmospheric environment, including moisture content, particulate matter, and turbulence, before it reaches the sensor. The incoming energy therefore may be modified substantially depending on the wavelengths involved and atmospheric conditions. The character of the data that may combine a variety of mechanical, optical and electrical components may be modified by the sensor itself, which serves to modify or mask the measured radiant energy. Subsequently, the signal tends to be telemetered back to the earth, received and processed to yield the final data aimed for. However, the quality of the image we receive may have degraded due to a variety of systematic and apparently random disturbances; here image restoration comes in to remove the degradation effects. Image restoration can be divided broadly into two subcomponents, namely radiometric restoration and geometric restoration.

Radiometric Restoration– This consists of the removal or diminishment of distortions in the quality of electromagnetic energy registered by the detector. Mostly, some of the common distortions requiring radiometric corrections may be cited as uniformly elevated values, striping, random noise, and scan line drop out. It is also important to include digital numbers (DN) that are used to convert the raw, unit less relative reflectance values of the original bands into true measures of reflective power (radiance).

Geometric Restoration – Registration in this type of restoration can be achieved usually using a systematic rubber sheet transformation process that gently warps an image. However, with aerial photographs, systematic distortions, including variable topographic relief tilt and varying altitude, cannot be removed through a rubber sheet transformation procedure. In order to remove such distortions therefore, photogrammetric verification can be employed to provide accurate map measurement. Furthermore, failing this, some success can be achieved through re-sampling of the central portions of the high altitude photographs.

Image Enhancement– This is predominantly concerned with the modification of images in a way that the appearance of the image is optimized to the visual system. Notwithstanding the high importance of digital intervention, visual analysis is given due emphasis in that it invariably plays a very strong role in all aspects of remote sensing. The range of image enhancement techniques being broad, the following fundamental components form the backbone to the enhancement process: Contrast Stretch, Composite Generation and Digital Filtering.

Image Classification – This is an operation concerned with the computer-assisted interpretation of remotely sensed images, including in the area of GIS manipulations. There are two types of image classifications, namely supervised and unsupervised.

Supervised Classification – In supervised classification, the software system is used to develop a statistical characterization of the reflectance for each information class of the known site, called training sites. Subsequently, the image is classified by examining the reflectance and decision is made about which of the signatures it resembles most. There are several technical approaches used in making such decisions, called classifiers. Ronald (2001:30&31), in this regard, offers three groups depending upon the nature of the output expected and the nature of the input bands. These classifiers are known as hard classifiers, soft classifiers, and hyper spectral classifiers.

Hard classifiers are distinguished in that they all make a definitive decision about the land cover class to which any pixel belongs, whereas soft classifiers on the contrary do not make a definitive decision about the land cover class to which each pixel belongs. Instead, soft classifiers develop statements of the degree to which each pixel belongs to each of the land cover classes being considered. Nevertheless, both types operate on multispectral imagery – images where several spectral bands have been captured simultaneously as independently accessible image components. This logic was extended to many bands producing what is known as to be hyper spectral imagery (Ronald, 2001). Although there is no big difference between hyper spectral and multispectral imagery, the former characterizes high spectral resolution and volume of the data handled.

Unsupervised Classification– In contrast to supervised classification, unsupervised classification requires no advance information about the classes of interest. Nevertheless, it organizes the data into the most prevalent natural spectral groupings, or clusters, present in the data. These clusters, as land cover classes are identified by the analyst through a combination of familiarity with the region and ground truth visits.

Whether supervised or unsupervised, in the classification process the assessment of the accuracy of the final image produced is necessary. Comparison should be made between the land cover found in the field and that, which was mapped in the image for the same locality. Iteratively, the error matrix (confusion matrix) may be used to identify particular cover types for which errors are in excess of that desired. In addition, to refine further the classification works, the error of commission and error of omission approach can be used on the information in the matrix developed.

In this study, the unsupervised image classification type would be used for convenience purposes and that no training sites shall be applied for this particular evaluation purpose.

Image Transformation – Another operation also refers to image transformation that can be applied to the derivation of new imagery relating to some mathematical treatment of the raw image bands. Although Digital Image Processing offers a wide range of possible image transformation ways, two are mentioned as they specifically relate to environmental monitoring applications, namely vegetation indices and principal component analysis.

Vegetation Index has been developed to help in the monitoring of vegetation. Most of the vegetation indices are based on the interactions between vegetation and electromagnetic energy in the red and near-infrared wavelengths. Thus, vegetation index can be achieved by comparing the measures of infrared reflectance to that of red reflectance. Accordingly, although a number of vegetation indices have been developed, the one, which has received the most attention, is Normalized Difference Vegetation Index (NDVI). This is calculated in the following manner:

NDVI = (NIR - R) / (NIR + R)

Where, NIR = Near Infrared and,

R = Red

Principal Component Analysis (PCA), being a linear transformation technique related to factor analysis, has been shown recently to have special application in environmental monitoring function. It has been used traditionally in the remote sensing as a means of data compaction. PCA produces a given a set of image bands, a new set of images, known as components which are not correlated. When noise effects dominate later components, PCA can be used as a noise removal technique.

Finally, while image transformation shall not be used in this study, as there is no new derivation of imagery is required; image restoration, image enhancement, and image classification would be applied as necessary in the data analysis process for they are most appropriate to this study in various ways that characterizes the particulars of the research subject study area.

Analysis Approach

This study employed the use of Arc GIS and remote sensing techniques including satellite imageries using LANDSAT sources to determine the trend of land degradation, which was used for the assessment of the extents of deforestation, farming, and possible settlements / resettlements. The methods and approaches used in the assessment of land degradation of the study area were remote sensing and GIS (QGIS with SCP plug-in tool) techniques. As the assessment of land use / land cover (LULC) change through time, multi-lateral Landsat satellite imageries with a five year interval time frame was employed in the process. The imageries used from the Landsat for mapping and assessments were for the years 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2019. These acquired satellite imageries were captured during dry seasons where the cloud cover was minimal or null.

The nature of color bands, wavelengths and level of mapping using different imageries from different Landsat since 1985 to present were discussed. The major steps to address the processes were: Image preprocessing, including geometric rectification, image registration and atmospheric correction; LULC classification using a maximum likelihood classifier (MLC); LULC change detection using a post-classification comparison approach; Development of fraction images using the spectral mixture analysis (SMA); Monitoring of land degradation trends; Examination of relationships between LULC change and land degradation trends.

Data Processing

In this case study, eight types of data sets from multi-lateral LandSats satellite images were collected and deployed. The eight type multi-temporal Landsat imageries are of the 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2019 imageries from 1 to 8 Land Satellites. In this case, 1985 and 1995 were accessed from L5, 2005 and 2010 from L7, and 2015 and 2019 from L8 satellites. These bands are B1, B2, B3, B4 and B5 from 1-7 landsats and B2, B3, B4, B5 and B6 are from landsat 8. These satellite data were acquired from the USGS Login web portal and Earth Explorer and GLOVIS websites. Each land sat consists of different spectral bands with different spatial resolutions. Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images for instance consist of nine spectral bands with a spatial resolution of 30 meters.

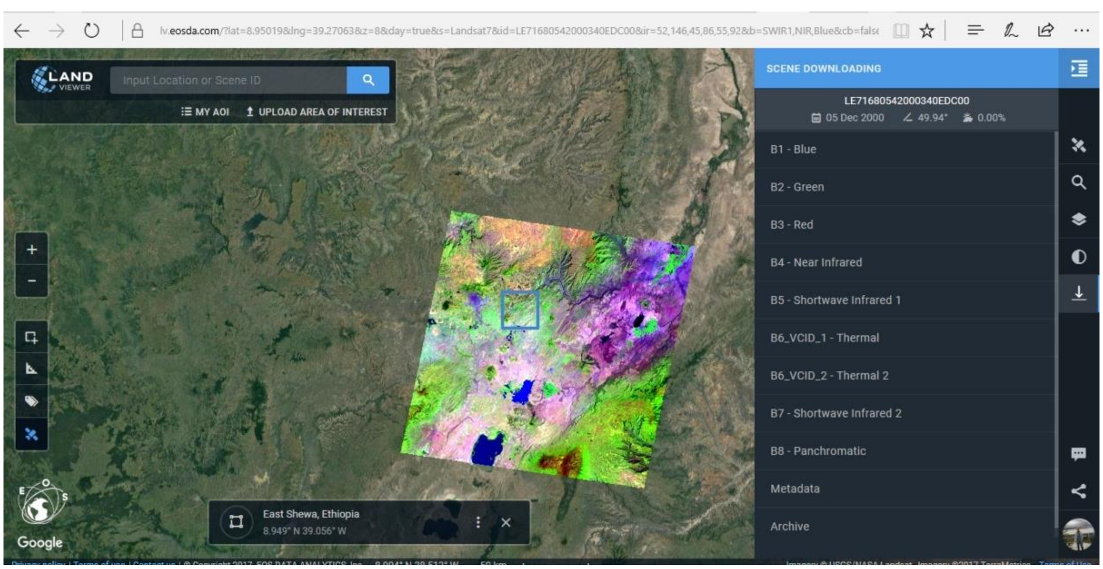
Image Classification

In the processes of making satellite imageries, detection of changes is a fundamental procedure and has a unique aim of building a more direct association between the biophysical phenomena on the ground and the acquired imageries (Coppin; Jonckheere; Nackaerts; Muys & Lambin, 2004). In this perception, to understand the behavioral change of the land cover change, it is advisable to understand the color-coding and the band combinations.

The main color-coding adopted in general is described as follows: *4-3-1 agriculture* band combination is useful for monitoring agricultural crops. In the image, bright green represents vigorous, healthy vegetation while non-crops, such as mature trees, appear in a dull green. Coniferous forests appear as a dark, rich green while deciduous forests appear as a bright green. Sparsely vegetated and bare areas appear brown and mauve. *3-2-1 natural color* is the natural color band combination and is made up of visible bands. Ground features appear in colors similar to their appearance to the human visual system, healthy vegetation is green, recently cleared fields are very light, unhealthy vegetation is brown and yellow, roads are gray, and shorelines are white. This band combination provides the most water penetration and superior sediment and bathymetric information. It is used also for urban studies. *7-5-3 false colors (urban)* band combination provides a *natural-like* rendition while also penetrating atmospheric particles, smoke and haze. Vegetation appears in shades of dark and light green during the growing season, urban features are white, gray, cyan or purple, sands, soils and minerals appear in a variety of colors. The almost complete absorption of Mid-IR bands in water provides well-defined coastlines and highlighted sources of water within the image appear as dark blue, water is black or dark blue. Hot surfaces such as forest fires saturate the Mid-IR bands and appear in shades of red or yellow. One particular application for this combination is monitoring forest fires. Flooded areas should look very dark blue or black. *4-3-2 color infrared (vegetation)* is a standard *false color* composite. Vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan. Coniferous trees will appear darker red than hardwoods. This is a very popular band combination and is useful for vegetation studies, monitoring drainage and soil patterns and various stages of crop growth. Generally, deep red colors indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue. This band combination gives results similar to traditional color infrared aerial photography. *4-5-3 land / water* band combination is good for picking out land from water. In this false color image, land appears in shades of orange and green, ice stands out as a vibrant magenta color, and water appears in shades of blue. *5-4-3 vegetation analysis* provides the user with a great amount of information and color contrast. Healthy vegetation is bright green and soils are mauve. This band combination is useful for vegetation studies, and is widely used in the areas of timber management and pest infestation. Therefore, in this study, based on these color features on the ground surface, the Normalized Differential Vegetation Index (NDVI) can be applied often to monitor and / or predict different conditional phenomena on the ground surface.

Application of NDVI

The NDVI is a standardized vegetation index, which allows us to generate an image showing the relative biomass. The chlorophyll absorption in Red band and relatively high reflectance of vegetation in Near Infrared band (NIR) used for calculating NDVI, (Figure 3-13).



<u>Figure 3-13: Application Area of NDVI</u>

The main application of NDVI is in the area climate change, agricultural production, desertification, land change, vegetation health and other related project areas. The NDVI [(NIR-Red)/ (NIR + Red)] is used to quantify the land cover change which ranges from -1 to +1 or [-1, 1].This means the vegetation cover ranges from lower to higher contents. If the range approaches -1, it shows the vegetation cover has diminished drastically and vice versa. The details are given as below based on the types of land satellite;

NDVI = (Band 4-Band 3)/ (Band 4+Band 3)

Where, Band 3 is red color and Band 4 is near infrared for land satellite 4 to 7

NDVI (Band 5-Band 4)/ (Band 5+Band 4)

Where, Band 4 is red color and Band 5 is near infrared for land satellite 8

Analysis of remote sensing involving satellite imageries pertaining to years, 1985,1990,1995,2000, 2005, 2010, 2015, and 2019 was conducted using ArcGIS software. This analysis was supported with community mapping and ground trothing activities for verification purposes. The results were compared and Land Use and Land Cover Change detection was made. In addition, Normalized Differential Vegetation Index was addressed particularly for it largely relates to the objective of this study. However, the detailed analysis of this subject matter has been carried out and presented under chapter five.

3.9 Validity and Reliability

Validity refers to the accuracy of instruments, data, and findings in research (Polit & Hungler, 1995). In this study, validity was ensured (confirmed) through expert critiques that had taken place (on the questionnaire) involving five people who were involved in the field of environmental sciences and used to verify the validity of research instruments. These experts did not participate in the study of the sample areas. The critiques involved provided good input to giving the final shape to the research questionnaire.

Reliability refers to the extent to which results are consistent over time and an accurate representation of the total population under study (Twenehboah, 2009). It relates to how well the instrument measures what it was designed to measure.

Accordingly, in this study, reliability was achieved through involving eight people who critiqued on how the questionnaire survey essentially measured what it was supposed to measure and found that the survey data was reliable. All participants were experts of the research field area who did not have part to play further in the study activities.

3.10 Scope and Limitations

The study focuses on the nature, causes and effects of long-term degradation of natural resources (vegetation/forest, water and soils) of the Belbela-Wadecha watershed area. The study took mainly into account of the long-term human impacts, about 35 years, on the natural resources of the watershed ecosystem. It involved the engagement of community in the identification of the environmental problems and in responding to them as well.

As not less than 80% of the population of the country is dependent on agriculture, most of the population is made up of peasant farmers who are hugely dependent on land and water resources. A focus on these natural resources is a bottom line task. Associated with this, particular focus was given to soils and vegetation degradation. The development and sustenance of the vegetation supports conservation of water resources through facilitating infiltration and percolation processes vertically and laterally to the ground water storage system. Vegetation conservation also plays a critical role in stabilizing the soil medium and improving its organic content, among other roles. Soils are an important resource base for crop production for peasant farming community's life sustenance.

Therefore, a focus on land and vegetation/forest deserve special care, as they are finite resources that are critical to sustaining the majority of agrarian population. Targeting these resources is not therefore a matter of choice; it is a matter of necessity. However, as a purposive nonprobability sampling technique was used, the results may not be taken as a representative of the whole of the watershed area. Nonetheless, it does offer a practical insight and good baseline information for further larger surveys including replication of similar studies elsewhere as deemed important.

It is understood also that not much research has been done targeting environmental management and irrigation development side-by-side as a package of a project as opposed to the singular focus of development being largely exercised to date. Hence, packaging this approach as a standard norm of operation in water related projects is a probable scenario that would support both sound environmental sustainability and economic sustenance in development projects.

In addition, the researcher believes, from point of view of his experiences and academic background, the operation of both environment management and irrigation developments in parallel, not separately, will ensure sustainable development and immense benefits to present and future generations.

3.11 Ethical Considerations

Mertens (1988) argues that ethical guidelines in research are needed to guard against any possible atrocities. Prathapan (2014) contends that ethical guidelines need to be maintained relating to, among others, three main issues, the Belmont report, and principles of beneficence, human dignity and justice. This study therefore, would satisfy all requirements of the ethical disciplines.

In this study, ethical clearance from UNISA's College of Agriculture and Environmental Sciences' Research Ethics Committee, being a requirement, was obtained.

Full explanation of the nature of the study was given to the participants, including the right to refuse in whole or in part to participate. Participants were assured verbally that no revelation of their personal information would be made. Participants' consent was obtained, free will, and without coercion.

Participants were protected against any physical or psychological harm and the researcher-participant relationship was not exploited such that participation or information they provided was used against them.

Debriefing was made to the participants upon completion of the research task, including the use that will be made of the data collected.

As part of the ethical clearance requirements in this study, permission was obtained from the relevant organs, which has accordingly been made use of to collect the data required and that data was gathered with all due ethical considerations. Accordingly, the necessary ethical clearance documents (Annex – 8) have been attached herewith for reference.

3.12 Trustworthiness

A research project is trustworthy when it reflects the reality and ideas of the participants. Trustworthiness involves the following four elements: Credibility, Dependability, Confirmability, and Transferability. For qualitative research, a category of authenticity can be added (Mertens, 1998).

Credibility, in this study would be ensured if the research findings reflect the perceptions of the people under study. At the time of the study there would be a documented account of communication systems between the participants and the inquirer (researcher), relating to interactions, observations and other engagements, for further possible uses. This could be tested by asking if there had been any correspondence between the way participants perceive social constructs and the way the inquirer represented their viewpoints, according to Mertenns (1998). Furthermore, Mertens (1998:181) outlines the strategies that can be used to ensure credibility, namely prolonged and substantial engagement, persistent observation, peer debriefing, negative case analysis, progressive subjectivity, member checks, and triangulation. In this study, substantial engagement, persistent observation, peer debriefing and triangulation tasks were undertaken.

To ensure transferability, it is perceived that the findings of the research study shall be that it ensures applicability to similar situations or participants (Holloway & Wheeler, 2002). Accordingly, the community at the pilot scheme mentioned that they would an agent to help replicate the success of the pilot plot on a wider scale on the watershed area and where potentially feasible.

Dependability of a research project refers to stability of data overtime and over conditions (Polit et al., 2001). In this research study, to ensure dependability, two methods of assessing dependability of data would be considered: stepwise replication and inquiry audit.

Confirmability refers to neutrality or objectivity of data (Polit et al, 2001:315). The research findings are the result of the research and not the researcher’s assumptions and preconception.

This study would undertake quite neutral research process and keep records of all inquiry data involved. These inquiry data would be used to trace the data to their sources through confirmability audit process, to ensure confirmability.

Mertens (1998: 184) state, "Authenticity refers to the presentation of balanced view of all perspectives, values and beliefs - It answers the question "Has the researcher been fair in presenting view?" The author of this research concurred with Mertens (1998) above and could ensure the balanced view of all perspectives in the study process.

3.13 The Output of the Study

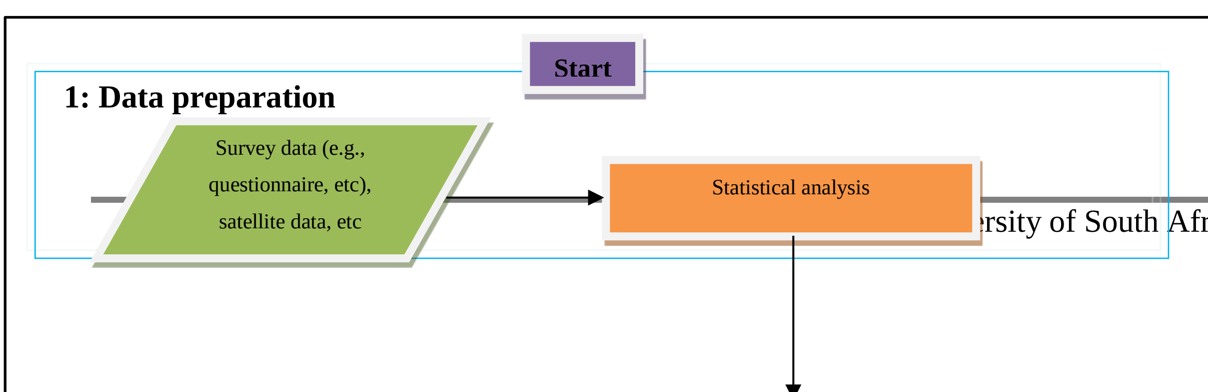
The study would culminate in producing research outputs and prospects that would help design ways as to how agricultural development and environmental sustainability can both operate in parallel and in harmony with a view to benefiting the community in the watershed environment in a sustainable manner. The findings also seek to encourage the community to own this sustainable approach and nurture the watershed system for current and future uses.

3.14 Organization of the Thesis

The research thesis comprises seven interlinked chapters. Chapter one introduces the context of the research, background and the objectives of the research. It also describes current watershed management policies and policy implementation. Chapter two provides a literature review on watershed management issues. Chapter three describes the research design and methodology. Ethical considerations and Trustworthiness are covered also under this chapter among other related important topics. Chapters four, five and six present the findings and results that will be used for policy formulation. Chapter seven presents the findings on the management and responsibility issues; and Chapter eight provides the overall conclusion and recommendations of research results including hypothesis remarks for future works and applications, and its scholarly contribution to the society and the science.

3.15 Flow Chart of the Research

In general, for simplicity, the foregoing study follows four stages to focus on, Figure 3-14. Stage 1 addresses the data collection and preparation, *Stage 2* and *Stage 3* depicts the data processing, modeling, analysis and interpretation of results, and *Stage 4* focuses on watershed management strategies and policies based on the results and information outcomes to benefiting future developments and decision-making process.


Start
1: Data preparation
Survey data (e.g., questionnaire, etc), satellite data, etc
Statistical analysis

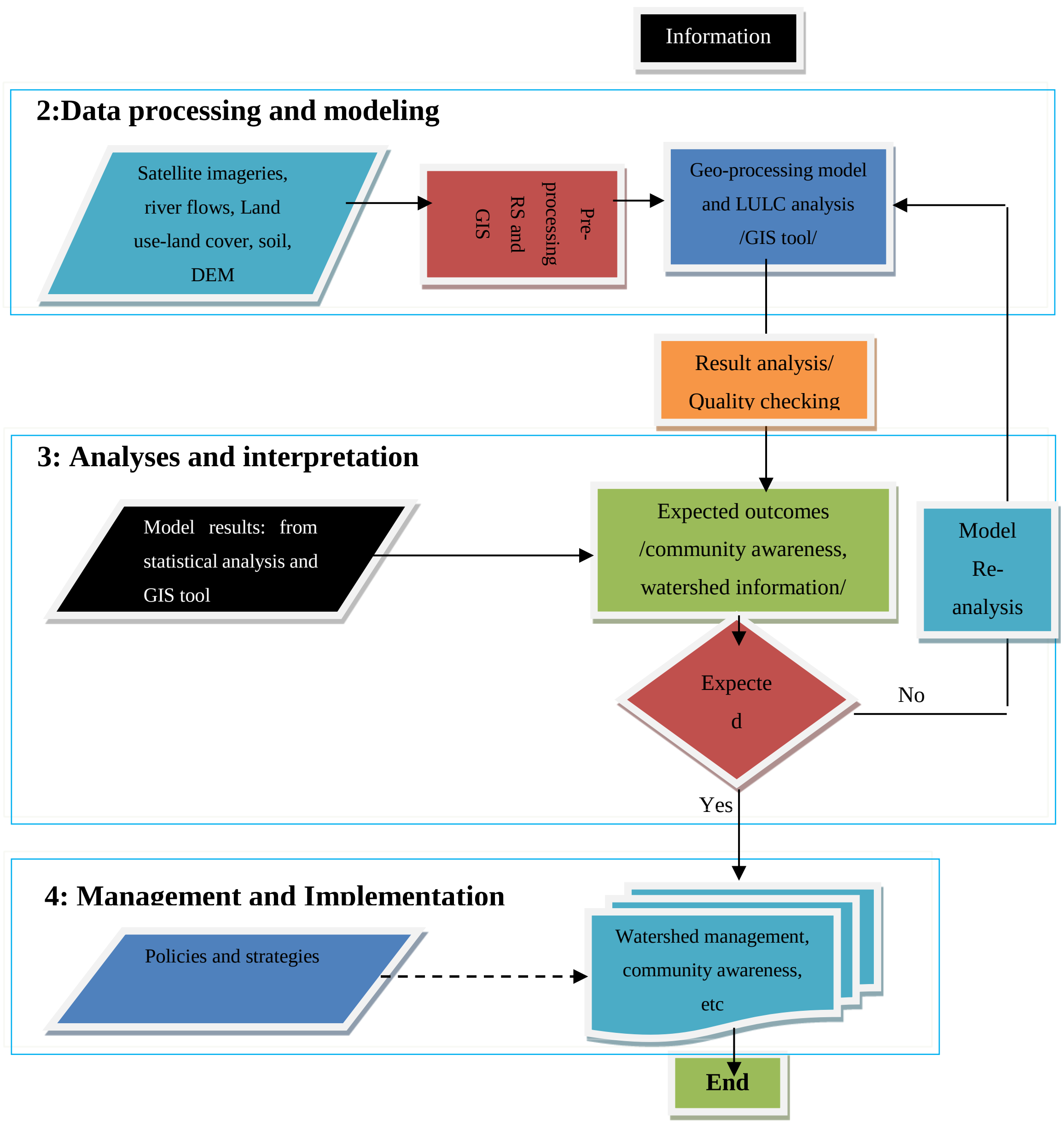


Figure 3-14: Flow Chart Showing Research Framework

4 Discussion of the Findings on the Questionnaire and Focus Group Discussions

4.1 Introduction

This chapter deals with the results and discussions pertaining to the questionnaire survey and the focus groups. For clarity purposes, Tables and Figures are included below relating to the respondents' educational attainment, comparison of ages, age and educational pattern, economic status, household source of energy for cooking and marketing, ownership of household items and order of energy use; analyzed through the application of SPSS software, version 25 supported with chi-squared test.

In addition, particular attention was given to ensure if proper response to the research questions had been made, thus meeting the objectives of the study, resulting from the collected data.

4.2 Socio-Demographic Characteristics of Participating Communities

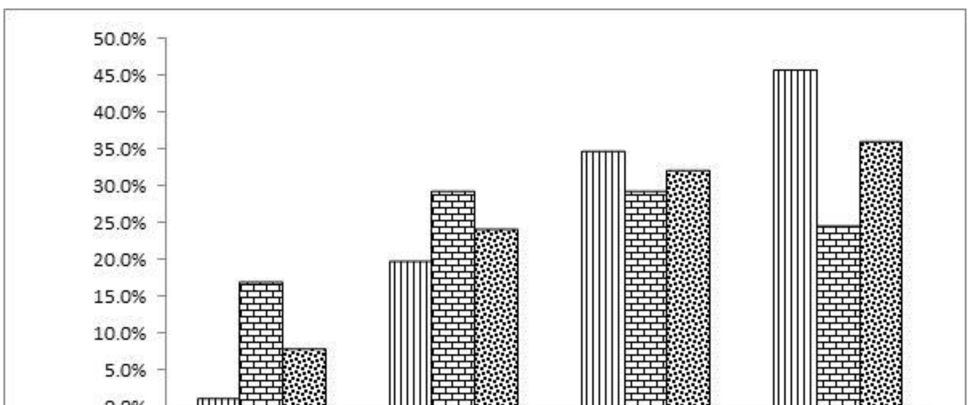
4.2.1 Age and Educational Attainment of Respondents for Both Sample Sites

General: It appeared that there were a small proportion of member communities (about 8%) of ages ranging between 22 and 30, posing questions such as "What about generation succession?", especially for the Godino community. About 25 percent of the population of both participating communities did not undergo any form of education, whereas the rest, in all age ranges were educated to levels spanning from primary school to secondary or high school formal modules. Most of the respondents could state their ages without hesitation, most likely due to their educational levels (Table 4-1).

It was noted from the focus group discussion that the community would like to be supported on a regular basis relating to basic education provision. Basic education refers to the practical educational applications with a view to support the farmers technical knowhow and help them have knowhow on technologies and practices pertaining to agriculture (including animal husbandry), health and other affairs to enhance productivity and ensure human wellbeing.

4.2.2 Age Comparison of Respondents

About 34 percent of the community respondents of Godino area were between 41 and 50 years of age, while about 29 percent of the residents of Qoftuu area were of the same range of age. About 20 percent and 30 percent for Godino and Qoftuu respectively fell between 31 and 40 years, while about one percent and 17 percent were between 22 and 30 years for the same areas respectively. About 45 and 25 percent for Godino and Qoftuu communities respectively were found to be above 50 years of age. Accordingly, a bar chart, Figure 4-1 more clearly shows the age status of each sample communities. Table 4-1shows that there is relatively even distribution of age categories in the Qoftuu community, which would better support mobilization of human resources in each category of age for economic development.



	22-30	31-40	41-50	Above 50
Godino	1.0%	19.7%	34.6%	45.7%
Qoftu	17.0%	29.2%	29.2%	24.5%
Total	7.7%	24.0%	32.2%	36.1%

Figure 4-1: Age Pattern of Godino and Qoftu Communities

4.2.3 Educational Comparison of Respondents

More of the respondents in Qoftuu area attended secondary school compared to Godino. This is because there was no such a facility in Godino area during the study. The study further indicates that about 24 percent of Qoftuu respondents and 31 percent for Godino did not attend school (Figure 4-3). This Figure clearly shows Qoftuu community had better education opportunities compared to Godino, which makes the Qoftuu community better equipped for economic development than the Godino community.

4.2.4 **Determining Statistical Significance**

To determine if there was significant between the ages and educational attainment of the sample site communities, their ages and educational levels were subjected to chi-squared (x^2) tests. Accordingly, the results show that the association between age and educational attainment is marginally significant (Table 4-2), x^2(6, N=233) =12.07, p<0.1.

In addition, to determine if there was significant difference between the communities/household items in both study areas of Godino and Qoftuu kebeles (Kebele is the smallest administration unit in the Government hierarchy), the communities and the utilization of household items were subjected to chi-squared tests. The result revealed significant association between the study communities and the utilization of the whole household items (Electricity, Telephone, Television, Radio, Video deck, and Refrigerator), Figure 4-4. In this regard, Qoftuu community used better household facilities than Godino's that relate to Electricity, Telephone, Television and Refrigerator showing the possession of these facilities and the study sites were significantly associated, x^2(1, N=233) =10.41, p<0.05. This is because the Qoftuu community had better infrastructure than the Godino's due to its geographic proximity to Bishoftuu town which gave it a good chance to coordinate with the pre-existing infrastructure of Bishoftuu's as opposed to Godino which is relatively located further requiring more budget to invest in which was not possible at the time of the study.

Furthermore, Table 4-1, Figure 4-2, and Figure 4-4 relate to the details of age and educational pattern, age versus education and ownership of household items for both kebeles' communities respectively.

Table 4-1: Age and Education Pattern for Both Sample Sites

		Name of the community					
		Godino		Qoftu		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Age of respondent	22-30	0	0.0%	18	17.0%	18	7.7%
	31-40	25	19.7%	31	29.2%	56	24.0%
	41-50	44	34.6%	31	29.2%	75	32.2%
	Above 50	58	45.7%	26	24.5%	84	36.1%
	Total	127	100.0%	106	100.0%	233	100.0%
Education level of the head of the household	No education	39	30.7%	18	17.0%	57	24.5%
	Primary	48	37.8%	21	19.8%	69	29.6%
	seconddary	40	31.5%	67	63.2%	107	45.9%
	Total	127	100.0%	106	100.0%	233	100.0%

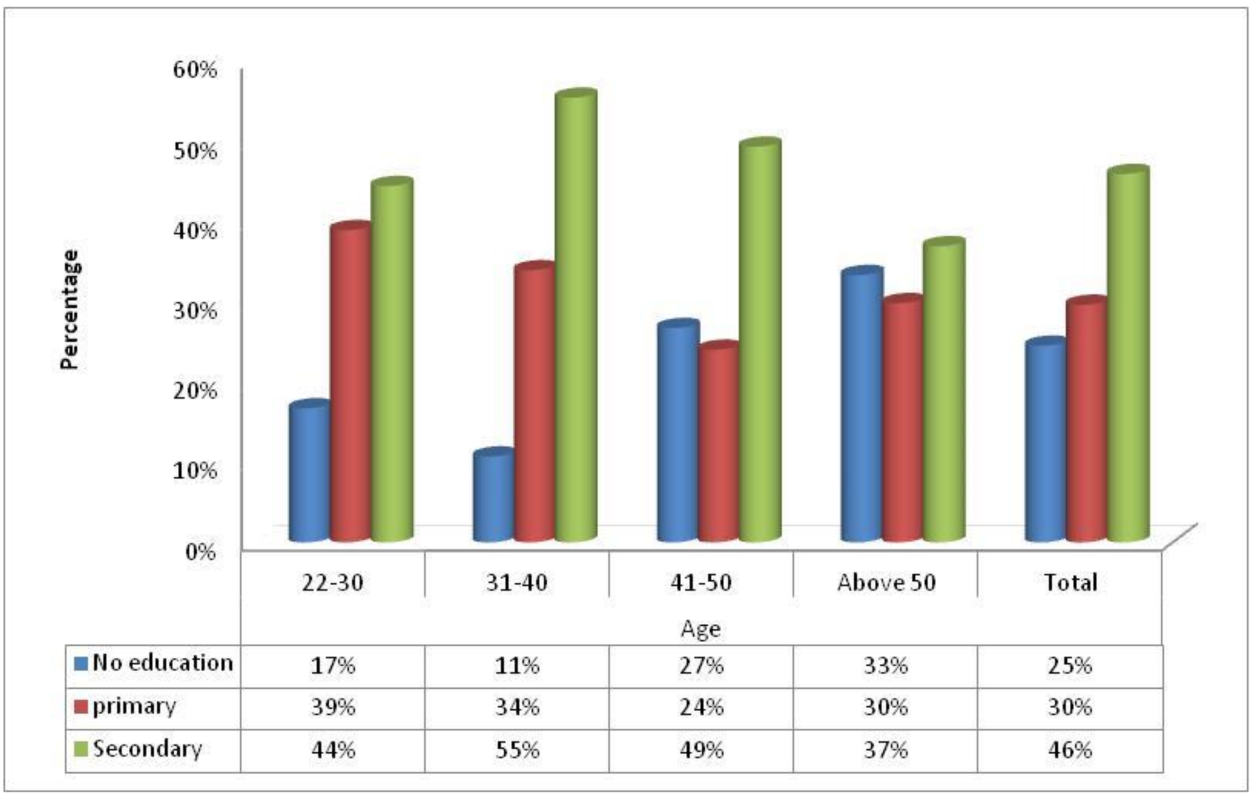


Figure 4-2: Age Versus Education for Both Sample Communities

Table 4-2: Significance Test for Education of Both Sample Communities

Pearson Chi-Square Tests		
		Age of respondent
Education level of the head of the household	Chi-square	12.070
	df	6
	Sig.	.060
Results are based on nonempty rows and columns in each innermost subtable.		

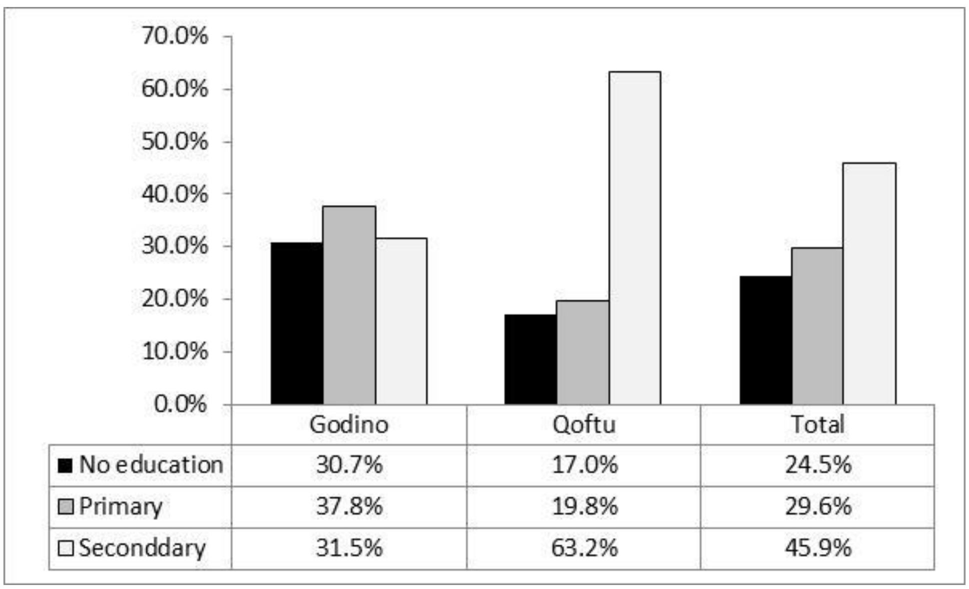


Figure 4-3: Education Pattern of Godino and Qoftuu Communities

4.2.5 Status of Energy Use of Respondents

General status of use of energy for both kebeles would be highlighted as follows. Although electrical power supply (infrastructure) was not a constraint, likely due to the proximity to Bishoftuu town and the floriculture industry, the majority of the respondents mostly used fuel wood, charcoal, crop residue and dry dung to meet their energy needs for cooking and heating purposes (Table 4-3). This was because their economic status did not allow them to use electricity or kerosene. The respondents also used these local energy sources as a means of economic income, in addition to agricultural produces, by selling them to markets to support their incidental expenses and to purchase items they required from the market.

Fuel wood consumption figures of Qoftuu and Godino sites Table 4-3) were 41.51 and 97.64 percent respectively. This shows that Qoftuu community is relying more on electricity. This was almost in agreement with the study results conducted on 30 developing countries by FAO (Cruz, 1991) which stated that 19 countries consumed 50 to 95 percent fuel wood for their energy requirements.

Table 4-3: Household Source of Energy for Cooking and Marketing

Site	Purpose	Electricity		Kerosene		F.Wood		Charcoal		C.residue		Ddung	
		N	%	N	%	N	%	N	%	N	%	N	%
Qoftu	Cooking	55	51.89	11	10	44	41.51	101	95.3	98	92.45	101	95.3
	Marketing	-		-		41	38.68	98	92.45	100	94.34	100	94.34
Godino	Cooking	23	18.11	30	23.62	124	97.64	124	97.64	124	97.64	124	97.64
	Marketing	-		-		7	5.51	7	5.51	5	3.94	7	5.51

All the listed items of energy resources were used in alternation, whichever is relatively easier to obtain based on their affordable economic capacity and immediate access for daily use at the time of need. No single source of energy was used continuously / permanently all year round. Because of the communities' low economic status less use of electricity and kerosene was noted. On the contrary, as noted above, forest products, crop residue and dry dung were mostly used. It can be understood that such type of use of energy sources can adversely affect the environmental natural functions and pollute the environment through release of greenhouse gases (CO_2, methane and other gases).

Therefore, creation of different income generating activities to cater for use of alternative non-biomass sources of local energy consumption is not only important to bridge the energy gap, but also addresses employment issues. Irrigation expansion in this regard is one of the potential sources for generating economic return, creating employment opportunities through agricultural operations and also contribute to the sustenance of the balanced watershed ecosystem through taking off the pressure that otherwise would have been exerted on natural resources for energy provision purposes.

In addition, in the course of making irrigation functions take place, protection of environmental amenities should have inherently taken place, due to environmental protection activities that would have been undertaken as a pre-condition to irrigation development. This would eventually support the delivery process of other sources of economic gains through the provision of opportunities including engaging legal logging, crafting, and beekeeping. These deployment areas should also absorb the pressure that otherwise would have been exerted again on natural resources for energy security purposes.

Comparison, however, was made between the kebeles to help understand which kebele would relatively possess better economic resources than the other one so that specific interventions would be identified with a view to help balance economic development opportunities between the kebeles. This was to help respond to the possible questions that would arise by the communities relating to economic imbalances which may result in the public complaints connected with lack of good governance.

Accordingly, Table 4-4 depicts an assessment of the order of energy consumption by type for each participating kebeles. This Table was formed from Annex – 7, Status of Energy Use of the Sample Communities that was, as mentioned above, prepared by employing SPSS software, version 25 which, is based on the questionnaire survey of the study area.

Table 4-4: Order of Energy Use of Respondents

Energy	Goidino (127)			Qoftuu (106)			Total		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Electricity	0	0	0	49	6	1	49	6	1
Kerosene	0	0	-	3	4	-	3	4	-
Fuel wood	126	0	0	7	13	7	133	13	7
Charcoal	1	27	9	14	35	37	15	65	46
Crop residue	0	92	9	5	33	41	5	125	50
Dry dung	0	8	109	27	12	20	27	20	129

As a result, Table 4-4 shows differences in the use of energy resources between both kebeles. The Table presents the order of priority of the use of energy by the sample communities, ranked zero through six. However, the rank of 1st up to 3rd was considered in this analysis to have a feel of the degree of the need of the community with a view to giving information to possible potential entity to help support the process of the intervention mechanism that may come into the view. Accordingly, 126, 92, and 109 out of 127 sample residents of Godino Kebele use Fuel wood, Crop residue, and Dry dung for their energy requirements in the order of 1st, 2nd, and 3rd instances respectively. Apparently, these figures place huge amount of adverse impact on the environment of the watershed ecosystem. On the other hand, 49, 35, and 41 out of 106 sample residents of Qoftuu Kebele use Electricity, Charcoal, and Crop residue in the order of 1st, 2nd, 3rd instances respectively.

The difference between these two participating kebeles, in the use of energy sources, is that Qoftuu has much less adverse environmental impact on the area owing to its relatively nearer geographic location to Bishoftuu town than Godino Kebele. By virtue of its proximity, Qoftuu was able to share the infrastructure better than the latter Kebele, which could not mobilize finances for the development of the required infrastructures. This Kebele also enjoys better educational attainment than Godino Kebele as shown in Table 4-1.

In addition, better access to electricity offers opportunities for diversified income generating activities including employment in the micro level enterprises, for example, wood, metal, and other crafting works supporting economic gains. This positively influences the communities living patterns by improving schooling, health, dietary needs, house and housing facilities, savings, technology access, market assessment, and better understanding of the circumstances of the global world thereby help respond as necessary.

Therefore, the livelihood patterns of the residents of Godino Kebele were not similar to those of Qoftuu Kebele due to the former's geographic location being relatively further from Bishoftuu town than the latter, thereby demanding more budgetary resource mobilization to account for, which under normal condition will have to be addressed based on the Government's priority checklist. Understandably, the limited capacity of the Government to make a timely and sufficient budgetary need available being the problem area, the Government would have to resort to other sources of funding in collaboration with the communities themselves and the private sector. The participating communities mentioned they were prepared to respond to the problems under their jurisdictions but were awaiting the Government to lead the way as their capacity was limited in undertaking major infrastructural developments such as electricity provision.

Such interventions, beyond economic and social benefits, support environmental, religious, cultural and tourism functions. Moreover, it affects catalyzing the generation of water resources, drive-pumping powers that can be used for irrigation development that provides employment opportunities that will keep people away from fuel wood collection and charcoal production for livelihood sustenance. In addition, there was a need mentioned for the continued dissemination of fuel wood-efficient stoves and fuel-shift stoves, including electricity and biogas.

4.2.6 **Ownership of Household Items**

66 to 95 percent of the participants from Qoftuu have access to electricity, telephones, and own television and radio sets while the Godino community owns far less than the Qoftuu's with only up to 25 percent owning television sets. However, all of Godino's community (100%) owns radios. In addition, as noted above, better electricity service was observed at the Qoftuu site compared to Godino, as most of the communities in Godino were not connected to the national grid, thus calling for intervention.

Uses of radios, telephones and televisions, as the respondents mentioned, are vital in terms of access to current affairs relating to understanding policies and directives of the both local and national governments including technological disseminations and information exchanges among various affected entities (Figure 4-4). These facilities were also believed to be useful for checking on regional, continental and global affairs and gauging oneself` against others who have attained relatively better development positions so as to learn better from them and manage to improve accordingly.

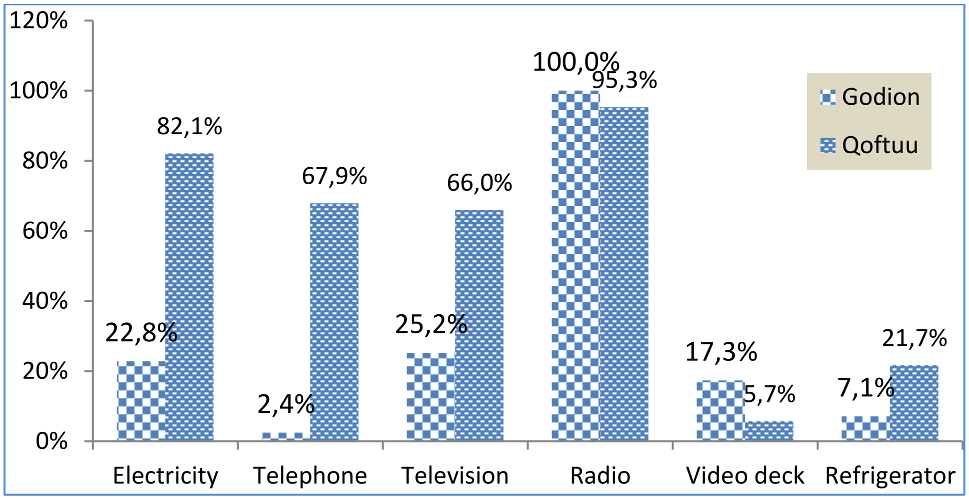


Figure 4-4: Ownership of Household Items (%), for Both Sample Sites

4.3 Questionnaire Survey and Focus Groups Discussions

4.3.1 Focus Group Discussions - General

Background information of the respondents described their socio-demographic characters reflecting on their identity, where they come from and belong to (their particular community), educational levels and how old they were. The data were found also to be very important in providing information pertaining to the study area in order to understand the area better in terms of the environment, socio economic status of the residents. It also supported to understand further the areas salient physical patterns including perceiving a mental picture of the concerns about the degradation of the watershed environment particularly relating to the land (soil) and the vegetation.

The data provided reliable information towards arriving at reasonable conclusions and recommendations that may help catalyze sound environmental management and sustainable irrigated agriculture operations to the benefit of both ecosystem sustenance and the socio-economic development status of the watershed communities.

4.3.1.1 Farmers' Focus Group Discussion

Some of the interactive discussions are as follows:

Guide question: What benefits do the watershed communities obtain from the watershed system?

Participant response: We are benefiting from irrigation development through vegetable production that supports our economic functions that we sell on markets to purchase items that we do not possess at homes in addition to using as food items and have some money in pockets for some incidental expenses.

Guide question: What are the general environmental problems in the area?

Participant response: As a result of soil degradation Belbela and Wadecha dams are silted up, we are not happy because our source of economic gains is being severely affected and employment opportunity is hampered that further impacted on the degree of severity of poverty. The Government is not supporting us in re-vitalizing the dam; hence, the Government should support us in the process of re-functionalizing the dam resource. Cultivation around the dam and other general soil erosion issues are also some of the problems affecting reservoir sedimentation including deforestation for logging and use for fuel wood. We also apparently feel a change in the climate cycle system. We further feel the diminishing source of fuel wood as compared to the last five or six years.

Participants' suggestions as coping mechanisms:

De-siltation and conservation measures would help mitigate the problem that should be undertaken by both community and the Government. The area around the dam should be left uncultivated and delineated as a buffer zone. This will help us look after the environment closely. In addition, we need Government policy support. We farmers want to participate in planning and design, rather than only participate in physical implementation, which is given as a directive from top Government structure to down level beneficiary communities. We also need NGOs to support us through Government facilitation mechanisms and the by-laws must be put into active operation accordingly.

4.3.1.2 Government Officials' Focus Group Discussion

Following the introduction of all the participants, a few interview guide questions for government officials (Annex – 2) were raised and corresponding responses were noted of which some are as follows:

Guide question: What are some of the general problems of environmental issues in Belbela-Wadecha watershed area?

Participant response: Deforestation process in the watershed area is exacerbated by lack of collaboration between the community and the Government to fight against and that adversely impacted on the natural resources degradation. The degradation effect is apparently increasing. No conservation work including conservation cultivation was done in the upper catchment.

Guide question: What benefits does the community of the area obtain from the watershed ecosystem?

Participant response: Irrigation is quite beneficial in terms of supporting economic gains. However, in terms of health related incidences including spray of chemicals for insect fighting, adverse effects were observed affecting fishes and beekeeping, among others.

In addition, about 50% of the sprayers do not have protective covers while spraying thus adversely affecting their health. Obviously, affected farmers in this respect keep complaining while no response was given yet; still the benefits of irrigation outweigh the disbenefits it constitutes.

Guide question: What specific problems do you observe as environmental degradation problems in the area?

Participants' response: Upstream community causes deforestation as that community is not the beneficiary of the stored water behind the dam for irrigation water supply purposes. Farming practices and the slopes of the cultivated land are not in harmony with each other that although the Government has set out a directive as a land characterizing >30% slope should not be cultivated, the farmers are still undertaking farming operations contrary to that directive.

Participants' suggestions as coping mechanisms:

Farmers need to be clustered to operate on various area closures based on pre-determined operational guidelines to help enhance re-vegetative growth as to minimizing/avoiding soil erosion phenomenon. Both upstream and downstream communities should undertake upstream conservation activities where upstream community would benefit from productivity increase because of the conserved nutrients from the retained soil particles resulting from the undertaken soil conservation measures. By-laws need to be enacted. Farmers need to be given awareness uniformly on the climate change process and its consequences. If irrigation has to be sustainable, areas of economic sources have to be diversified including forestry development, beekeeping and common land and others that would help take the pressure off natural resources. This should be done side by side based on a study that properly addresses each option as effectively as possible. This should consist of both upstream and downstream area to have economic projects that would constitute no use conflict, as each party would be accorded projects to benefit from. The corresponding various economic sources that had been put in place would support the sustainability of operation of the scheme. Creating buffer zones around the dam and right and left sides of the river course are necessary but need to be supported by policy enactment.

4.3.2 The Questionnaire Survey

The questionnaire survey also tried to elicit whether or not formal and /or informal institution(s) were supporting the environmental wellbeing and sustainable irrigation functions in the watershed area. In this connection, the respondents pointed out that although government, NGOs and community-based structures were there, they were all not active in delivering practical support on the ground to the study area. The government has put down policies, procedures, regulations and directives, but those instruments are not being put into action in practical terms. The respondents stated they were not happy with the policy provisions as they were not party to the formulation of the environment policy and that did not meaningfully contribute to their environmental, social and economic development. They also mentioned that the bylaws they had in place were not being implemented also to practically deliver down on the ground either.

The respondents suggested that some form of intervention by the Government would be necessary to put in place the practical operation of the government and communities' legal documents.

In addition, efforts have also been exerted to gather information relating to environmental concerns reflecting on agricultural operations, energy usages, catering for economic incomes (marketing), grazing and other human induced factors. The respondents replied to each of the questionnaires and noted that there were continued and ineffective operations of the stated items of activities to support the sustainability of the environment. The participants also suggested a possible way forward to the environmental problems.

In this connection, the respondents mentioned agricultural operations (cultivation), both rain fed and irrigated caused physical soil degradation and deforestation due to undertaking uncontrolled agricultural activities. The physically degraded soil particles were transported over the watershed area by running rainwater into streams and rivers to finally being deposited in the reservoirs causing reservoir sedimentation. The transported sedimentation volume displaced the useful irrigation water storage and got deposited there, thereby decreased the irrigation water capacity which in turn reduced the irrigable crop area as a result of irrigation water deficiency caused by sedimentation.

The respondents also mentioned that they practiced soil and water conservation activities through undertaking terracing, ditch cutting, tree planting, vegetation and crop cover, cultivation along the contour, and strip cropping along the contour. However, they added that as all parties did not uniformly undertake these operations, they were not successful. They further added that practical legal support should have been enforced if soil and water conservation practices were to be successful.

In addition, the respondents pointed out that their energy use patterns mainly comprised fuelwood, crop residue, dry dung and charcoal for house consumption and economic purposes. Fuelwood was the most widely used energy source among the respondents for both household consumption and economic purposes. Economic activities, in this regard, were used mainly to support financial requirements of the respondents for purchasing items from market, which they did not produce at their homes. It was underscored that fuelwood was an important item for their livelihood energy needs.

Moreover, the participants indicated that forest resources mainly delivered benefits in the form of soil erosion control, support rainfall source, and regulate temperature. In addition, the respondents stated that the degradation of vegetation and soil erosion resulted in the decline of forest and agricultural products as well as environmental instability. The communities also mentioned that, since they were dependent on the watershed natural resources for their livelihoods, they were cutting trees and selling it as fuelwood to generate income thereby adversely affecting the degradation of the natural resources of the watershed environment. The participating communities added that the main reason for vegetation degradation was related to the uses of fuelwood energy for household consumption, agricultural expansion, resettlements and grazing.

All participants at the study site opted for the irrigation sub sector as a critically important area for sustaining their livelihoods (Table 4-5). The communities further mentioned that irrigation benefited them in multiple ways, including helping them own better housing, better household food security, improved income, enhanced health status, better clothing and schooling opportunities. They also reflected on the benefits and disadvantages of the watershed ecosystem management. They stated that a well-managed watershed ecosystem would benefit their lived environment in a variety of ways, including regulation of temperature, rainfall, and provision of natural resources. However, they also stated that, on the other hand, a mismanaged watershed ecosystem resulted in an imbalance of air circulation, increased temperature, erratic rainfall patterns, and reduced availability of natural resources.

The affected communities reflecting on the issues raised above presented suggestions on the possible environmental solutions. Accordingly, almost all respondents claimed that although policies, regulations and directives are put in place, little or no attention was given to ensuring the practical delivery of the intended outcomes. Therefore, it was re-iterated by the participants that governments, both local and national, should make sure that government policies are really delivering beneficial results on the ground improving the livelihoods of the communities on the ground.

They also mentioned that, if the environmental sustainability and human wellbeing were to be achieved, organized and focused mass mobilization of local communities, supported by the implementation of government directives produced for the management of the watershed environment, were the bottom line tasks necessary to deliver on sound ecosystem management and sustainable irrigation agriculture operations. The government needs to ensure that the explanations of policy documents are attended well by all parties affected and are practically delivered on the ground as well, on the context of the end users, the beneficiary communities. Moreover, all respondents in the both sample areas, Godino and Qoftuu, indicated that although there is a government office, Oromiya Environment, Forest and Climate Change Authority, in the Woreda that deals with forest conservation activities, environment protection functions did not meet what they were supposed to achieve. Serious erosion process took place, plants, vegetation vanished, and dam life was shortened owing to reservoir sedimentation coupled with an intensive and unscientific ways of cultivation that took place twice a year during the growing seasons.

The result of degradation had been manifested in the decline of forest and agricultural products and has damaged the environment and its functions, adversely affecting the delivery of goods and services. The respondents were also aware of the effects of climate change that they felt through severe heat waves; temperature rises and changes in the rainfall pattern that affected the cycle of their farming operations. They also added they are made aware of the unusual phenomenon of the environmental crisis from the broadcasts through radio and television sets.

Based on the above problems, the respondents mentioned possible solutions and the likely outcomes. They pointed out that, although the local government and extension agents introduced them to the possible problems, solutions, and the probable outcomes, they were not supported practically so that they are able to deliver on the ground, which adversely affected environmental functions. In this regard, the respondents proposed a way out and the possible outcomes that were put forward include the following:

Soil and water conservation works should take place through deploying activities such as terracing, ditches, silt traps, cultivation along the contours, strip cropping, maintaining a vegetation and crop cover, and tree planting (reforestation). These activities protect the soil from erosion; maintain soil fertility and reduce water losses in storage reservoirs. The respondents re-iterated that forests benefit the watershed environment and the community in a number of ways including contribution to the rainfall source, temperature regulation, soil erosion control, biodiversity improvement, and environment protection. They also mentioned that if this had been brought to the fore accordingly it would have positively affected their livelihoods. They also stressed that if soil and water conservation and tree plantation activities had been done some ten years ago, the watershed environment condition would have definitely been changed for the better. This would have benefited in terms of sustaining forest beneficial contributions, stated above, which would in turn have benefited the community in terms of economic, social, and environmental gains, including spiritual and aesthetic values.

Finally, they suggested that the enforcement of environmental sustainability legislations, including bylaws at both local and national levels, would be a bottom line task if environment were to be protected and simultaneous irrigation development was to successfully be operationalized.

4.3.3 Environment and Irrigation Issues

The respondents stressed repeatedly that revitalization of the degraded environment was not just a common activity or routine share of duty but a question of life and death calling for immediate and practical intervention involving international organizations, national government institutions and local communities. They also added that the government should play the lead role in environmental management, but also the community needs to be re-organized in a practically manageable way of groupings and administered by agreed upon bylaws provisions where all the provisions are adhered to by all signatories in an unprecedented way.

The community participants also pointed out that irrigation had been and still is quite an important sub sector, requiring a mobilization of concerted resources of multiple stakeholders consisting of national and international communities where the communities, government, NGOs, and the private sectors are involved through well-coordinated and managed mechanisms. All the participating communities opted for irrigation facilities as a critical sub-sector for livelihood sustenance, particularly in a developing nation with erratic rainfall (Table 4-5). The disadvantaged groups, especially the poorer in society should be targeted.

In addition, it was suggested that monitoring, evaluation and feedback approaches should be designed by the communities and supported by the local governments and NGOs. It was also mentioned that the way forward can be set through joint regular meetings of Joint Association Laws for Watershed and Irrigation Beneficiaries (upstream and downstream communities, associated with JALWIB provisions), sub-article 8.2.5.1, aiming at environmental restorative and irrigation development works.

Table 4-5: Sample Community Opted for Irrigation

Is irrigation important to your living?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	233	100.0	100.0	100.0

4.3.4 Summary

Analysis of the data collected through the questionnaire survey and focus group discussions was carried out through the application of SPSS software, version 25. Analysis for both kebeles, Godino and Qoftuu, was undertaken based on age distribution patterns and education levels. A further comparison was made between the participating communities relating to the understanding they had on the need to conserve the environment of the Belbela-Wadecha watershed area. Energy sources and utilization patterns were explored also in the light of their effects on the watershed ecosystem in the study sites.

In this regard, the participating communities mentioned that sustaining the watershed environment would benefit the communities in multifaceted ways including provision of natural resource goods and services and serve as a source of water for water related development works and for climate regulation and hydrological cycle functions. Moreover, it was stressed particularly that irrigation development benefited from the water flow generated through a well-functioning watershed ecosystem, which supported the livelihoods of the communities through the income produced from irrigation agriculture development.

The respondents further mentioned that a healthy watershed environment could be a good site for diversifying income generating activities other than generating water for irrigation purpose, such as beekeeping and crafting opportunities. In addition, the status of household items of the participating communities was looked at also, including whether government support would be needed in the area for facilitating infrastructure development to mobilize economies for better service delivery functions.

The communities underscored that, although irrigation had been meaningfully supporting the livelihoods of the communities, the current irrigation functions have been affected significantly due to the reservoir of the dam being filled up with sediment loads displacing the useful water storage volume behind the dam, thus resulting in not enough withdrawal capacity for irrigation water supply from the dam reservoir.

The communities further noted that current conservation efforts / practices were weak due to weak enforcement of laws / bylaws. In addition, the community pointed out that, owing to lack of diversified income generating activities, a large portion of the communities depended on forest resources for their livelihoods, causing deforestation and degradation of the watershed area. It had been also noted that, although the communities have had knowledge and experiences to a certain degree on watershed natural resources conservation practices, this has failed in many places as a result of weak enforcement levels of environmental policies, by-laws and other government rules and regulations.

The participating communities also mentioned that if collective, strict, and close follow-up on the implementation of policy provisions, including by-laws, were made and rules and regulations observed, and if this was also further supported by monitoring and evaluation tasks, including closely implementing corrective measures, then both sound ecosystem management and sustainable irrigation agriculture would be functioning simultaneously. Hence, it was stressed that close attendance towards nurturing the watershed environment through strict imposition of regulations adopted by both national and local governments is not a matter of choice, but the necessary task to be taken on board.

5 Discussion of the Findings on the GIS Mapping and Ground Truthing

5.1 Introduction

This chapter deals with GIS mapping and ground truthing activities, including remote sensing imageries. Land Use Land Cover Changes (LULCC) detection and verification of results was verified through ground truthing in the watershed area. GIS and remote sensing findings relating to the period (covering 34 years) between 1985 and 2019 were discussed also.

5.2 The Remote Sensing and GIS

Results were analyzed and interpreted, based on visual inspection and statistical analysis, using ArcGIS software as follows. The LandSat 8 imagery of 2019 was captured on 2019.02.01 with a cloud cover of 0.02% and 2015 on 2015.01.05 with a cloud cover of 0.18%. LandSat 7 imageries for the years 2000, 2005 and 2010 were used also. Similarly, for the years 1995, 1990 and 1985 the Earth Explorer downloader was used to download images deployed from LandSat 4-5 Thematic Mapper (TM).

For the year 2019, LandSat 8 imagery captured on 2019.02.01 and was analyzed and used to understand the land cover changes. In this case, the NDVI [(NIR-Red) / (NIR + Red)] was used to quantify the land cover change which ranged from -1 to +1 or [-1, 1]. This meant the vegetation cover ranged from lower to higher contents. If the range approaches -1, the vegetation cover is diminished drastically and vice versa.

The major land use / land cover of the study catchment based on the nature of the terrain characteristics, such as catchment slopes that favor other deriving factors in the processes of land degradation (Figure 5-1).

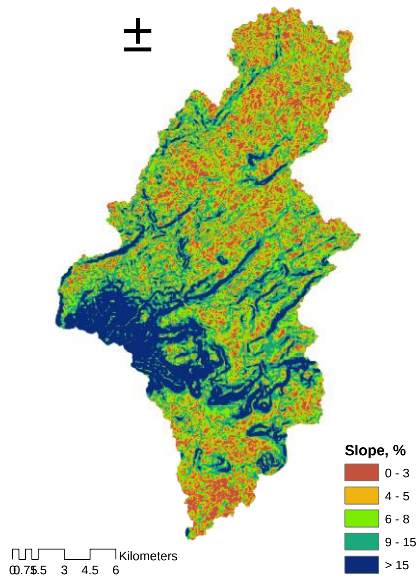
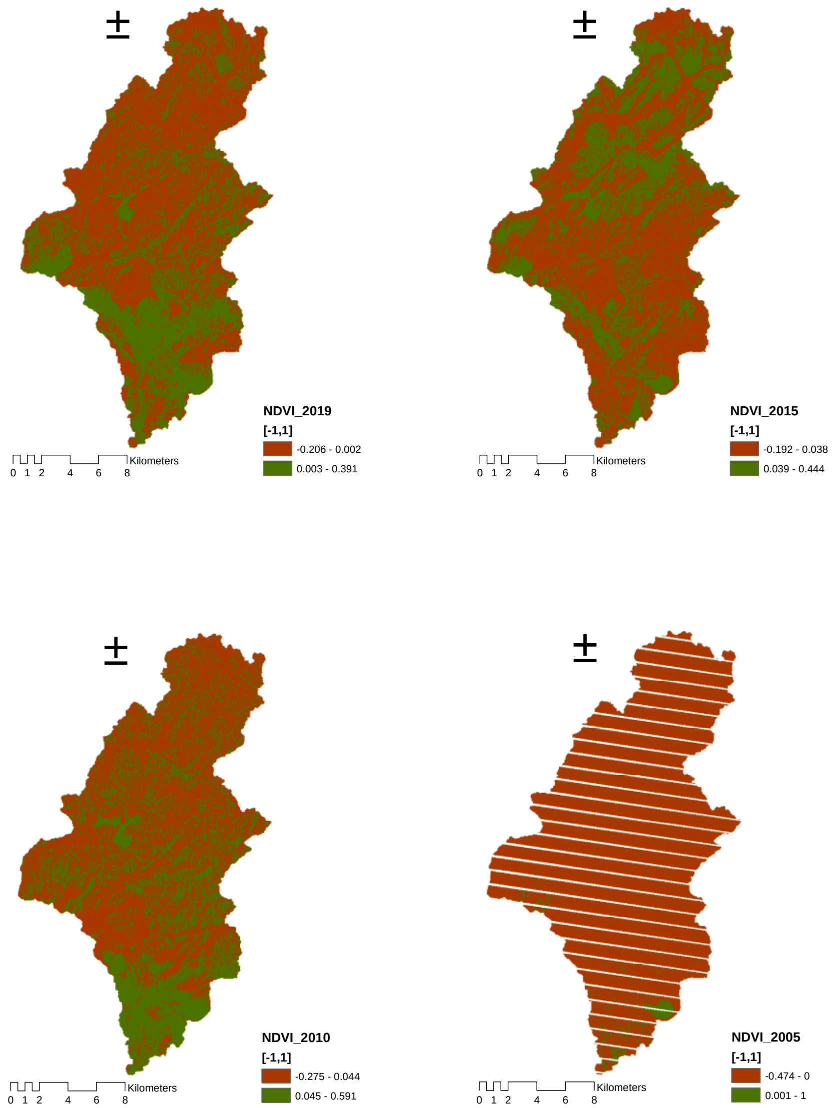


Figure 5-1: Slope Ranges of the Study Catchment

5.2.1 Normalized Differential Vegetation Index (NDVI)

The study produced NDVI for the years 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2019 as presented in Figure 5-2. Results show that there was indication of trends of land cover changes over time, from 1985 to 2019. These imageries are: imageries 1985 to 1995 from LandSat 4-5 TM, imageries of 2000 to 2010 from LandSat 7, and imageries of 2015 and 2019 from LandSat 8 were used in the analysis and described better on the ground. However, the 2005 imagery from LandSat 7, the NDVI was presented for year 2005 was not good enough in showing the land cover changes as that of the other imageries.


NDVI_2019
[-1,1]
-0.206 - 0.002
0.003 - 0.391
0 1 2 4 6 8
Kilometers
NDVI_2015
[-1,1]
-0.192 - 0.038
0.039 - 0.444
0 1 2 4 6 8
Kilometers
NDVI_2010
[-1,1]
-0.275 - 0.044
0.045 - 0.591
0 1 2 4 6 8
Kilometers
NDVI_2005
[-1,1]
-0.474 - 0
0.001 - 1
0 1 2 4 6 8
Kilometers

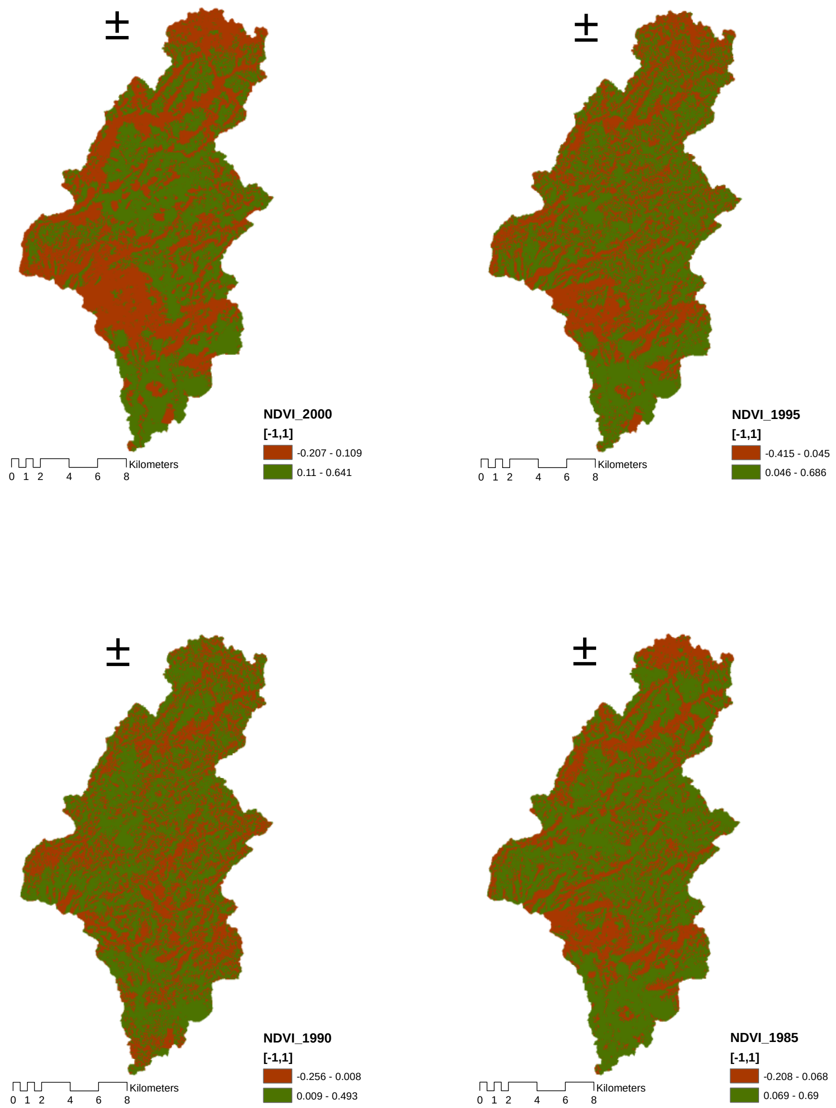


Figure 5-2: Trends Based on NDVI Conditions (1985-2019)

Figure 5-3 and Table 5-1 below also present the land cover changes through time, since 1985 to 2019. Figure 5-4 also illustrates classification statistics for the year 2019. In this case, there was increasing / decreasing NDVI value showing increasing / decreasing trends, which are related to the variability of seasons and climate shifts due to many other interrelated factors.

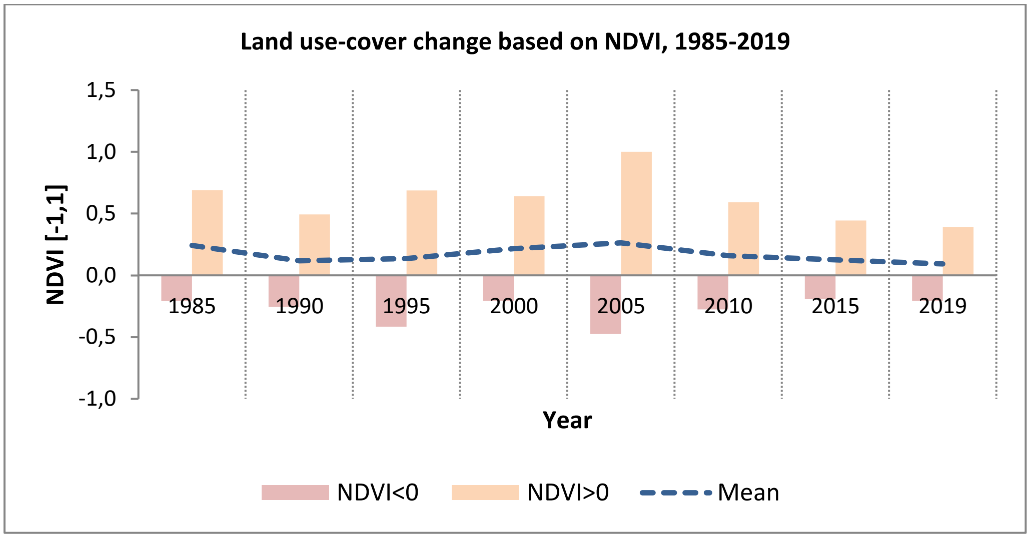


Figure 5-3: Land Cover Change, 1985-2019

Table 5-1: NDVI Results, 1985-2019

Year	Min	Max	Mean
1985	-0.2080	0.6900	0.2410
1990	-0.2560	0.4930	0.1185
1995	-0.4150	0.6860	0.1355
2000	-0.2070	0.6410	0.2170
2005	-0.4740	1.0000	0.2630
2010	-0.2750	0.5910	0.1580
2015	-0.1920	0.4440	0.1260
2019	-0.2060	0.3910	0.0925

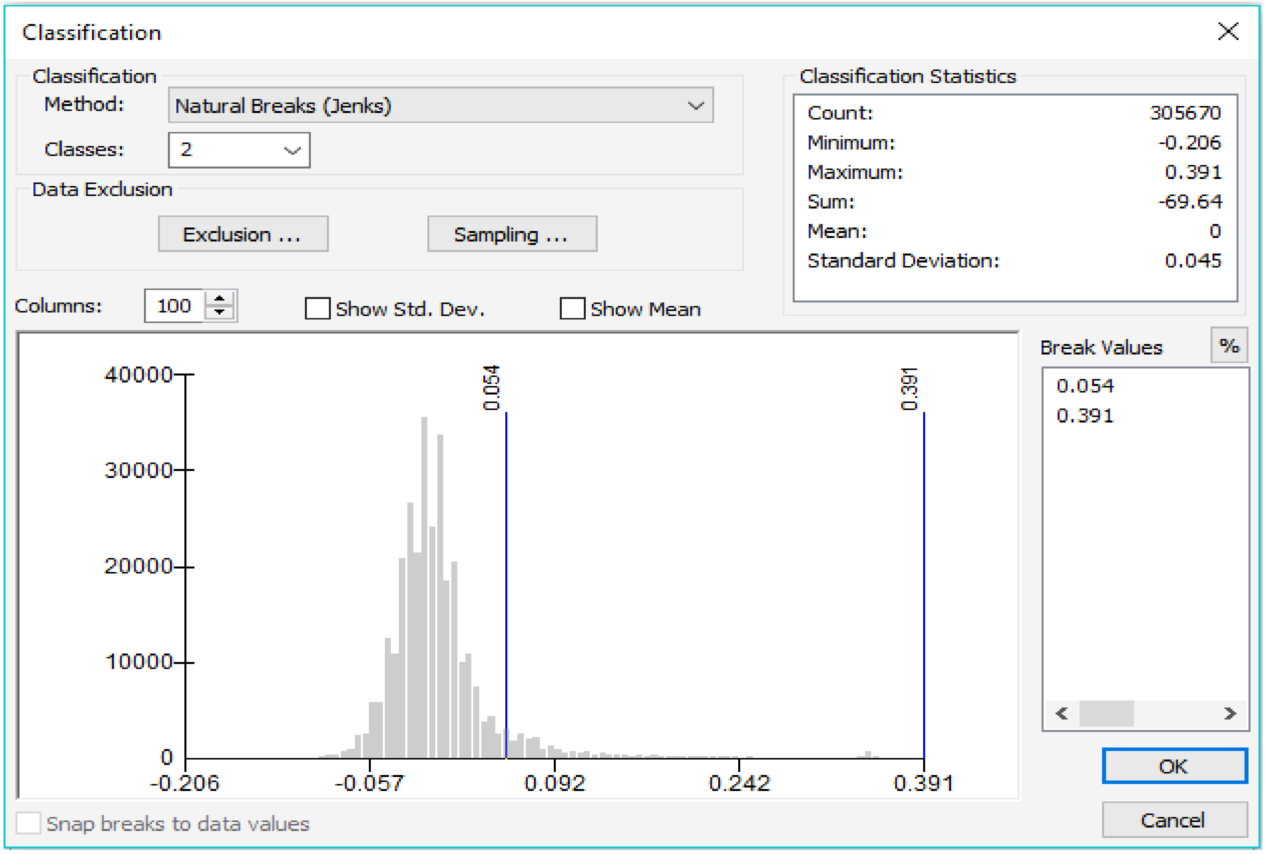
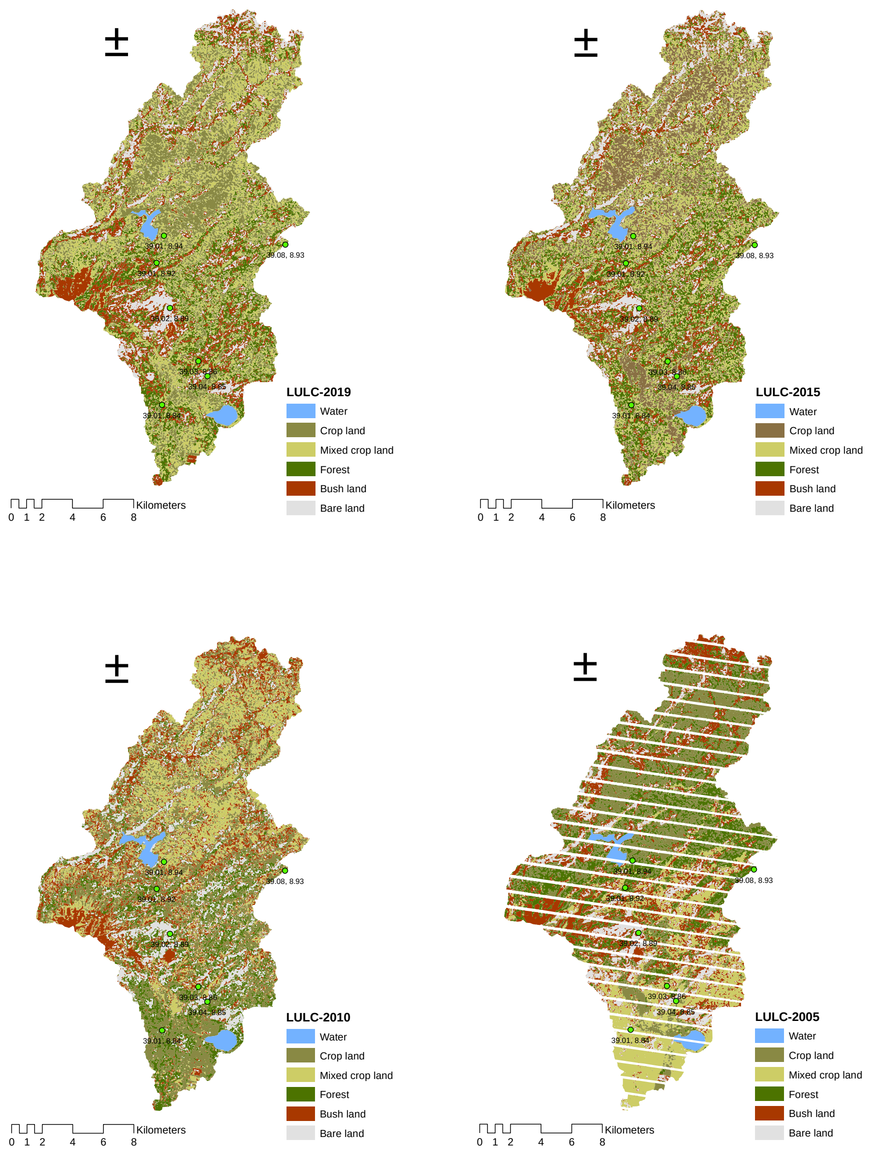


Figure 5-4: Classification Statistics, 2019

5.2.2 Land Use Land Cover Change (LULCC) Detection

The dominant land use classifications, such as the water body, forest cover, cropland, mixed cropland, bare land, and bush land are presented also below. The land use-cover change conducted relates to the unsupervised classification method in ArcGIS environment (Figure 5-5, Figure 5-6 and Table 5-2). Figure 5-6 shows graphical representation of LULC changes indicating how the trends of the changes took place as represented by several graphical lines relating to the LULC types. The data used in this Figure (Figure 5-6) again also used in Table 5-3 to benefiting a reader observe more clearly through the percentages of the changes involved. Based on this analysis, results indicated that there were decreasing trends of bush grassland and forest cover during the analysis period, 1985 through 2019 (Figure 5-6 and Table 5-2). On the other hand, cropland shows an increasing trend due to the land expansion for cultivation in order to satisfy food security of the farmers and local communities.


LULC-2019
Water
Crop land
Mixed crop land
Forest
Bush land
Bare land
Kilometers
0 1 2 4 6 8
LULC-2015
Water
Crop land
Mixed crop land
Forest
Bush land
Bare land
Kilometers
0 1 2 4 6 8
LULC-2010
Water
Crop land
Mixed crop land
Forest
Bush land
Bare land
Kilometers
0 1 2 4 6 8
LULC-2005
Water
Crop land
Mixed crop land
Forest
Bush land
Bare land
Kilometers
0 1 2 4 6 8

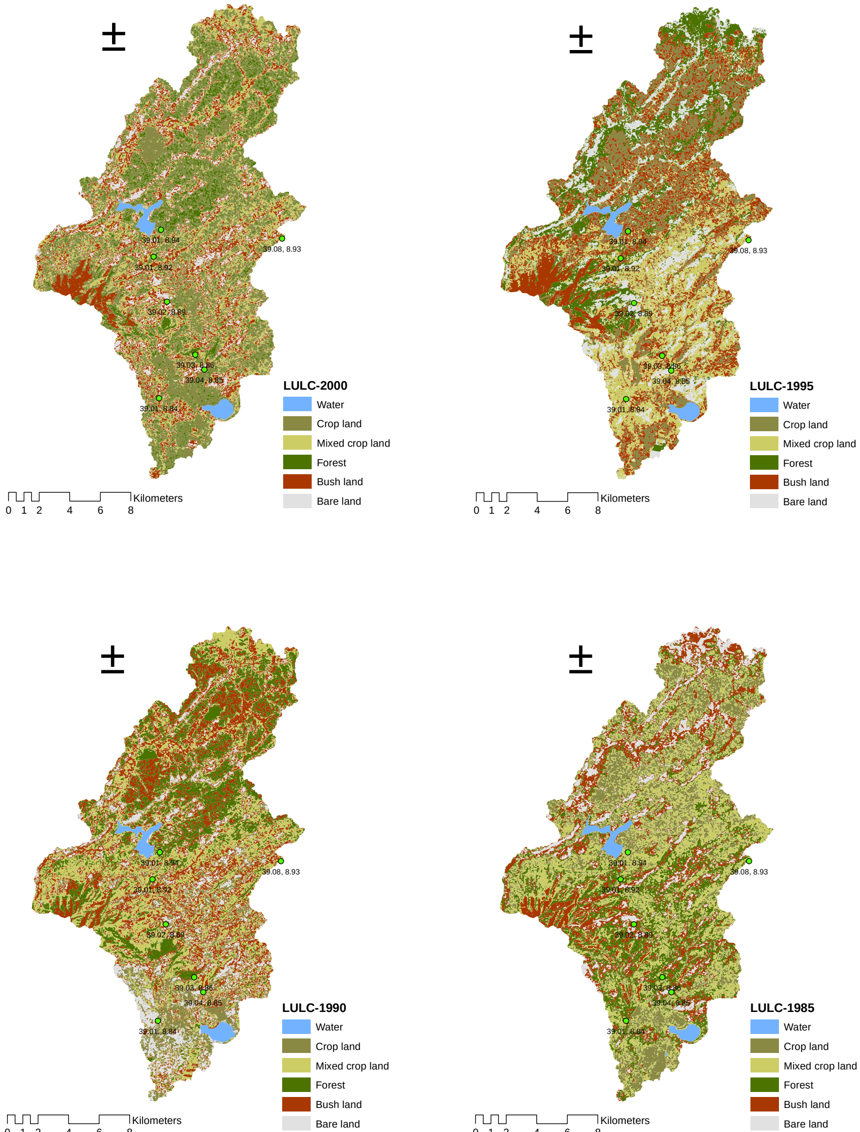


Figure 5-5: Spatial Trends of Land-Use-Land-Cover Changes

Table 5-2: Land-Use-Land-Cover Changes, 1985-2019

SN	LULC Type	1985	1990	1995	2000	2005	2010	2015	2019	Average (km2)
		Area (km2)								
1	Bare land	28.0	29.9	37.1	65.7	55.7	64.9	69.3	68.1	52.4
2	Forest	59.0	46.6	46.9	46.0	54.5	51.5	52.1	52.3	51.1
3	Bush land	66.2	68.5	81.7	61.1	60.3	58.3	30.9	25.8	56.6
4	Mixed crop land	76.3	70.5	47.6	45.2	53.4	47.9	70.8	75.1	60.9
5	Crop land	41.9	55.6	57.5	53.9	47.8	48.4	47.9	51.3	50.5
6	Water	3.8	4.0	3.8	3.6	3.2	4.0	3.7	3.0	3.7
		Total area (km2)								
		275.3	275.2	274.6	275.6	274.9	275.0	274.7	275.5	

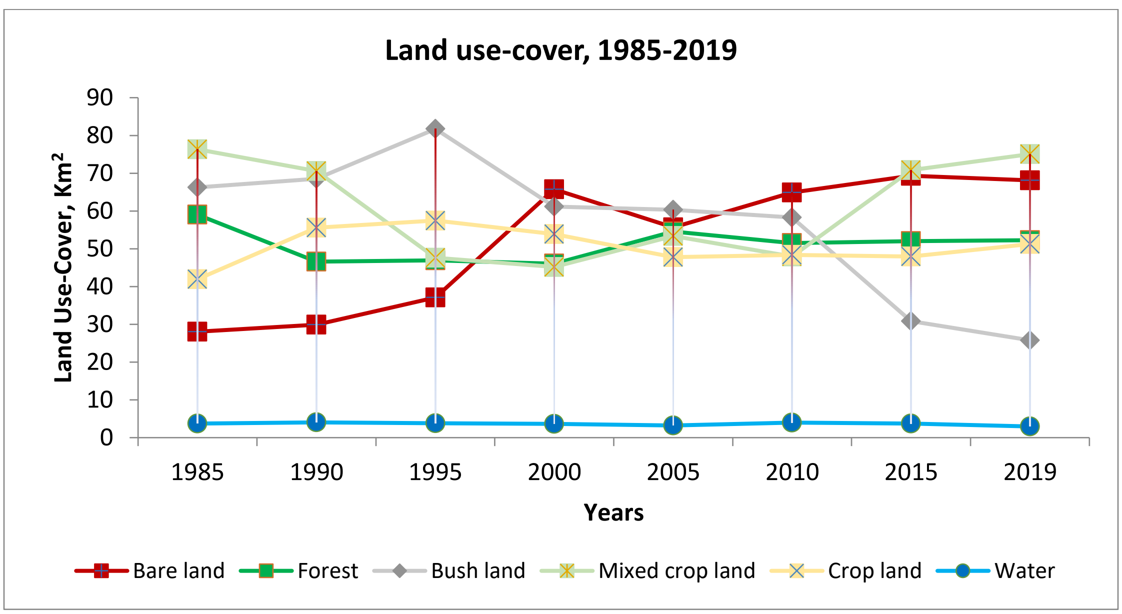


Figure 5-6: Trends of Land-Use-Land-Cover Changes

In addition, Table 5-3 indicates the average for the study period (1985-2019) and land use-land cover contributions for the study (watershed) area for the identified major land use conditions. For instance, the average contribution of bare land and forest for the study period and watershed area was about 52.4 km^2 (19.03%) and 51.1km2 (18.58%) respectively. Similarly, the area change values deducted from 2019 to 1985 is also presented, such that bare land and crop land changes show about 40.1 km2 (14.56%) and 9.31km2 (3.38%) increase respectively. On the other hand, forest cover change shows about 6.70km^2 (2.44%) decrease.

Table 5-3: Trends of Land-Use-Land-Cover Changes

Class	Bare land		Forest	Bush land	Mixed crop land	Crop land	Water		**Class**
Area contribution per year							Area change, 1985-2019		
	(%)	KM2					km2	(%)	
Bare land	19.03	52.36					-0.81	-0.29	Water
Forest	18.58		51.12			9.31		3.38	Crop land
Bush land	20.57			56.60	-1.24			-0.45	Mixed crop land
Mixed crop land	22.12			-40.4	60.85			-14.70	Bush land
Crop land	18.37		-6.70			50.53		-2.44	Forest
Water	1.33	40.06					3.65	14.56	Bare land
	100							0.07	
		catchment area, km2				**275.1**			

5.2.3 Verification of the Results

Figure 5-8 shows certain verification and supervision points on the selected areas in the watershed. Figure 5-9 compares LULC images with ground pictures for each LULC class of the watershed. Figure 5-7 shows community mapping and gully formation relating to 2019.

The imagery on 2019.02.01 was verified using the ground truthing that was captured on 2019.02.02. It is based on the near infrared band (Band 5) used in comparison with the pictures since B5 is active band in showing the vegetation covers.

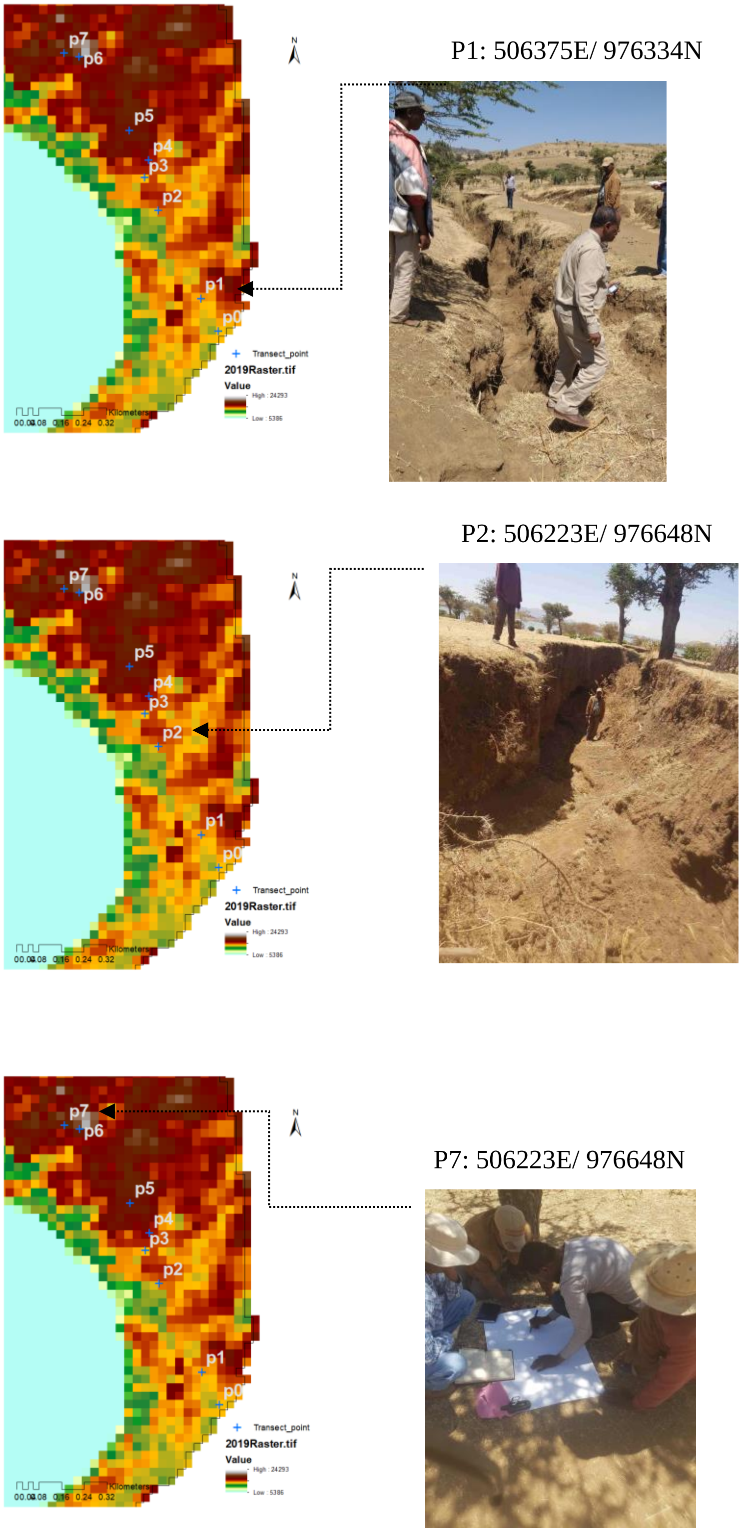


Figure 5-7: Community Mapping and Gully Formation

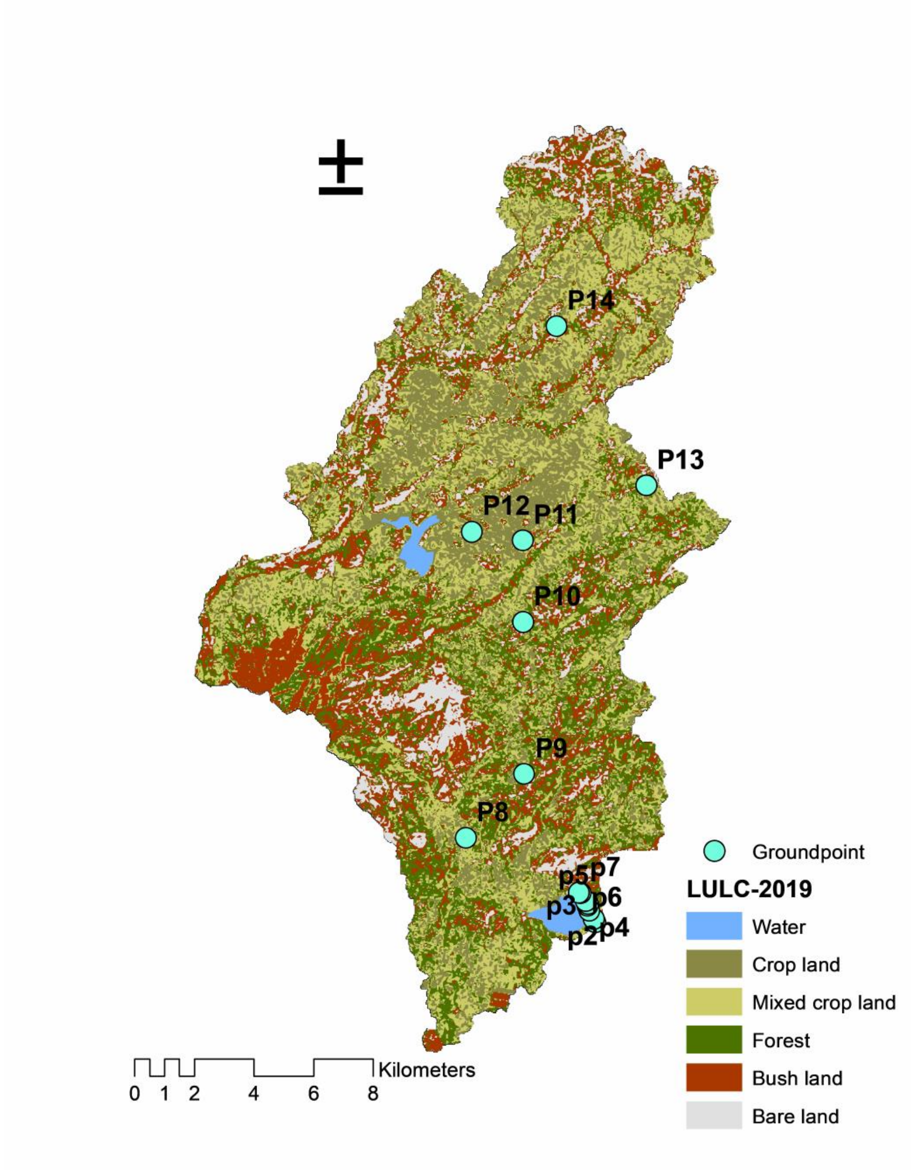
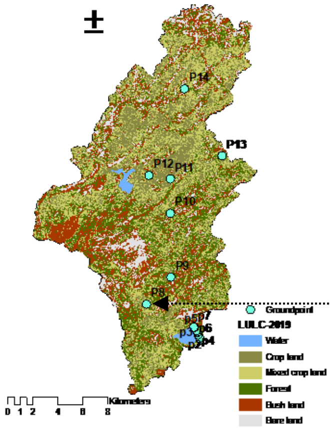


Figure 5-8: GPS Points for Ground Truth



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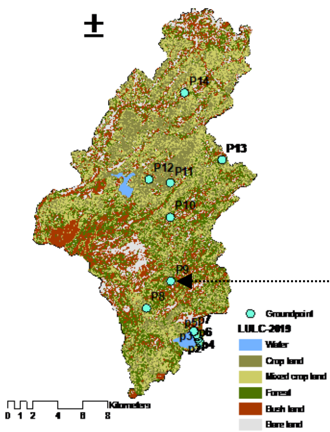

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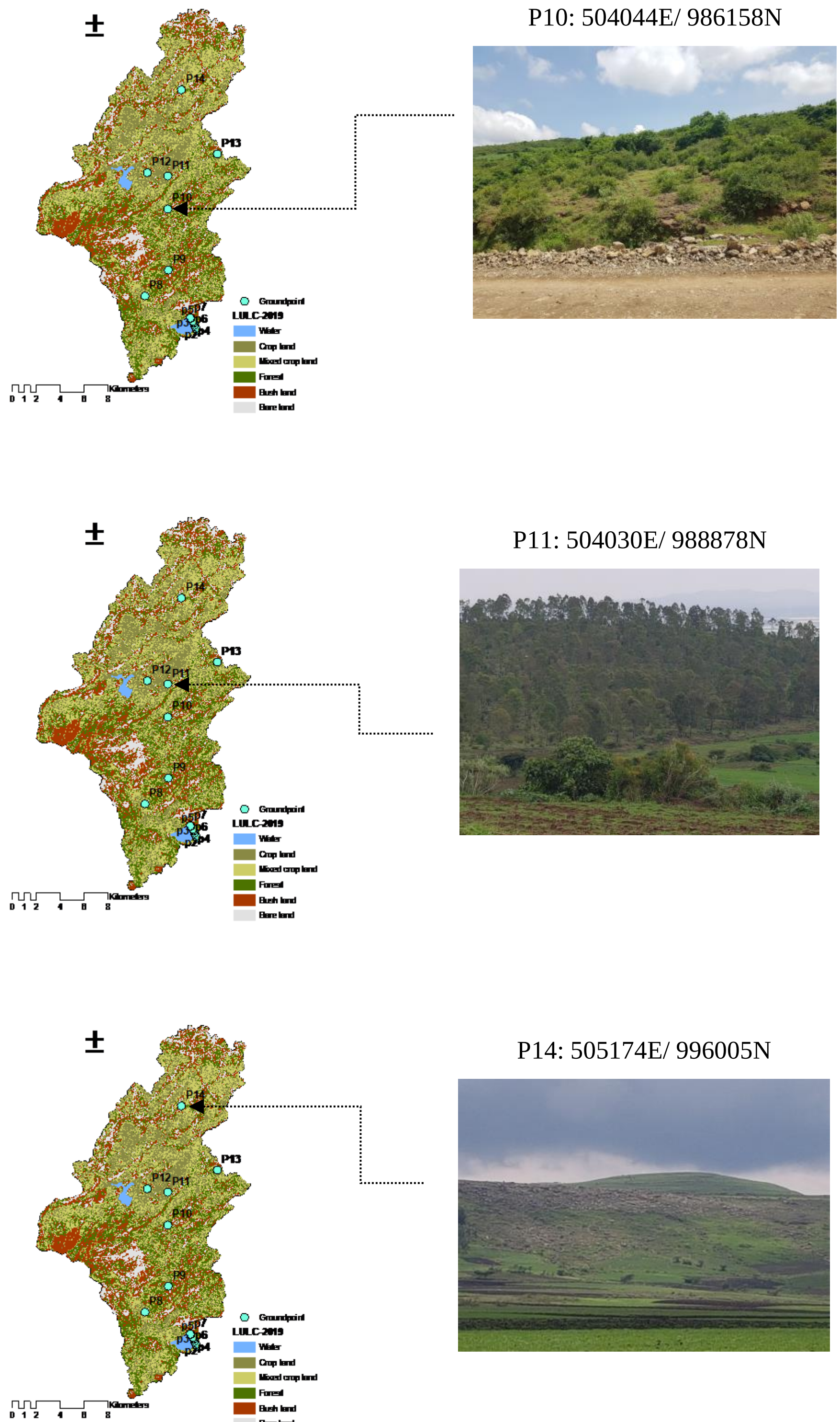


Figure 5-9: Images from the Satellite and Pictures on the Ground

Analysis involving satellite imageries pertaining to years, 1985,1990,1995,2000, 2005, 2010, 2015, and 2019 was conducted. This analysis was supported with community mapping and ground truth activities for verification purposes.

The results were compared and Land Use and Land Cover Change detection was made. In this regard, decreasing trends for bush grassland and forest cover were observed. However, cropland cover shows an increasing trend because of the land expansion for cultivation purposes to satisfy social and economic needs. Figure 5-6 and Table 5-2 illustrate these changes. Classification statistics for the year 2019 was done also. In addition, Normalized Differential Vegetation Index was addressed particularly for it largely relates to the objective of this study.

5.3 Summary

Analysis involving satellite imageries taken for the years 1985 through to 2019 at a five-year period interval was conducted. This analysis was supported with community mapping and ground truth activities for verification purposes. Moreover, Normalized Differential Vegetation Index was addressed particularly for it largely relates to the purpose of this study.

In this regard, Land Use Land Cover Change detection was made also, as a result. The results are clearly observed that land cover conditions for forest and bush grassland are in decreasing state whereas for cropland shows an increasing trend owing to the expansion of cultivation activities for securing social and economic requirements.

Furthermore, triangulation (comparison) of the results between the participatory mapping (of the PAR process) and the satellite imageries including GPS and GIS works was undertaken and the findings proved to be in agreement.

6 Discussion of the Findings on the Implementation of Pilot Scheme Using PAR

6.1 Introduction

Data focusing on the pilot scheme was collected with a view toward diagnosing the perceptions of the affected community in order to have a feel and to understand the logic they attach to why they feel the way they feel, to help design future directions in watershed management in the study context following the analysis of the data collected. In addition, soil and vegetation conservation practices, GIS mapping and responses from the participating community on the effect of the intervention was analyzed to support the design of the way forward. Finally, the participating communities and the researcher reached a consensus that the commissioning of the test pilot plot to the community before the researcher terminated the intervention would be necessary for scaling up community watershed management.

6.2 Pilot Scheme, GIS Mapping and the Community's View

6.2.1 Pilot Scheme Soil and Vegetation Conservation Practices

Implementation of the pilot scheme was initiated with a view towards demonstrating soil and vegetation conservation practices and scaling-up to areas characterizing similar land aspects. The purpose and aims for conducting the pilot test was to contribute to the ongoing soil and water conservation practices by the Government of Ethiopia to fight against soil and water losses through scientific conservation techniques by involving the community and related experts.

In this regard, the response of the community was exemplary that they were more active to have identified the area of the test plot based on the joint discussion process made prior to the site identification and undertaking research start-up activities.

The community mentioned they would participate in any activities in the testing process so that they would undertake similar activities elsewhere in the watershed in collaboration with other communities. In this regard, the community participation was so active that they were there and very active every time the researcher and the Botanist and/or ecologist were there for data collection, monitoring, evaluation, and feedback exercises for the research period covering

Twenty-Seven months. The outcome of the study indicated that community was more aware of the facts and approaches thereby built confidence to perform soil and vegetation conservation practices.

Soil conservation relating to the test pilot has been computed as shown in Annex 6, using Universal Soil Loss Equation (USLE) approach, employing particular site parameters; and associated standards were used. The computation revealed that conservation of forestland cover condition is 10 times more effective than that of the thick grass cover condition when used on terracing. This type of practice is also favorable with rainwater harvesting techniques, supporting water allocation options for the purpose of forest conservation.

In addition, comparing among conservation practices of strip cropping, contouring, and terracing for crop cover condition, terracing plays the greatest role in fighting against soil loss phenomenon. Bench Terracing and Hillside Terracing are the most common type of terracing used (Lakew D. et al., 2005).

Finally, according to Table 10-4 (p. 340), the estimate elicits that the terracing type of conservation is the most convenient activity of all land cover conditions in avoiding and / or minimizing soil loss. It is also important to note that terracing conservation practice for forestland cover condition is the most effective type of mechanism to control soil loss as compared to the other conditions of crop cover or grass cover condition and associated conservation practices (Table 10-4).

The following series of photos taken at different seasons of weather conditions, wet and dry, show the tree planting activities on the demonstration plot. The site monitoring was going on for twenty seven consecutive months, that resulted in soil conservation and wind break functions (Figure 6-1, Figure 6-2, Figure 6-3, Figure 6-4, Figure 6-5 and Figure 6-6).

Figure 6-1: Hedge (wind break) Planting at the Pilot Scheme

Figure 6-2:Early Stage Growth and Watering of the Seedlings

Figure 6-3: Discussion with the Supervisor at the Pilot Scheme

Figure 6-4:First Year Growth of the Seedlings

Figure 6-5: Start of the Second Year Growth of the Seedlings

Figure 6-6: Seedling Growth in Pilot Scheme - Twenty Seven Months After Planting

6.2.2 Findings from the Pilot Scheme

The pilot scheme demonstrated that those environmentally adversely affected areas can be rehabilitated through afforestation if complemented with the participation of the beneficiary communities and supported by the enactment of community laws / by-laws that are reflected in the local and national policy provisions. This would need to be supported further with periodic monitoring and evaluation of the project, including auditing to ensure that the outcome of the project supports the environmental, and the socio-cultural (including social, cultural and religious beliefs) and economic potential of the area.

The pilot demonstration site helped to identify the types of plants that are most suited to the environmental conditions of the area to help resuscitate the degraded land most conveniently and quickly. This in turn benefits the area further in supporting production forestry, which is production outside the natural forest that can account for the demand of energy, fuel wood and industrial timber requirements. In addition, besides helping conserve biodiversity by taking the pressure from the natural forest resources which would otherwise adversely affect the ecosystem of the area, the forest establishment may also create potential source of employment generation, thereby taking care of poverty-driven-forest-degradation. If the pilot scheme is scaled-up it would prove more successful achievements to the watershed communities.

Certain species of plants have also attracted community attention from the pilot scheme as fast growing species that can support the economy of the community. For example, Kaachaa that is widely used for fodder, as well as Avocado and Grevilia as sources of fruit. This would result in the positive shift of the perceptions of the community towards supporting the idea of reforestation as demonstrated by the pilot scheme. Vegetation has multi-faceted benefits as expressed through its different areas of functions, including in the area of water resources protection where it helps maintain hydrological cycles, acts as a mechanism to fight against extreme events, including flooding and drought, through regulating and stabilizing water run-off. Other benefits resulting from vegetation cover include soil retention and temperature regulation.

In this connection, it is thought important that policy support for watershed ecological management would be necessary. Moreover, the pilot scheme in the long term would contribute its share towards stabilizing greenhouse gas emissions through contributing to carbon sequestration and in that; it takes on a moderating effect on the local climate. In this regard, Pearson (2013: 201) states that, "At smaller scales, vegetation has a moderating influence on local climates and may create quite specific microclimates".

It may be inferred also that adopting a similar reforestation approach through scaling-up activities of the watershed pilot scheme area would be beneficial, involving integrated conservation agriculture and agroforestry development and watershed management. Practicing agronomic measures (mulching, crop management), soil management (conservation tillage), and mechanical conservation methods (terracing, waterways and related structures) would benefit in contributing to the watershed ecosystem rehabilitation process in terms of minimizing soil erosion, enhancing water infiltration and supporting the well-functioning of the ecosystem.

6.2.3 GIS Mapping and Participating Community's View

6.2.3.1 GIS Mapping on the Pilot Scheme Vegetation Cover Change

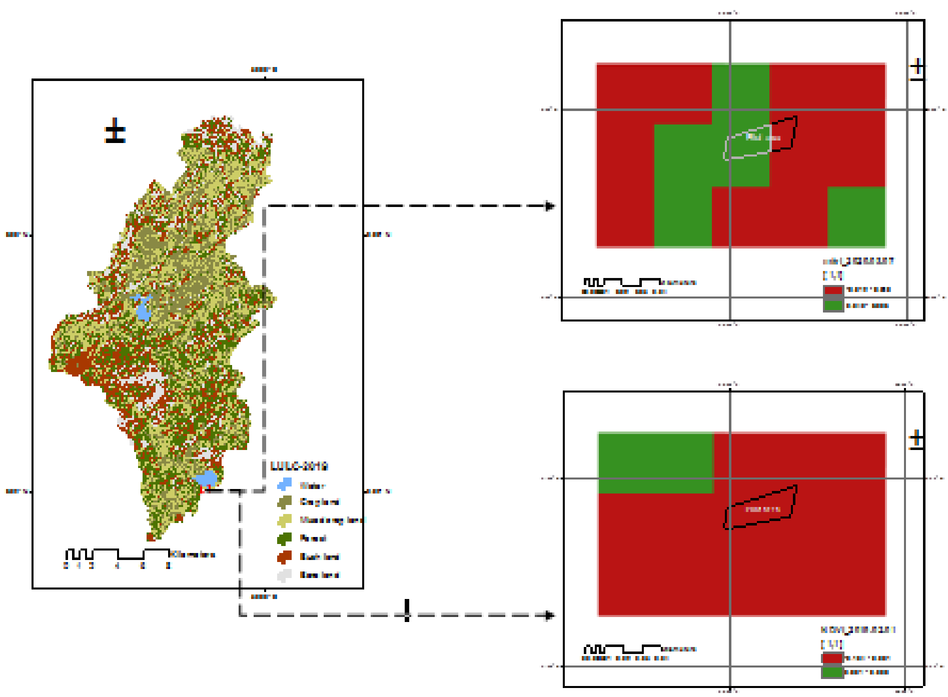


Figure 6-7: Pilot Scheme Vegetation Cover Change

Image analysis of the pilot scheme, from February 01, 2019 to March 07, 2020, shows an increasing trend of vegetation cover. In this regard, out of the total sample pilot area (0.3ha), 63% shows an area covered by vegetation (Figure 6-7, March 07, 2020). If the coverage is inspected more closely by fixing a threshold value of 0.001 within the index interval, about 0.085 of the land was covered by vegetation since February 01, 2019 to March 07, 2020, which is greater than this threshold point, indicating a successful achievement.

6.2.3.2 Participating Community's View

The participating community members mentioned that they are convinced that soil erosion can be arrested, ground water can be recharged, trees can be grown and the ecosystem can be reverted to a sustainable environment through reforestation efforts. Subsequently, they reiterated that vegetative growth could support income-generating activities, including planned logging, wood crafting, beekeeping, fruit production and agroforestry development opportunities. The community further mentioned that this produces potential economic gains that help them support their livelihoods whilst at the same time the watershed ecosystem would turn out to constitute stable functions of environmental amenities.

Moreover, most of the community members pointed out that some other communities elsewhere should be invited to pay a visit to the pilot scheme to facilitate exchange of experiences in that the current operational look of the scheme may attract a replication and expansion of the scheme activities to further areas as a result. The researcher believes that this is the objective, which the demonstration endeavored to achieve and therefore it can be said that the pilot scheme trial exercise was successful. However, it has been noted that it still requires a continuous enforcement of laws / bylaws to ensure a uniform mobilization of each of the community members' contributions on the successive project task operations with a view to benefiting both sound ecosystem regeneration and sustained irrigation agriculture development, thereby supporting the socio-economic benefits to the affected communities.

Finally, understanding was made between the researcher and the affected community that proper handing over of the test pilot to the participating community would have a significant role towards encouraging and possibly causing a more positive step forward to help replicate the pilot scheme elsewhere on a larger scale. In addition, it was mentioned that the handing over task further encourages, among other things, the continuation of previous, perhaps improved, procedural task operations to contributing to more outcomes that are positive.

6.3 The PAR Process Model

The validation of the conceptual Participatory Action Research (PAR) process model has shown that the comparison results between the participatory mapping and the satellite imageries are found to have similar outputs. In this regard, the first attempt of the trial of the PAR process model showed that the first cycle proved to be 'Yes' without requiring to have conducted a revision to the first approach, thus indicating the Model result is well in line with the output of the participatory mapping and satellite imageries. This elicits that the Model satisfies the requirements stated by Prathapan (2014) in which he stated that the output proves to be called a 'Theory or a Law', shown in the PAR model Figure 6-8 below.

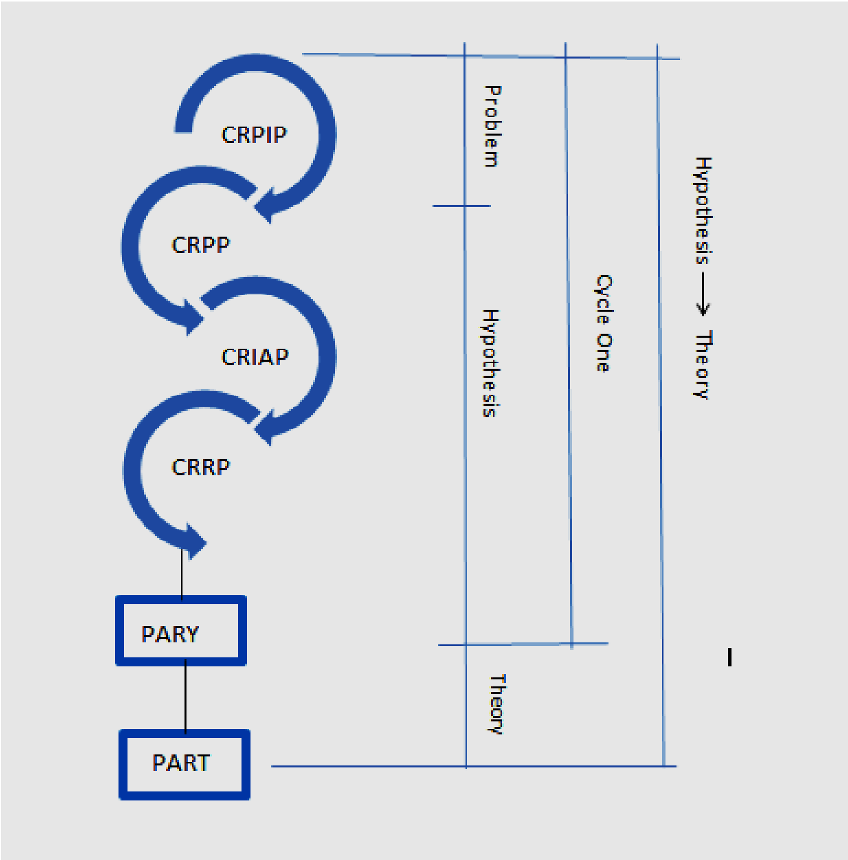


Figure 6-8: Result Figure of PAR Process Model

6.4 Summary

Soil conservation practices, based on different land cover conditions were analyzed to account for soil loss problems and support infiltration process. Computational analysis for soil loss shows conservation of forestland cover conditions was a more effective type of measure than that of thick grassland cover condition and much more effective also on terracing conservation practices.

The GIS mapping and participating communities' view in relation to the pilot scheme reflected a success story in the implementation effort of the pilot scheme. The comparison of the results between the participatory mapping of the first attempt of the PAR process and the satellite imageries through triangulation showed that the findings are in agreement. The PAR process Model, in this regard, also illustrates that the output of the first cycle of the trial of the Model was found to be in line with the output of the participatory mapping and satellite imageries satisfying the requirements set forth by Prathapan (2014) that the approach may be termed as a 'Theory or a Law'.

While doing the analysis, due focus was given to whether or not the content of the research questions and objectives were addressed and that elicited a successful achievement.

7 Discussion of the Findings on the Management and Responsibility Issues

7.1 Introduction

Delving into the findings of the analyses (Chapters 4, 5 and 6) made, it became evident that watershed management and responsibility issues need to be given further attention if the watershed natural resources are to be resuscitated and if irrigation development is to operate in sustainable manner. Therefore, it is believed that revisiting two more important areas in the study would be necessary to support the endeavor. These emerging areas of intervention mechanisms are 'Sustainable watershed natural resources management' and 'Responsibility for managing watershed natural resources'.

Understanding has been made also that this finding would help offer a clearer focus on supporting efficient and effective implementation of the project. Furthermore, apart from supporting the implementation process, it is thought it would further help realize the delivery of the outcomes of the research objectives that the community friendly watershed ecosystem management and sustainable irrigation agriculture development are brought to the fore. Hence, these two items of intervention mechanisms are dealt with in the following sub-sections (Sub-articles 7.2 and 7.3) accordingly.

7.2 Sustainable Watershed Natural Resources Management

The study identified key areas that still deserve further intervention efforts towards bringing the sustainable watershed natural resources management to the fore with particular reference to Belbela-Wadecha watershed environment and its related irrigation agriculture development. It also places particular emphasis on the governance issues, including the interacting systems among humans, institutions, and the environment of the watershed ecosystem.

In this regard, this chapter will deal with those identified areas of intervention including revisiting the instruments for sustaining watershed natural resources, institutional and human capacity building requirements, policy implications, stakeholder mobilization and participation. In addition, focal areas of intervention, and monitoring and evaluation and remediation of the watershed activities have also been noted as part of the intervention gaps. Accordingly, the chapter proposes intervention mechanisms towards effecting a sound ecosystem management and sustainable irrigation agriculture operations.

7.2.1 Instruments for Sustaining Watershed Natural Resources

Sustaining watershed natural resources is an important task that supports environmental and socio-economic benefits for enhancing the livelihoods of the watershed communities. The Government of Ethiopia has taken steps towards improving the environmental functions of the affected areas in the country and the living patterns of the communities. In this regard, to support its move, the Government drafted, ratified and promulgated policy support instruments.

Related instruments/institutions adopted by the Government include (according to Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia with the varying year of promulgation shown against each of the Proclamations Nos below):

- Proclamation No 295/2002, A Proclamation provided for the establishment of environmental protection organs
- Proclamation No 299/2002, Environmental Impact Assessment
- Proclamation No 300/ 2002, Environmental Pollution Control
- Proclamation No 542/2007, A Proclamation Provided for the Development Conservation and Utilization of Forests.
- Proclamation No 94/1994, A forest law enacted
- Proclamation No. 456/2005, Provisions restricting rural lands to tree planting, perennial crops, and forage production.
- PASDEP, 2005, Plan for Accelerated and Sustained Development to End Poverty

The study revealed that although the above policy instruments and related implementing organizations had been put in place to support the sustenance of watershed natural resources, the policies are not delivering as effectively as they ought to have, thereby failing to bring impact on the ground consistent with the institutional terms of establishment and policy objectives set forth. The study further reveals that the implementing institutions need to revisit their organizational capacity to help deliver on sustainable watershed natural resources functions, including taking up law enforcement mechanisms.

In addition, although Ethiopia entered into multilateral environmental agreements (Table 7-1:) to enhance its capacity in the implementation of environmental sustainability, still the Government needs to shed more light on the deliverability level of the engagements. In this regard, it is thought prudent that implementation instruments and institutions are effectively mobilized and, without exceptions, observing the treaties so that environmental protection endeavors succeeds in benefiting both sustainable socio-economic and watershed ecosystem functions.

Table 7-1: Multilateral Environmental Agreements to which Ethiopia is a Party
Source: Mwebaza et al., 2009

No	Multilateral environmental agreements	Adoption	Entry into force	Adoption by Ethiopia
1	Convention on Biological Diversity	21 May, 1992	29 December, 1995	31 may 1994 Proclamation 98/1994
2	Cartagena Protocol on Biosafety to the convention on biological diversity	January 2000	September 2003	Signed 24 May, 2000 Ratified 22 September 2003
3	Convention to Combat Desertification	1994	26 December 1996	Ratified - 1997 Proclamation 80/1997
4	International treaty on plant genetic resources for food and agriculture	November 2001	June 2004	Ratified - 2003
5	Vienna Convention for the protection of the Ozone layer	March 1985		Became Party January 1996
6	Montreal Protocol on Ozone depleting substances	September 1987	1 January 1989	Became a Party on January 1996
7	UN Framework Convention on Climate Change (UNFCCC)	1992	March 1994	31 May 1994
8	Kyoto Protocol to the UNFCCC	December 1997	16 February 2005	21 February 2005
9	Stockholm Convention on Persistent Organic Substances	May 2002	17 May 2004	Signed – 17 May 2002 Ratified – 2 may 2002 Proclamation – 2 July 2002
10	Rotterdam Convention on the Prior informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	10 September 1998		Ratified – 2 July 2002
11	Basel Convention on the Transboundary Movement of Hazardous wastes and their Disposal	1989	1992	Ratified – February 2000 Proclamation 192/2000
12	Basel Ban Amendment	22 September 1995		Ratified – 3 July 2003 Proclamation 356/2003
13	Protocol on Liability and Compensation for damages resulting from Transboundary Movement of Hazardous Wastes and their disposal	10 December 2000		Ratified – 3 July 2003 Proclamation 357/2007
14	Bamako Convention on the Ban of Import into Africa and the Control of the Transboundary movement and management of Hazardous Wastes within Africa	30 January 1991	22 April 1998	Acceded 2002 Proclamation 355/2003
15	Convention on international trade of endangered species of wildlife and flora	Signed – March 1973	Entered into force 1 July 1975	Ratified 4 – July 1989

7.2.2 Institutions and Capacity Requirements

During community interactions, the research revealed that the communities needed capacity building support in terms of having clearer picture of the process of project development and its management, where focus would be given to institutional and human capacity development. In addition, the community underscored those closer institutions to the scheme need to be there for closer and timely attendance to the project needs to ensure a healthy and sustainable operation of the scheme. Moreover, the community mentioned delegation / decentralization of functions to the community (formal / informal) would address challenges more effectively than formalized bureaucratic operations from distant locations.

Catherine (2007) argues that decentralization to the Woreda (the second lowest administration unit in the Government hierarchy) level plays a greater role in decision making by the citizens on the ground. Catherine (2007) also stated that such opportunities might be constrained by certain factors, including lack of capacity and unclear policies. However, the researcher argues that decentralization to the Kebele (the first and lowest administration unit in the Government hierarchy) and the community makes development more effective, particularly in community owned development schemes supported with capacity enhancement and provision of clear policies to deliver on the ground.

In this regard, Wabekbon (2009) also suggested that more focus should be given to the institutions closer to the development projects, both formal and informal institutions. It is noted also that capacity building of both Woreda and Kebele levels remains a critical function to be taken care of.

In this study, a Joint Association Laws for Watershed and Irrigation Beneficiaries (JALWIB) has been proposed, sub-article 8.2.5.1, as a local legal framework document to adjoin both upstream and downstream communities to operate as an institution which aims at defining their benefits, rights, and obligations with a view towards securing a sound upstream ecosystem and sustained downstream irrigation functions.

Training and capacity building of the association needs to be conducted in terms of the JALWIB's benefits, rights and obligations and procedures, prepared by both Woreda and Zonal offices, whereby community representatives effectively participate in the preparation process of the training documents and are concurred with the whole community members. It is important to note that JALWIB and Restoration Framework Model (RFM) model (Figure 8-2, p. 271) would cross function in a way to ensure sound ecosystem management and sustainable irrigation agriculture development.

Bryan (undated) stated that episodic organization is often more than sufficient to accomplish particular tasks related to irrigation administration where formalized bureaucratic models favored by development agencies often fit poorly with local needs. Hence, formation and administration of water related organizations such as water users associations can be more effective, in a less formal approach. In this case, JALWIB may be adopted as it is a new approach involving not only sustainable water use issues but also constitutes sound upstream watershed resources functions.

7.2.3 **Monitoring and Evaluation and Awareness Creation**

The study elicits that there has been no defined and focused monitoring, evaluation and feedback provisions exercised on the Belbela-Wadecha watershed ecosystem on a regular basis. Because of these shortcomings, there has been no information flow that would enable the stakeholders make sure that the scheme was on the right track. This deficiency further obstructed opportunities, which would have otherwise helped to design related directions as to making remedial decisions leading to the setting any defective parts of the scheme right.

Monitoring and Evaluation works were supposed to have been done regularly at the Kebele level (Godino and Qoftuu in the case of this study) through defined tasks meant for monitoring and evaluation purposes. Specific responsibilities ought to have been assigned to each individual person including clearly defined terms of references where provisions for timeframes and meeting reporting quality standards are also included, showing possible way forward, resulting from the evaluation account.

The JALWIB in this regard also can be put into use as an effective tool in the process as its mandate covers monitoring and evaluation functions.

In addition, awareness making relating to all necessary issues, including objectives of the project (Belbela-Wadecha watershed ecosystem), community duties, mandates, responsibilities, and rights and obligations is crucial to both project success and sustainability of the system. Mahi (undated) suggested that awareness generation and training impartation would be important, as there is a lack of general awareness. Hence, training should be imparted in decentralized manner, reflecting on the related subjects, to any resource mobilization activities.

7.2.4 Policy Implications

Interactions with the community during this study elicited that there were between the demand of the community and the response of the Government. The community stressed that they needed to be listened to more appropriately and wanted the issues they raised to be implemented and that delivery on the ground should be justified. This revealed that the response of the Government was not sufficiently addressing the queries of the communities. Therefore, if watershed natural resources have to be sustained, the government should be able to carefully listen to the issues that the watershed communities raise, appropriately respond to their quests and safely keep the jointly prepared bylaws document with the participating communities.

Following proper documentation of the proceedings of the both parties (the Government and the Community), the Government should be prepared enough to launch the collectively prepared document(s) (regulations, guidelines, directives and policies) and responsibly discharge its mandates as stipulated in the policy provisions with a view towards realizing the demands of the community. The community also needs to proactively attend to the healthy operations of the scheme and take timely corrective measures as necessary, while regularly and properly attending to all the provisions set forth.

In addition, challenges in terms of policy provisions are that foreign funding, especially from western sources, reflects the priorities of western values, including western educational curricula, living patterns, science and intrinsic values (Ntiamoa-Baidu et al. (2000). On the other hand, national governments seek to see the natural resources from point of view of economic values as opposed to the rural inhabitants who wish to see more of the subsistence value of biodiversity.

However, it is wise to note that it is essential to harmonize such extremities so that foreign funding becomes compatible to the national policies in such a way that the funding arrangements should not be in conflict with the national programs. However, when such provisions are not in harmony with the national implementation strategies, it should be renegotiated towards benefiting the user communities.

When national and local interests are in conflict, the government should seek to focus on addressing local issues as a priority matter. This approach will contribute to sustainable functioning as the communities give due regard to opportunities offered by the government that consider the community's issues as a priority agenda and supports their economic needs.

Furthermore, natural resources can be sustained if alternative sources of income generating activities are facilitated for the communities with a view towards addressing the pressures that cause the degradation of natural resources such as fuel wood production. Failure to do so may result in continued environmental degradation resulting from exploitation of natural resources for securing the livelihoods of communities, which in turn results in driving the communities into a permanent poverty trap, agitating the communities to pose complaints such as issues on 'lack of good governance'.

Hence, the government, to respond to such questions, should seek to support community development projects through policy reform, as a priority agenda, in collaboration with affected communities.

7.2.5 Government, Community, and the Public Sector

A watershed inhabited by a community is the resource of that community, including the natural resources found in the watershed area. These natural resources include land, water and vegetation among others. Since the livelihood of that community is dependent on those watershed resources, the communities are more naturally responsible for maintaining them, and keeping the watershed ecosystem intact through sustainable use of the resources for economic, social, aesthetic, spiritual, environmental and other beneficial purposes. This supports livelihood diversification and risk reduction. In this regard, USAID (2006:19) states that, "By having alternatives for generating income, poor people can shift or borrow assets to avoid destitution."

However, in this regard, the communities may need certain technical support, including efficient harnessing of the water infrastructures for irrigation purposes through local and national institutional arrangements and enforcement of related regulations accordingly.

It is believed that efficient institutions at both local and national levels are the backbones of sound ecosystem management and sustained irrigation development. However, supporting and ensuring the practical delivery in the implementation process of such projects remain the core issue to be resolved.

Transfer of power, as a policy reform, from central institutions to local level actors should be exercised. In this regard, Strand, Marullo, Cutforth, Stoeker, Donohue (2003a, cited in Jonathan D., 2006) states that it is essential to actively Re-allot power between all involved constituents and members in the community–based research process. This approach may empower the communities and local institutions to have better and effective access to address their needs and issues at stake, which may be relayed then to the higher institutions, regional and national levels for follow-up and support services, where keeping active community participation center stage in any cycles of project making is uncompromised. This way it may receive the attention of the relevant national institutions to help promulgate as a policy provision and cascade responsibilities to the institutions at various stages.

This approach may take care, more effectively and readily, of possible source of complaints that may arise from the community and the community institutions. This approach again would help the communities and the governments address possible implementation issues at the grass roots level or at the genesis of the matter.

Communities, local level institutions and the public sector are the key entities, coordinated and co-management functions facilitated by higher level institution, that play central roles in implementing institutional policies, especially in NRM. Ghorbani et al. (2015) argue that facilitating collective management between different component interests is one of the important factors that an institutional network undertakes towards making a watershed management successful. "An appropriate institutional network structure includes multiple levels of government and non-government interests to create natural resource policies and resource conflicts in management options." (Ghorbani et al., 2015: 165). If this function includes the communities in drafting policy provisions, meaningful policy implementation will be real requiring less or no need of policy enforcement procedures, as it would be totally of an inherent exercise, contrary to the imposed policy provisions upon the users.

It is believed that effective coordination of activities of natural resources management takes place where multi-sectoral institutions are involved with clearly defined and shared mandates and that these mandates are well attended to by all parties including that no duplication of efforts are made.

Ghorbani et al. (2015) supports this idea that coordination of activities among multiple institutions in line with their responsibilities ensures effectiveness of the natural resources management.

Furthermore, it came out during the study process that human aspects including, attitudes, behavior, and beliefs would be important in contributing and influencing watershed management practices. Therefore, inclusion of social science helps in appropriately and effectively implementing watershed management projects would be an advisable way forward. Ajzen (2001) argues that: the importance of the behavior can be influenced strongly by the attitude towards specific behavior. "Attitudes are based on beliefs and involve a positive or negative assessment of the performance and outcome of behavior" (Ajzen, 1991; Fishbein and Ajzen, 2010, cited in Kiristin F. et al., 2015).

7.2.6 General Focal Areas

The basic challenges that the government institutions are facing, in natural resources management, include issues of institutional capacity gap in terms of effectively operating at the grass roots level and enforcing policies, strategies, proclamation provisions, regulations, directives, bylaws and other related legislations at various stages in the government structures. UNEP (2002) also states that capacity building is required in the field of environment including on policy development at regional, sub-regional, national and local levels and on the development of environmental laws. Lack of adequate capacity for effective coordination of different portfolios is another source of the problem that obstructs effective implementation of programs and projects. UNEP (2002:11) also supports this idea of enhancing synergies between and among multiple institutions that: "sustainable development involves a complex interplay between economic, environmental and socio-cultural considerations, it follows that for a country to achieve sustainable development it must consider all these issues in making short- and long-term development plans". Fighting against lack of good governance and corruption issues are also other challenging areas seriously threatening effective operation of government legislations in many places.

It is no doubt clear that the Government of Ethiopia has effectively put institutions in place, related portfolios, implementing instruments including policies, laws, proclamations, strategies, programs and projects. Nonetheless, a question that arises: is clear awareness on the practical operability of the instruments made to the implementing entities, monitored, law enforcement ensured, feedback including remedial actions undertaken and impacts on the ecosystem and the community assessed? Such questions need to be attended to seriously, if tangible benefits have to be there on the ground.

7.2.6.1 Focal Areas for Belbela-Wadecha Watershed Community

Regional and local governments need to commit themselves as to enforcing the restriction measures and updating them as deemed necessary remains the central roadblock in the watershed development exercises. Therefore, focus should be given to the coordinated move of Government, Community and the Public sector all observing the rules and regulations towards implementing watershed natural resources conservation and development that protects the ecosystem and ensure irrigation agriculture sustainability which in turn supports the drive away process of poverty.

In addition, focus needs to be given to decentralize functions to Woreda, Kebele and local levels institutions' administrations to ensure transparency and accountability. Decentralization provides opportunities for more accountability and multi-stakeholder participation at various stages in developmental exercises decision-making (Ghorbani et al., 2015). Accordingly, this perception needs to be supported by the governments, to help enhance the delivery process on the ground, through proper coordination among institutions including civil society organizations and private sectors.

7.2.7 Development Stakeholders

Communities need to be supported in their development endeavors until such time when they find themselves fit to run a project by themselves and gain self-confidence that the outsiders can withdraw from the project. As modern practices of the stakeholders are concerned, the governments inputs at getting the project started is important and also NGOs can provide support in technical matters including the provisions of training opportunities covering training materials.

In addition, Local-Traditional Authorities and the Community Entity should be given proper attention that their local knowledges are key, the researcher believes, to meaningfully benefit the communities' projects. All affected parties should also appropriately recognize the bylaws that its contributions are effective in addressing project problems more practically as these bylaws are developed from what the communities have already observed and are observing.

7.2.8 Modern Practices of the Stakeholders

Belbela-Wadecha watershed community bears the prime responsibility towards protecting and managing the natural resources' ecosystem of the watershed. However, as the community at this stage is not at the required capacity level to resolve all possible challenges that would arise in the course of implementation, other stakeholders, including Government and NGOs need to be involved in the furtherance of watershed environment development. The support of the Government includes, cascading legislative provisions, instituting and arranging enforcement organs, determination and coordination of the involvement pattern of different parties, NGOs and other development partners including private sector. IIMI (1990) supports this approach that the government holds this responsibility to formulate legal frameworks, enact and monitor and evaluate the outcome thereby design the subsequent steps as required.

The contribution of the private sectors is immense that they can be a source of knowledge base in providing training in the related areas, sharing hands on experience, enhance technical capacity and support identifying possibilities for funding supply.

In order to engage the contributions of the stakeholders on issues that are focused more and effective, the participating community should always be able to cite their issue of focal areas and lodge claims against concerned parties while not forgetting that the community being part of the solution.

7.2.8.1 Focal Areas

According to the researcher's view, although efforts are underway at various fronts by the Government to constitute a developed nation, the Government needs to seek more focus on primarily setting a well thought out technical coordination mechanisms than occasionally shifting around the portfolios that were assigned already to various institutions, as it adversely affects implementation and management of the projects. In this regard, Tweneboah (2009) argues that occasional shifting of portfolios involve extensive mobilization of resources including, budgetary and human needs resulting in adverse effect on the implementation of projects/programs,

This may cause inconsistency of information flows adversely influencing wise decision making process that otherwise would affect the potential delivery capacity of the project. In addition, if the end user is not empowered, early on withdrawal of the outsider and portfolio shift would make the whole exercise much worse. Hence, the researcher argues that community empowerment and participation is central towards accounting for much of the problems in the project making including those issues of sustainability. IFAD (2008: 16) concurs with the centrality of this idea that: "Empowerment of poor rural people and their organizations is a prerequisite for sustainable improvements in their access to land and tenure security".

In addition, the local and national governments may seek to have pre-defined mechanisms early on in the project making that may account for any possible anomalies. Such possible gaps can be bridged better by involving the user communities without exceptions in identifying the likely challenges, as they are also the right party to seek the right solution to their circumstances. In addition, the beneficiaries need to be fully empowered before, as mentioned above, external assisting body terminates its input.

NGOs and development partners' operations are usually not often in line with government development directions, owing to advocating their own agenda (Tweneboah, 2009). This would cause distrust between implementing government sectors and other development partners thus seeking reconsideration of the arrangements of the functions with a view towards harmoniously discharging collaborative roles and responsibilities.

7.2.9 **Local-Traditional Authorities and the Community Entity**

The researcher argues, in order that the traditional methods of attending to the natural resources the use of customary governance including bylaws need to be brought to the fore. To realize this thought, there should be effective enforcement mechanisms in place from the national government side and enhanced capacity of the communities to cope with differences and harmonize issues to get their internal regulations and bylaws going. Pradhan NS. et al. (2012: 30), in this regard, state that "Disregard of existing locally established and effective mechanisms for the management of water resources has eroded community interest in, and ownership of, the interventions". The researcher further argues that the government should give a more focused support to the local institutions so that the institutions are put on a solid foundation to effectively deliver on their mandates.

It is again important that coordination of activities among the local institutions is critical that efforts need to be combined to deliver on the meaningful benefits to the community in terms of resources conservation where the environmental and agricultural benefits can be derived with a view to affecting sound ecosystem functions, social, economic, and religious / spiritual beliefs.

The respondents also suggested it during field data collection that the policy makers should not ignore environmental values of the user communities for economic purposes. Caldwell (1993) attaches importance to the local functions reflecting as, as people and their social systems impact on natural resources, the problems created cannot be sorted out completely by science and technology, as partly they are a result of the diversity in human perceptions, expectations, and values.

Therefore due regard should be given to the local communities by policy makers for they are the right party to relatively more appropriately solve problems in their circumstances, as the problems that would be created in the communities' territory may not be outside their perceptions, expectations and values, thus sorting out related issues would be more feasible.

7.2.9.1 **Focal Areas**

The researcher believes that traditional laws / governance and the general framework provisions set out by central government need to be reconciled in a way local norms are given due consideration when statutory and customary governance functions are in discordance, with a view towards addressing the local views. Lakew D. et al. (2005) states that, two work norms, namely: "Work Norm Guideline - 2000" and "Interim Work Norms" have been developed and that the former work norms have been reviewed by the regions through field testing process and endorsed by the MoA. Nevertheless, there is not any mention made for the latter norms as to whether or not awareness has been made to the relevant stakeholders. In this regard, one would raise a question: Is the community engaged in the process involved. The process clearly shows that the community was not party to the process involved, thus putting sustainability in question.

Therefore, if the community projects have to be successful, for example, watershed ecosystem management, the community must be involved in the process so that both norms operate in harmony and accountably addressing sustainability issues. Porto M. et al. (1999) argues that the civil society is granted a permanent seat in the watersheds' management committee, the highest decision level committee for the establishment of water policy and for planning its use. There has also been an extensive consultation with civil society, including state and federal governments and the private sectors in the formulation of the National Water Law (Porto M. et al., 1999).

It is also important that effective development operation and management mechanisms of natural resources at the local level is given due emphasis to ensure beneficial and sustainable operations at both local and national levels with a view towards addressing social and economic challenges at all levels.

The researcher further argues that it cannot be overemphasized that the local community members and their inputs to giving support at both local and national levels should be recognized as the most determining factor, which contributes the most important functions in development planning, design, implementation, operation and management processes, of natural resources. In this connection, Muniu F. N. (2018: 72) states that, "The degree of the community to contribute project resources has bearing on its performance". Muniu F. M. et al. (2018: 71) further states that, "Involving the users in the planning, implementation, operation, protection, and maintenance of water supply system enhances sustainability". Hence, focus must be given to traditional authorities and community groups, if watershed ecosystems are to practically and sustainably deliver on the benefits of environmental wellbeing and healthy economic functions mainly targeting irrigation development.

7.2.10 **Summary**

Studies on the Belbela-Wadecha Watershed natural resources management revealed that stakeholder participation at various stages in the project making process and law enforcement mechanisms were not as strong as it should be. The study further indicated that these gaps are attributed to lack of sufficient implementation capacity, weak coordination activity, and lack of objective focused decentralization functions. It was also found out that there had not been sufficient monitoring and evaluation including impact assessment carried out regularly and effectively. Lack of focused awareness creation and failure to adhere to local traditional development imperatives were noted also to be other areas requiring intervention.

This is therefore to note that relevant local institutions need to be put in place and charged with defined list of tasks and mandates with a view to ensuring sustainable natural resources and irrigation development. There should also be given due regard that institutions need to pay due attention to the focal areas cited above while respecting traditional methods, customary governance, bylaws and government regulations. Capacity building and awareness creation in each cycle of project making, including monitoring, evaluation, and remediation activities are thought also to be central elements to making the projects successful.

Moreover, The researcher argues that a participative move of affected stakeholders plays a central role in making a project more beneficial resource supported with a well thought out and planned mobilization of development stakeholders and resources, including sharing of expert knowledge and hands on experience in the areas of management and governance. Nancy J. et al. (2001) support this idea that if watershed development has to be successful all stakeholders including policy makers, researchers and others need to be party towards making the project happen. This benefits capacity enhancement of the community and government entities so that programs / projects meet their objectives addressing issues of both environment and irrigation development in a sustainable way.

In addition, Elsa M. et al (2007) advocate the idea of knowledge sharing with the communities and concur with the resulting enhancement of their understanding towards making a successful project/program. Elsa M. et al (2007) further state that an innovative outreach model, 'knowledge exchange train', which was developed combining educational outreach with capacity building approaches to broaden public participation in planning for sustainable development has increased the public awareness of the communities and offered mechanisms towards broadening their participation levels in planning and governance.

7.3 Responsibility for Managing Watershed Natural Resources

An analysis of the sentiments of the respondents from the questionnaire survey revealed that the natural resources in the watershed area, where the communities live, belong to those communities themselves who could use the resources since birth. The respondents also mentioned that, with the support of the government the community wished to take the lead in managing the natural resources of the watershed area.

Although the involvement of the community all the way through is a key task to the success of projects, especially the community owned ones, the government role still remains important in providing capacity and capability requirements, including financial support. Muniu F. N., et al. (2018: 75) concurs with this approach that, "in some projects, the money contributed by the community was very little to cause any impact and required the intervention of the government".

In addition, it has been noted during the study that there are certain existing items of works that still require further intervention endeavor. Therefore, in order that responsibility for managing watershed natural resources are effectively discharged and tangible benefits for the beneficiary communities are put in place, those existing problems and possible intervention mechanisms would be needed to be looked at.

Hence, the identified intervention mechanisms include evaluation of the current state of the natural resources management (NRM), creation of community awareness on the importance of NRM, stakeholder mobilization, implementation and withdrawal phase issues including monitoring and evaluation and feedback provisions. Approaches for managing the natural resources of the watershed ecosystem have been proposed as follows.

7.3.1 **Evaluation of the Current State of the NRM**

Discussion during the study revealed that there have been limitations in the natural resources management practices of the Belbela-Wadecha watershed ecosystem. These limitations include, lack of organized and holistic information flow as to enabling the involved entities undertake effective natural resources management functions to help the watershed environment offer the optimal benefits to the community and the wellbeing of the ecosystem.

Therefore, it is necessary to assess the current state of NRM including the level of community engagement. Consultations need to be carried out involving traditional leaders, existing community members, related records, if any. Information needs would include a check on whether or not there was a coordinated and regular engagement of the community in ensuring the wellbeing of the natural resources, enforcement of bylaws and government legislations. In addition, it would be important to shed more light on the possible need of community training on the technical support needs to patronage that the natural resources are more productive.

7.3.2 Creation of Community Awareness on the Importance of NRM

It was noted during the study process that, although the community was aware and could acquire certain knowledge on the related Belbela-Wadecha watershed ecosystem natural resources degradation problems, they reiterated that the community still needed some kind of technical support to help them perceive more adequately the importance and meaning of proper NRM to the watershed ecosystem and their livelihoods.

The study process further revealed that this aspect can be addressed through enhancing their technical background capabilities in the subject of sound ecosystem management and sustained agricultural development, adapting to changing circumstances in the area and forecasting possible shortcomings including devising the future directions. MoARD (2005: 13) concurs with this approach stating, "Technical support is also needed to visualize watershed potentials and logic".

In this regard, interventions, including awareness campaign needs should be made on how problems can be resolved and benefits derived from adept NRM practices. This can be undertaken through conducting forums including meetings, workshops and distribution of print materials specifically prepared for this purpose.

Understanding was made during the study process that the awareness creation campaign should also include mobilization of specialized knowledge as related to the area and at some level inclusion of scientific approach including ecological expertise relating to irrigation development and implementation of the environment of the watershed natural resources. Floress K. et al (2015: 94) concurs with this approach that: "The generation of accurate, context specific, and policy relevant knowledge on complex social-ecological systems is needed for enhancing success in watershed management". In addition, MoARD (2005: 30) states that, "Together with kebele leaders provide an introduction of the relevance of watershed principles and management issues to the community. Discuss the sub-watershed interactions and some of the linkages in terms of land degradation such as low productivity, reduction of landholding size, incidence of droughts, flood damages, drying of springs, disappearance of perennial rivers and forest coverage, and others". On the other hand, the trainers of the community need to be trained in line with the training needs set forth, by Woreda or zonal experts supported with qualified experts in the area from the related higher-level academic institutions. Moreover, Floress K. et al. (2015: 94) states that, "Greater awareness among policy makers, and ordinary citizens of the dynamic interdependence between the human and biological components of watersheds, as well as the uncertainties and unpredictability that characterize such coupled social-ecological systems, is needed to inform more sustainable watershed management policies".

7.3.3 Stakeholder Mobilization

The study indicated that there had not been purposeful, focused and organized mobilization of the communities of the watershed area of the Belbela-Wadecha ecosystem. This is because, although there were bylaws that the community ought to have adhered to, most of the communities did not observe the laws or law enforcement measures were not as serious as it should be. The law enforcement measures that would be applied against the likely defaulter should be as serious as at least commensurably / reasonably influencing (adversely) on one's economic gains or impose additional labor contribution.

Therefore, the researcher argues that the law enforcement restrictions, for example as to holding a defaulter accountable and face fines of certain amount of money, or extra labor work etc, should be imposed to induce some kind of related consequences as to making him / her feel guilty and help oneself retreat from such disciplinary mistakes in the future. Mule H.M. (undated: 9) agrees that service delivery has to be in harmony with the societal norms, that if the norms have to be effective, "laws, regulations, and enforcement mechanisms including sanctions are put in place". This is because, the assumption is that the bylaws would be respected and obligations fulfilled to benefiting the ecosystem, thereby support and enhance the livelihoods of the affected communities through improving their socio-economic gains.

Figure 7-1 shows the framework for involving the local community in natural resource management. The researcher concurs with this approach but argues that it needs employing (Joint Association Laws for Watershed and Irrigation Beneficiaries') JALWIB's provisions especially those involving irrigation developments downstream. In addition, the researcher suggests that allowing for further consideration, in the implementation process of the framework (Figure 7-1), of activities indicated in Figure 8-2 would support the success of the framework referred to above in the light of benefiting both sound operations of the environment and sustained irrigated agriculture functions.

7.3.4 **Implementation Phase**

After understanding and consensus is reached, program / project implementation should be undertaken through full community participation in the soil and water conservation (SWC) intervention measures to ensuring long-term community welfare. IWMI (2016) states that implementation of SWC, including other watershed management technologies, has proved success, through community participation, in terms of socio-economic level improvements.

NRM and project implementation should account for the diversified economic generation schemes that take pressure from the use of natural resources (like support avoiding wood / tree cutting for fuel wood use) and reduce or eliminate the risk of poverty. USAID (2006: 19) states, "Perhaps the most common means of reducing risk is to diversify livelihoods".

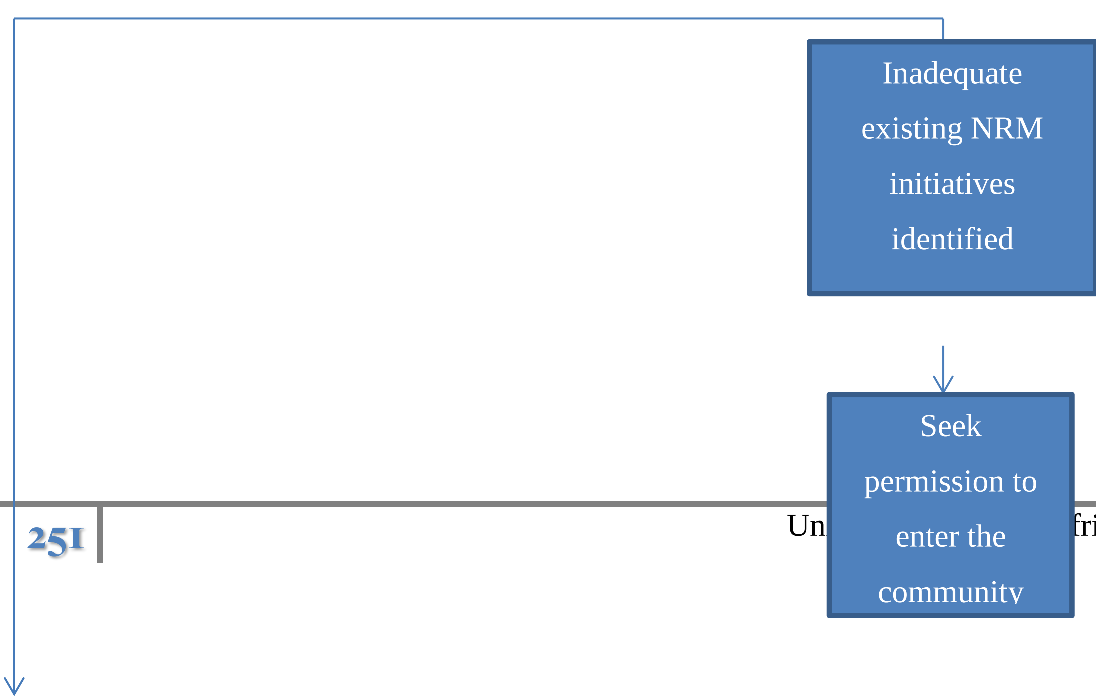
The researcher believes that it is important to use again certain procedures and tools that were used in the awareness creation phase to help reinforce more, advocate, believe, adopt and implement practically and contribute to behavior changes. Mercy Corps (2008: 46) argues, "Awareness campaigns and issue socializations offer an opportunity to demonstrate behaviors to large groups of people", and that should be undertaken through different means of broadcasting services, including on-air dramas.

7.3.5 **Monitoring, Evaluation, and Remediation**

Following the implementation phase, it is essential to put a regular monitoring and evaluation process in place. This approach helps to see if the project had made difference in the communities' livelihood patterns and indicate possible areas of intervention for corrective measures. Marisol M. et al. (2000) agrees that evaluation has a role in measuring how much difference would a project or program make in a given locality. The process should include reflecting on the prior implementation scenario, current state of operation and possible future contribution to the welfare and livelihoods of the watershed communities. This process should also help consider if changes or modifications are necessary to the approach followed.

7.3.6 **Withdrawal Phase**

Now the community should be well aware of the watershed and project functions, benefits and controlling mechanisms of the likely problems involved to ensure sustainability. The community at this stage should be able to readily share responsibilities and willingly support the implementation of the bylaws of the watershed communities. Therefore, it is assumed that the community should be ready at this stage to manage the natural resources in an organized and communal way where the environment is kept intact, natural resource degradation is taken care of and benefits are shared accordingly.



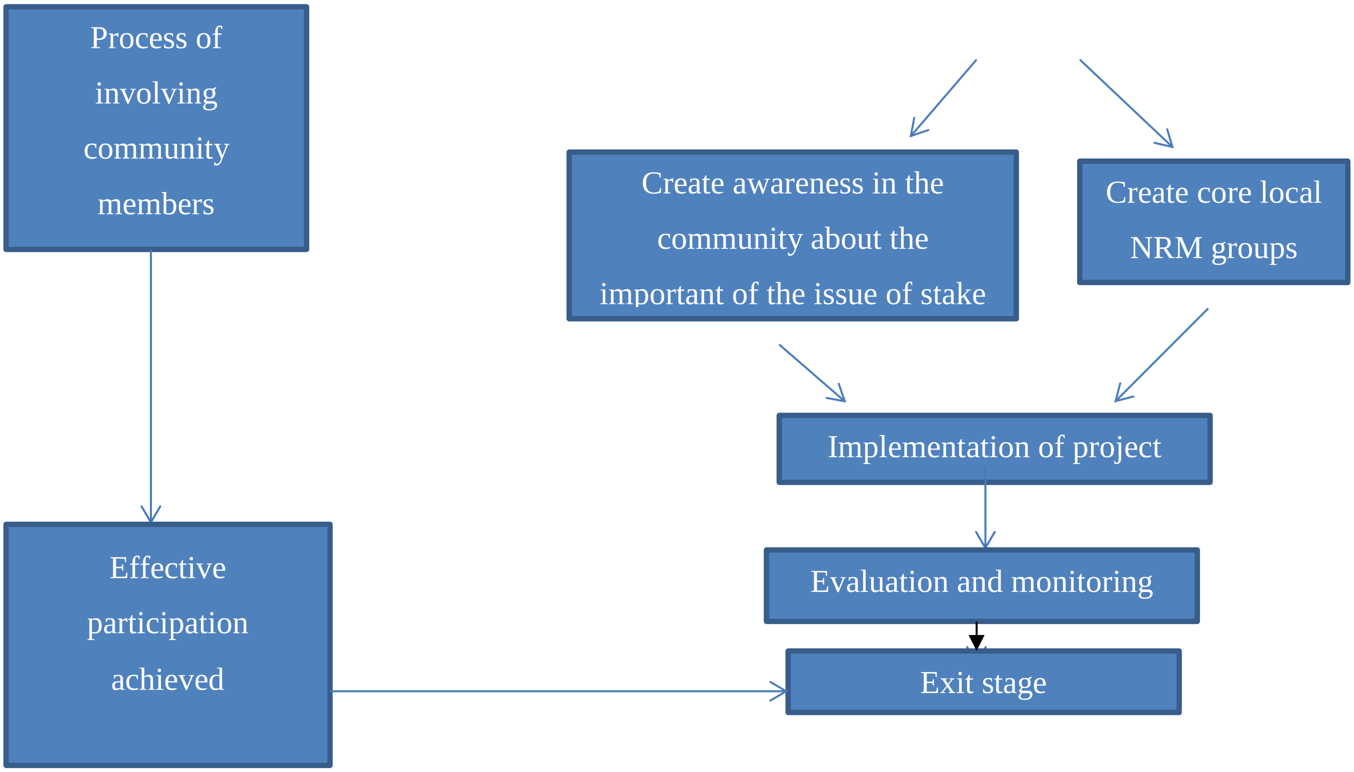


Figure 7-1: Framework for Involving the Local Community in Natural Resource Management

Source: White et al., 1994

7.3.7 **Summary**

This sub-section notes that responsibility for managing natural resources needs to focus on the evaluation of the current state of the natural resources management and community awareness making in the area of conservation of the natural resources. It has been noted also that early on mobilization of the stakeholders would be important that focus would be given to each cycle of project making with a view to ensuring the consistency of operations involved supporting the implementation of friendly ecosystem and sustainability of irrigation development. Mercy Corps (2008) states that, early stage mobilization effort being the most important activity in the mobilization process, benefits community ownership of a project.

In addition, it has been reflected that proper attention should be given to implementation phase supported with monitoring, evaluation, and remediation activities and highlighted that it would be an important issue to pay attention to, that, care must be exercised during the withdrawal phase. Mercy Corps (2008) argues that monitoring and evaluation provides information to enable people make decisions, tracks project progress and benefit learning and exit strategy is important which deserves planning and developing mechanisms for implementing handovers and defining activities that should continue after outside support withdraws and help the community (stakeholder) maintains those activities.

Finally, the researcher suggests that strict adherence to the provisions set and purposeful observation of laws / bylaws should be undertaken to ensure the success of the programs / projects towards delivering on environmental and economic benefits. These achievements primarily benefit the affected communities, where in turn the government relatively benefits from reduced and pressing social demand, by the community, on economic imbalances, which would otherwise result in posing repeated and relentless questions to the government, such as lack of good governance. It is understood also that the government enjoys more gains through the yearly taxations on the improved revenues of the communities resulting from increased outcomes accruing from better implementation and management of the projects and / or programs.

8 Conclusion, Recommendations and Prospects

8.1 Introduction

This chapter, apart from concluding the study, reflects on the information gained by the research study process relating to the causes and effects of watershed natural resource degradation. The study further draws on how to operate sustainably on both watershed environment management and irrigation agriculture development. The chapter also reflects on the objectives of the study, and addresses issues in the discourse relating to the purpose, aim and responds to the related research questions of the study set forth with a view to tackling the research problem, sub-problems or hypothesis referred to in this study. In addition, it reflects on recommendations involving policy issues and other related technical matters. A few possible areas for further intervention have been indicated also.

8.2 Conclusions: Findings' Summary and Study Objectives Re-Visited

This section deals with the summary of the findings and objectives of the study.

8.2.1 Short Summary of the Findings

Under this sub-section, brief reflections on the summary of the findings of the study are made. The brief summary of the findings' chapters of the study relates to the issues of demography, questionnaire, focus groups, GIS mapping and ground truthing, implementation of the pilot scheme and the PAR.

In this regard, it was found out that although the communities were aware of the would be benefits from the sound environment, sustained irrigated agriculture development, regulated climate and job created facilities; enforcement restrictions of laws / bylaws still take center stage to ensure the sustainability of the watershed ecosystem functions.

Land use land cover change detection for main crop classes for the years 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2019 was made. Community mapping and ground truthing for the year 2019 had been also undertaken. The participatory mapping (PAR) and the satellite imageries were compared and the findings proved to be in agreement that the approach may become a Theory or a Law. The conceptual PAR process model had been put in place, validated, assessed and verified.

Furthermore, the findings of the research also relate to issues pertaining to management and responsibility functions that have come out to be of further area of importance deserving due attention to support sustained operation and management of environment and irrigated agriculture. In this regard, gaps in awareness raising, participation approach, capacity needs, and coordination activities including identification of focal areas were discovered, among others, and that need to be enhanced. Besides, it was suggested that formation of relevant institutions and assigning proper staff with defined list of mandates would be a wise beginning of the process to help achieve the aims and purposes of the study.

It was realized also that evaluation of the current state of the watershed of the study area would be important to help design sustainable operation mechanisms including proper and timely mobilization of the resources involved and that monitoring and evaluation and remediation tasks would be cleverly set forth. Conceptual models for participation and restoration processes including SPSP model had been proposed accounting for local circumstances. In addition, the findings' chapters had reflected on the policy gaps and suggested ways forward.

Subsequently, objectives of the study were re-visited as shown in the following sub-sections.

8.2.2 **Livelihood Practices and Impacts of the Community on the Watershed**

The study (applying GIS and Remote Sensing, PAR, questionnaire Survey, and focus group discussion techniques culminating in LULCC detection and proposing a way forward) shows that respondents heavily and directly depend on natural resources especially on forests for energy (fuel wood), agricultural expansion for food security, livestock grazing, and resettlement uses resulting in deforestation and natural resource degradation. The research also revealed that the depletion of resources of the Belbela Wadecha watershed ecosystem due to the loss of the natural resources base to deforestation has led to more poverty and food insecurity among the watershed communities.

It is understood that forest is the natural resource base that significantly contributes towards stabilizing functions of soil particles and nutrients, catalyzing water infiltration and agitating vegetative growth, sustaining biodiversity, regulating ecosystem and benefiting irrigation agriculture development to protect and sustain livelihoods of the affected communities.

Respondents mentioned that nurturing the natural resources over which their livelihoods depend is not a matter of choice but the only way forward for survival and it is a key tool to overcoming poverty. Therefore, it was thought important to consider the resource dependence pattern and the impact it poses on the livelihoods of the resource users, when planning, designing and implementing the natural resource programs through involving the participation of the beneficiary communities as a key mechanism in making the projects meaningful. Ali (2011) advocates that: communities need to be involved in the project management planning process with a view to making it meaningful to them through the effective application of their particular skills and knowledge.

8.2.3 Policies in Watershed Management Involving Irrigation Development

To ensure the sustainability of the natural resources, involvement of the resource users in the development on the ground of the natural resource projects from the start to finish is central. In this regard, Johnson et al. argues that user participation in all project cycles including from early phase is important in ensuring the sustainability of the project. If the end user was not involved in the conceptualization of the project but just brought on board as a surprise to be an end user, this cannot always guarantee sustainability. This is because, the community would miss project assumptions, roles and responsibilities and other underlying project functions that would otherwise help them in the rehabilitation and maintenance works, in the event such activities are deemed important.

Thus, knowing such early phase of project functions is necessary in that maintenance would be undertaken by the community themselves without undergoing to seek external support services as community would have been well aware of the assumptions and related project component functions. Johnson et al. (2001) advocates that community participation is engaged early on and through the cycles of project making towards ensuring sustainability. This is because, the community would have been made part and parcel to the whole project making process thus nothing would be unfamiliar to the user to undertake project related operations.

In addition, the other important benefits that can be derived from involving the communities are that, as the communities are the owner of the scheme and the direct beneficiaries of the gains generated from the system, they are inherently attached to the scheme and thus keep safe operation of the scheme. Ali (2011), in this regard, argues that community involvement results in benefiting locally relevant solutions accounting for social, economic and environmental needs of the community thereby foster the sustainability of the scheme. The researcher, in relation to this, argues that the sustainability of the scheme will be there because the entire livelihood Patterns of the community including, socio-economic needs, and access to education, health facilities and other related amenities are directly dependent on the scheme. Therefore, these legitimate benefits of the socio-economic uses naturally motivate them to safeguard and nurture the project resulting in the sustainability of the system.

In this connection, the inputs from the beneficiary communities should naturally be important to draw relevant policies, laws and programs that are effective for both poverty elimination and natural resource conservation. Johnson et al. (2001) argues that community participation is necessary to identify problems and suggest solutions including policy recommendations. It was also noted from the questionnaire and focus group discussions that although there were laws and bylaws in place, but they were not being implemented as to deliver practical solutions. Hence, bylaws such as Joint Association Laws for Watershed and Irrigation Beneficiaries (JALWIB), shown under sub article 8.2.5.1 of this study, would be needed to be party to the laws and policy provisions. As such, it was reiterated that enforcement mechanisms should be seriously applied.

In addition, formulation of laws and policies need to address possible questions that include: Are the watershed natural resources degraded due to the community being un aware of the ecological functions? Are the resources degraded because of the lack of other economic facilities? Questions such as this need to be accounted for in the policy provisions in a way to provide solutions to each possible question. The policy provisions may need to consider inclusion of articles stipulating environmental education programs, including the role of forest and its hydrological functions affecting water production, alternative economic generating activities, enhancing environmental awareness, where by environment and irrigation agriculture operate side by side.

This shows that natural resource management, through the implementation of IWRM, cannot only be an issue of restoring ecology but also economic, social and political matters. Atinkut M. (2015) argues that through the IWRM, various sectors and sub-sectors including, ecosystem restoration protecting upper catchments where forests are safeguarded, production of water use for agricultural purposes and increased water supply facility for domestic consumption. Policy recommendations should also account for issues as such and other related policy gaps that the communities may pose for inclusion in the policy provisions including reformulation and enforcement of the bylaws.

8.2.4 **Community Experiences, Challenges and Outlook in Conserving the Environment**

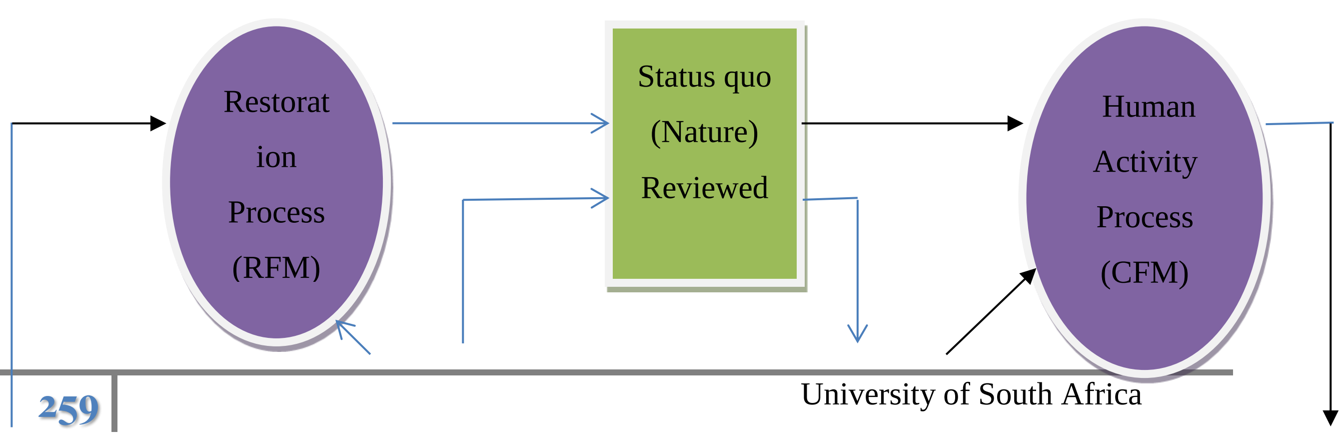
The degradation of natural ecosystem, unless technically intervened by affected stakeholders, can get worsened to an irreversible level. Therefore, restoration of the ecosystem as a challenge is not an option and cannot be overstated that failure to restore the natural resources may mean failure in life. The cause for environmental perturbations are largely human induced and immediate sorting out of this problem should be the primary task to engage in.

Questions such as 'what are the underlying motivations that drive people to exert pressure on the natural resources?’ need to be adequately analyzed and appropriately addressed. The question also inherently carries issues pertaining to the intervention of humans on the natural resources like cutting trees and clearing vegetation for immediate economic and social gains, energy needs and agricultural expansion benefits affecting on, one way or another, natural ecosystem functioning that in turn adversely affecting the livelihoods and environmental health of the watershed ecosystem.

Therefore, satisfying the interest of the community and keeping the proper functioning of the ecosystem intact is the challenging task of a two-fold homework on the table that needs to be addressed effectively with the spirit of no time to waste. In this regard, the following framework model (SPSP: Status quo – Problem – Solution – Process), Figure 8-1, which combines the models depicted under Figure 1-14 and Figure 8-2 in one system of function, is proposed. The models, Figure 1-14, illustrates *Problem* - Conceptual Framework Model (CFM) and Figure 8-2, illustrates *Solution* – Restoration Framework Model (RFM).

Accordingly, SPSP model, Figure 8-1, may be deployed as a provision to supporting a sound environmental ecosystem whereby intrinsically a sustained irrigation development can be realized - needless to mention that the community involvement is placed and kept at the center stage of development exercises. This Model, the researcher would say therefore, would help take the account of the main objective of this study – with a view to securing a sound environment and sustained irrigation development.

Photos, shown at the very front and end of this work, of successful examples elsewhere would be envisaged, and even may be improved through the application of this SPSP Model accounting for its peculiar circumstances.



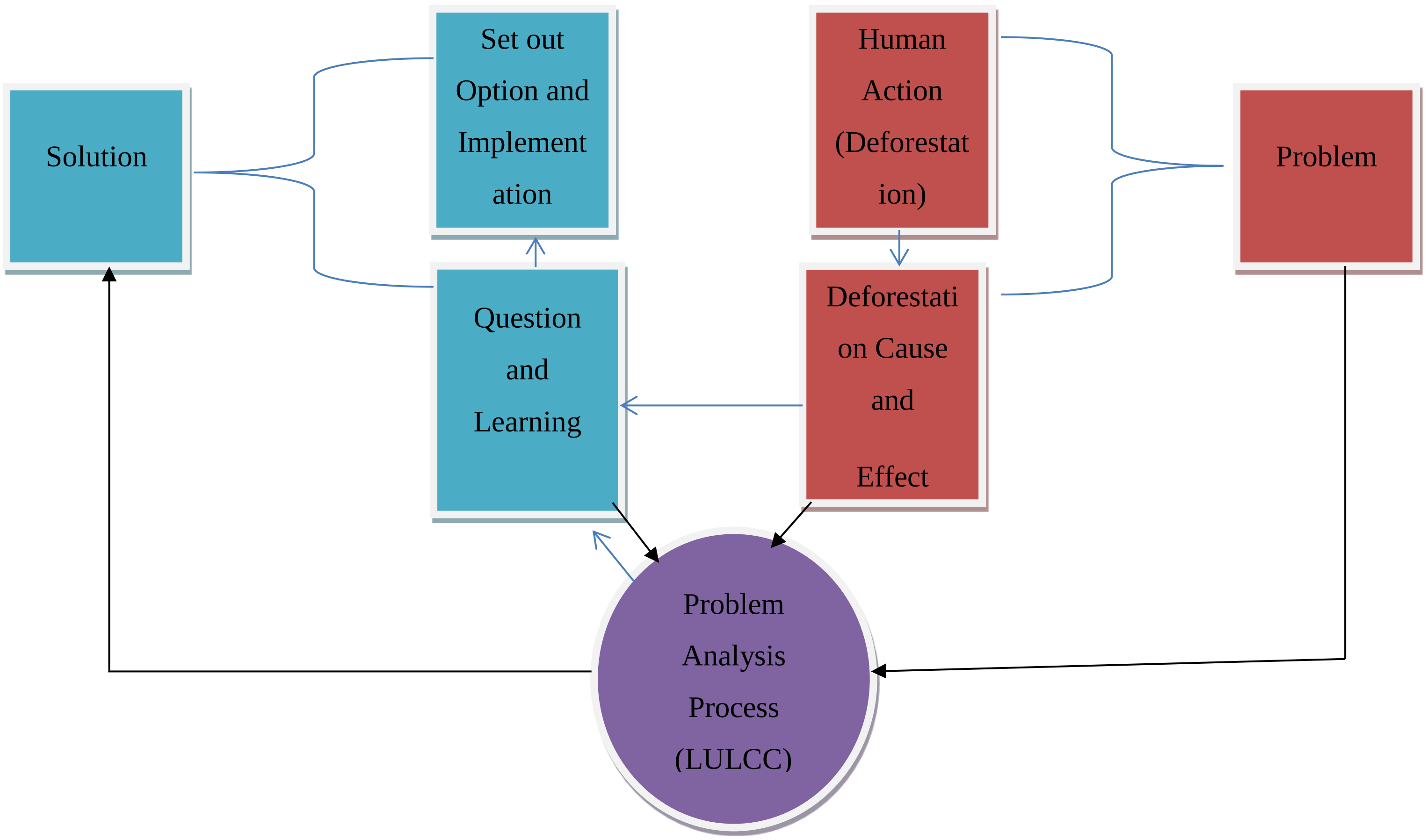


Figure 8-1: SPSP Model: Status quo-Problem-Solution-Process

Description of the SPSP Model: There are two boxes in the model, inner and outer boxes, both originating from and ending at the status quo box (nature) (which originally would have characterized unaffected environment - a state of natural setting / natural ecosystem. However, later on changed to disturbed ecosystem because of human intervention - this is the point where the study under caption had begun from).

The inner box (containing four interconnected incidents as indicated in the rectangular form of an object polygon – two in red and the other two in light blue coloring) consisting of four elements exhibiting that those elements are interconnected to further connecting back to the status quo polygon – rectangular object in green coloring. These four items are *human action (deforestation)*, *deforestation cause and effect* – both impacting on the livelihoods of a community as a negative consequence resulting from the deforestation phenomenon, *question and learning* – relates to the deforestation cause and effect (study), and *set out option and implementation* - resulting from the analysis part of question and learning, as shown in Figure 8-1.

These items of the inner box generally characterize two main functions, the problem and the solution. The problem induced, as Figure 8-1 illustrates, by human action (the two rectangular boxes in red coloring). The solution suggested the inclusion of certain item of intervention mechanisms (the two rectangular boxes in light blue coloring), as shown in the same figure above, to catering for the deforestation causes and effects thereby assist in the restoration process of the natural resources. Therefore, the presence of the inner box provides clearer understanding, than the outer box, on the possible sources of the problem and probable solution, thus making the model clearer and more plausible.

The outer box also characterizes two main functions, the process and the outcome. The process relates to three distinctive issues, *human intervention* (CFM), *analysis* (LULCC), and *restoration* (RFM) (indicated as circular or elliptical objects – all in purple coloring). The problem analysis process of LULCC enables to question why the problem took place. It also helps move towards seeking way out solution to reinstating the status quo thus support ways of learning to deal with such incidents in the future with a view to bringing resuscitation function to the fore, as shown through the inner rectangular object polygon of the solution part that starting from the problem analysis process of the circular object. In between of each process shows the outcome function (shown as regular polygons). The outcome also refers to three important phenomena, *problem* – resulting from the deforestation and its effects, *solution* – suggested from the problem analysis including question and learning and implementation options; and *status quo restored / resuscitated phenomenon* - resulting from effective implementation of the suggested solutions, as shown in Figure 8-1.

In addition, the outer box reflects well on the characteristics of the inner box. Thus, the both boxes should not be regarded as characterizing different roles and activities. They should be used in a way the two boxes operate as an integral piece of function such that the approach would help guide the natural resources' restoration processes take place as effectively as possible.

The status quo (nature) can only be maintained or improved if damaging human intervention halts and this being supported with regular monitoring, evaluation, and subsequent remedial measures taken up. In this regard, it is believed that serious adherence to the provisions of the JALWIB bylaws document is solemnly advocated.

The author of this Thesis calls this approach 'SPSP model'. The Model, as described above and shown below, involves four apparently distinct but inter-connected domains. The acronym for the Model is explained below.

S: Represents Status quo (nature) and the reviewed environment (in green).

P: Represents Problem that occurs because of human intervention in the natural resources (in red).

S: Represents Solution resulting from the problem analysis process (in light blue).

P: Represents Processes of human intervention, CFM, analyses of associated problems, LULCC, and restoration, RFM, (in purple).

Therefore, in order that the problem goes away, human adverse intervention should stop, otherwise the problem recurs ending in the vicious circle even if the model is put in place. Hence, if the model has to effectively function, enforcement of laws and bylaws are the only effective way forward to ensuring a sound environmental operation and sustainable irrigation development to benefiting both livelihoods and the environment

8.2.5 Model for Participatory Watershed Management and Sustainable Development

It is perceived that sound and lasting watershed environment and sustained downstream irrigation development would need to operate effectively and simultaneously, not at the expense of each other. Obviously, irrigation development, specifically an irrigation system that draws off water from a reservoir, largely depends on the water collected from the upper watershed area. The watershed area can only generate water appropriately if the natural resources, mainly vegetation / forest and soils are kept intact. On the contrary, barren land and deforested catchment cannot generate and retain running water to benefiting water infiltration and groundwater recharge. Moreover, adversely affected catchment gives a good chance for the water to flow fast downstream, giving no time for the flow to be captured in the aquifer depriving water for reservoir filling. This is because, the river streams would fall short of water which otherwise would supply through springs from the foothills in the watershed and that would support regrowth of vegetation.

In this regard, it seems imperative to arrest the flow coming from upper catchment that helps facilitate storage functions thereby provide with water supply for vegetation growth and forestry development that in turn supports stabilization of soils and hydrologic cycles, which subsequently and naturally initiates development of a sound environment. Therefore, in order that this phenomenon comes to the fore, protection and rehabilitation of the watershed environment through undertaking activities such as soil and water conservation, afforestation options, among other things, would be a bottom line task. This process should also be a precondition to any possible water related project developments downstream with a view to abstracting a lasting flow of water coming from upper catchment in addition to benefiting sound ecosystem of the upstream areas. This is again particularly important to attract the community and the Government to move forward, builds irrigation projects, and helps win the confidence position of the potential investors again attracting to come forward and invest in this development endeavor.

To materialize such environmental and irrigation development projects, Government and potential funding agencies may wish to know if the envisaged projects could be sustainable, which only then they would be encouraged to mobilize finances and other related resources, especially the NGOs, bilateral and multilateral institutions. The foregoing approach therefore proposes a model (RFM) for sound upstream environment and sustained downstream irrigation development placing more emphasis on the environmental protection activities.

8.2.5.1 **Stakeholder Mobilization, Community Participation and JALWIB**

In the context of mobilization in this research study of watershed environment, there are two different communities living in two different areas, up stream of Belbela - Wadecha reservoirs and downstream of the Belbela reservoir where irrigation development was implemented. Obviously, upstream residents are not the beneficiaries of the irrigation water downstream owing to their geographic location. Likewise, the downstream residents may not be the beneficiaries of the resources of the upstream of the reservoir. This study, in this regard, advocates that the two areas need to operate jointly if the both areas have to offer sustainably corresponding beneficial uses to respective communities, both upstream and downstream residents. Therefore, both communities would need to mobilize jointly resources so that sustainable environment and agriculture operations in both respective localities can be brought to the fore.

To this effect, there must be regulations that bring the two communities together in a way the both communities benefit from both localities. The both communities would undertake upstream environment protection works since the downstream community benefits from a sustained supply of flow of water coming from the upper catchment to the reservoir for irrigation development. The upstream community benefits from a recharged groundwater because of conservation practices undertaken initiating infiltration of water that would support regeneration of forests and regrowth of vegetation, conserved top soil that is favorable for crop growth thus increased productivity, beekeeping opportunity that would result from the development of trees, vegetation; and selected logging including other intangible environmental services. These activities, on the whole, form good basis for the diversification of income sources that would take the pressure off the natural resources (significantly minimize fuel wood harvesting if not halting the same), other than benefiting sound ecosystem and sustained operations of irrigated agriculture.

Therefore, provision of legal framework would be necessary like bylaws drafted by the joint association (formed to run and administer Belbela-Wadecha watershed ecosystem project) of the both communities (upstream and downstream of the irrigation water reservoir), and that may be termed, 'Joint Association Laws for Watershed and Irrigation Beneficiaries' – JALWIB.

The functions of JALWIB will include issues relating to those jointly identified items of works and joint implementation of those functions will relate to planning, design, administrative affairs, construction, operation and maintenance, communications, technology, training needs assessment, logistics, financing, monitoring, evaluation and feedback provisions, and coordinating, among other things. Any of these items of activities would be jointly (upstream and downstream community beneficiaries) designed and agreed upon at the outset of the program and supported with pre-set timelines for implementations accordingly.

It should be noted that any agreement of procedures need to be adhered to without exceptions and that failure to stick to should be accompanied by certain agreed upon corrective measures. In addition, procedures for calling on the general assembly would be set for substantive issues for discussion including those observed during the previous project times, which may involve policy matters and other related important items of works that were unforeseen early on or experienced later on.

Furthermore, formation of small groups in accordance with the particular resources features and aspects of the site condition shall be made. These small groups can support one another by employing their related group labor forces and skills accumulated over their lifetime experience. In this regard, integration, coordination and mobilization of the related group work forces in various areas may be needed. This may include but not limited to, the group organized on beekeeping task that can go out and support the other group organized on agroforestry development and vice versa thereby support the promotion of integrated water resources management; and following similar approach, other groupings may be mobilized to support each other. It should be noted also that the downstream community has the obligation to support any of the groupings formed upstream, with respect to the stipulations provided in the JALWIB provisions.

The community has a long-standing experience in mobilizing such joint forces through a traditional work parties system, including Wonfel or Debo (Lakew D. et al., 2005). This approach is well in line with the issue raised under item 2.5.2 above and believed to address the point reflected upon the need for building on traditional work parties under this same item. Rights, obligations and responsibilities of individual, team (small groups), and the general assembly would be clearly stipulated.

In this regard, rules and model positively affecting traditional / local institution have been developed. In this regard, it is hoped that it would address the issues raised by Lakew D. et al. (2005), under item 2.5.2 above. The referred to Model is depicted under Figure 8-2, RFM Model - Restoration Framework Model.

The rules referred to include the bylaws, which the communities affected would draft and agree upon, as raised under this sub-article and referred to as JALWIB. These provisions need to be ratified by the general assembly of the association and the copies of the ratified document should be filed with the both communities' Kebeles and Woreda administrations for use and reference when needed and that someone will be held responsible for the administration of this bylaws document.

8.2.5.2 Conditions Precedent to Irrigation Development

Irrigation development is not an option for developing countries such as Ethiopia, especially at this time when population growth seems to be unstoppable phenomenon, placing challenges on the capacity of sufficiently and sustainably feeding this population. In addition, the carrying capacity of the land is shrinking because of explosion of bigger density of human population than ever before signaling land for cultivation is diminishing and that food production per person is decreasing, unless otherwise steps are mounted to catering for the likely gap in due course.

Therefore, the frequency of cultivation per plot of land and increase of productivity per unit area are the obligatory moves we need to make eventually. In order to do this, provision of irrigation water per round of irrigation season is mandatory. Therefore, productivity gains should come from agriculture supported by irrigation and other technology package. IFAD (2009: 3) states that "All regions of the world, and especially the diverse and vulnerable rain fed systems of sub-Saharan Africa, need technologies, knowledge and practices that simultaneously increase their productivity, their resilience to climate change and their contribution to its mitigation". Irrigation water stored behind the dam should be able to be supplied permanently with the water generated from the upper catchment.

In order that the reservoir area is supplied permanently with a volume of water needed, the related watershed environment should be sound enough to generate flowing water to the reservoir system. The Ethiopian Highlands Reclamation Study (1986) state that Conservation can no longer be viewed separately from development; a nationwide strategy of conservation based development is needed.

If degradation continues as at present, future effects of life will be appalling. Hence, implementing scientifically supported soil and water conservation practices and afforestation including irrigation development (also stated, in this study, as a condition precedent to irrigation development supported with RFM Model and JALWIB provisions) is not an option. This may include cultivated land management (comprising agronomic measures – mulching and crop management, soil management – conservation tillage including contour tillage, ridging and ridge tying and minimum tillage and no tillage and mechanical methods – terracing, waterways and structures) and other related rehabilitative functions.

Implementation process of such factors including operation and maintenance roles need to be supported by legal provisions including strong and operative bylaws, which deserve unreserved government commitment to enforcing laws and other policy provisions, that has been and still is a gray area.

Enhancement of support of NGOs and government that the farmers receive shall include an up-to-date technology package in terms of providing inputs for productivity increase, environment protection functions, including mechanisms as to how the farmers should give due attention to every step necessary in the production cycles. In this regard, IFAD (2011:149) states, "In South Asia and in Mexico in particular, farmers' increased production came primarily from higher yields resulting from the technology package and policies associated with the Green Revolution".

The joint association (of upstream and downstream communities) needs to meet at least on a quarterly basis to assess and re-evaluate performances related to the associational functions. The meeting will reflect on future management directions particularly relating to building the capacity and capability of the farmers in a way input from the outsider would be minimal or nil targeting to effect a solely community operated and fully managed project with a view to catalyzing a self-sustaining scheme.

8.2.5.3 **Irrigation Project Design, Costing, and Funding Options**

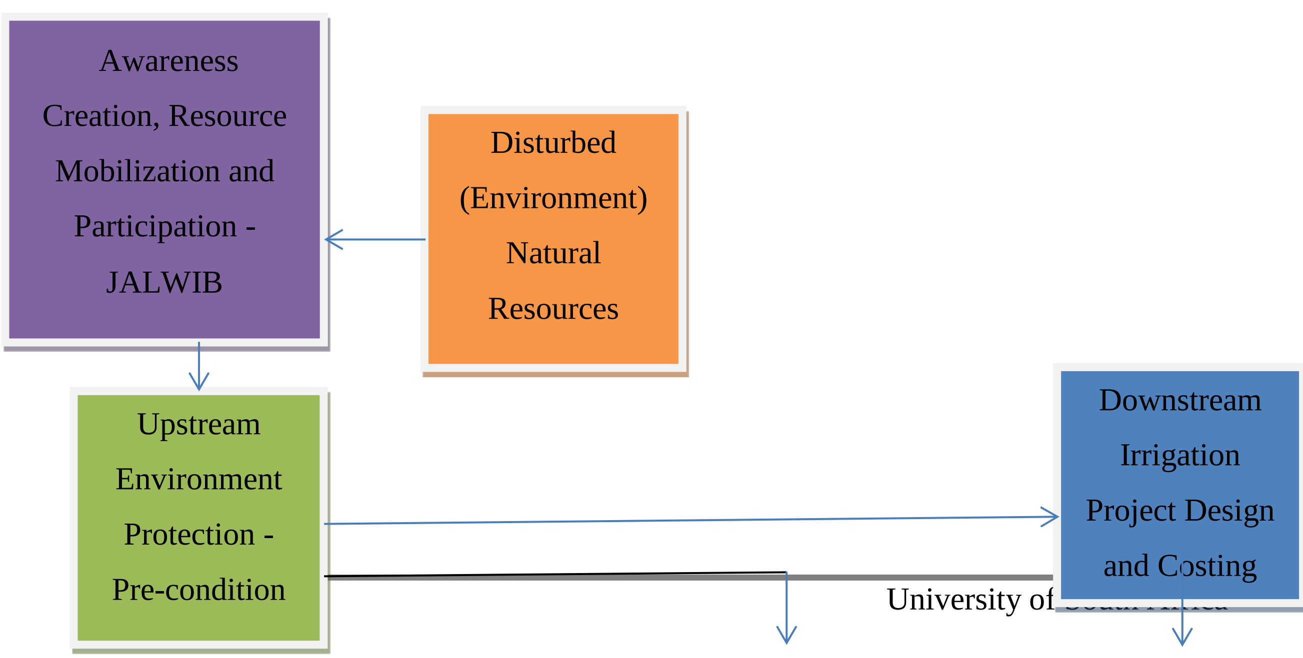
In order that sustainable environment and irrigation scheme is brought on board, there must be a good design that combines environmental management and irrigation development and views as a single project operating in parallel where the indispensability with each other and the critical importance of each functions are given due focus. As such, project costing (for environment protection and irrigation development) would be done where the project document clearly reflects a characteristic feature of a bankable document that in a way any potential funding agencies would offer finances to run this packaged project. On this, identification of possible funding agencies is a critical step forward in making the project come to the fore. Therefore, reflections on the possible potential funding institutions would be necessary. This may include:

- Government (local, state or federal or both)
- NGOs (local and international)

- Communities (beneficiaries)
- International volunteer agencies (Peace Corps etc.)
- Business Co-operatives
- Embassies
- Social welfare institutions
- Private companies Individual (Family)
- Civil Society
- Bilateral and multi-lateral agencies
- International religious institutions (churches, mosques)
- Professional associations including universities and research organizations.
- Farmers
- Research organizations.

In the project proposal, (bankable) document would have been stated was an article describing that the possible funding agency may wish to pay a visit to the proposed project site before the possible release of funding. It should be clear here that particularly upstream environmental protection activities would have already taken place, as a condition precedent to downstream irrigation development works. Therefore, project funding approval and disbursement processes may take place only after the visit of the potential funding agency and ensuring that precondition set forth is satisfied to get the project going.

Mid-term review, monitoring, evaluation, and impact assessment provisions would be made part of the process. It is thought therefore that this approach may help catalyze sound environment and sustained irrigation development. In order that this approach materializes, this study proposes a model - 'Restoration Framework Model' (RFM), advocating sustained environment and downstream irrigation development, shown in Figure 8-2. In order that this model properly functions, local legal framework would be necessary to be put in place that involves both upstream and downstream communities. Therefore, it is thought that the application of bylaws, JALWIB (a form of legal document), would be necessary to unite them, as noted in sub-section 8.2.5.1 above.


Awareness Creation, Resource Mobilization and Participation - JALWIB
Disturbed (Environment) Natural Resources
Upstream Environment Protection - Pre-condition
Downstream Irrigation Project Design and Costing

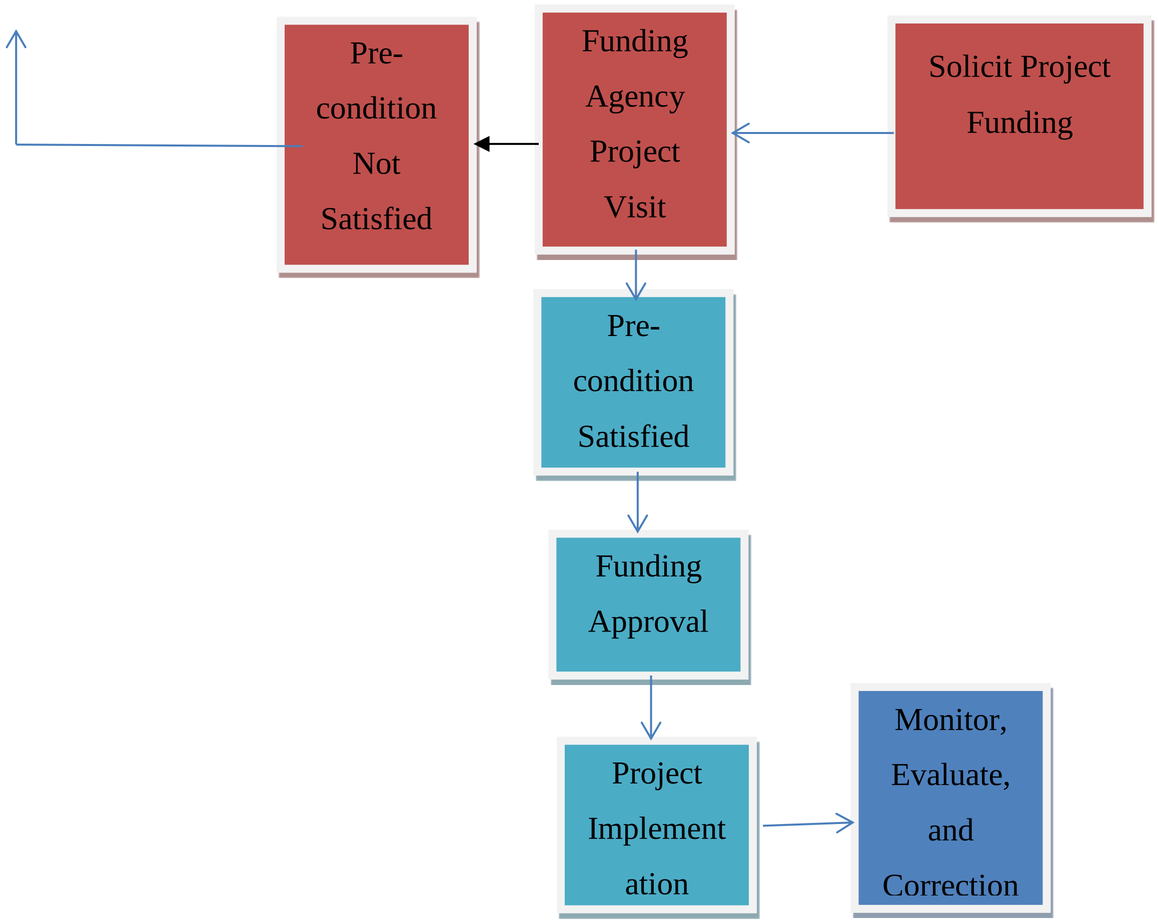


Figure 8-2: RFM Model: Restoration Framework Model

This sub-section apart from reflecting on the summary of the findings of the study has revisited the objectives of this study to make sure, if the objectives of the study and the research problems, sub-problems or hypothesis are addressed sufficiently. Application instruments, GIS and Remote Sensing, PAR, FGD, and Questionnaire Survey were used in the process. The results of the study call for particular and quick intervention by all parties in the line. That, if projects related to the natural resources use have to be successful, it needs to appropriately plan, design, implement, monitor, evaluate, and affect possible feedbacks in partnership with the beneficiary communities, without exception. Given the living pattern of rural dwellers, in developing countries, where the natural resources of the environment serves them as a source of wellbeing and livelihood, effectively maintaining healthy ecosystem cannot be an option. Especially addressing those most disadvantaged groups would contribute the most meaningful share to the success of the program and ensure the sustainability of the projects.

The communities of the watershed environment should not be seen only as caretakers of the natural resources but also as sharers of the benefits accruing from the natural resources (Tweneboah, 2009). This is again important because if the communities see the resource management exercises improving their economic and social wellbeing, they own the resources, get more involved and nurture them.

Effective mobilization and wise deployment of resources, as an effective tool to making projects successful, can be put in place if involved and operative structures of development stakeholders [Government (Federal, Regional, and Local), Community entities, NGOs, and Private sectors], supported with relevant list of tasks and defined mandates, are appropriately set up. Therefore, proper set-up of the affected institutions and coordination mechanisms should be given due attention. Canada's International Development Research Centre, IDRC (2010), in this regard, states that stakeholders including individuals, groups or institutions that are served or influenced by the program's/ project's objectives should be identified to help shape the strategies that the organization undertakes. Such stakeholders include institutional donors, corporate donors, local NGOs, cooperatives, communities, government and academic institutions (IDRC, 2010). The involvement and participation of these stakeholders in the making of the project contributes their respective shares towards ensuring the successfulness of the watershed ecosystem sustainability.

In this regard, it is believed that this envisaged arrangement, supported with monitoring, evaluation, and remediation activities at each cycle of project functions, should ensure sustained watershed natural resources followed by generation of water resource flows. This generated water resources can be tapped by dam structures for subsequent use as irrigation water for agricultural developments thus benefiting economic, social, and other related beneficial uses, including generation of environmental flows for vegetation consumptive uses supporting further sound and sustainable environmental operations.

Therefore, instituting operative hierarchical structures at various levels and charging them with relevant tasks including devising monitoring, evaluation, and remediation mechanisms is believed to be a clever approach in making sound environmental management and successful development of irrigation agriculture. Pradhan NS et al. (2012) discusses that weak institutional structures combined with ill-defined mandates in the government sector have limited the communities' local capacity to cope with the prevailing circumstances in their area(s). Hence, formulation of active institutional arrangements and clever policy provisions are thought to critically refocus on the enforcement mechanisms.

It would be very important to evaluate the outcome and impact of the projects in general and SLMP-2 project of the country in particular. This project characteristically relates to the currently captioned research study, and it is nearing the end of the planning period giving potential opportunity to conduct progress evaluation and impact assessment, against its planned objectives, mission, goal, and activities and finally propose corrective measures as necessary with a view to carrying on experiences gained to supporting future development endeavors elsewhere.

Furthermore, the first instance of PAR process model illustrates that the findings of satellite imageries and community mapping were found to be alike. This confirms that the similarity of the achievements made may be called a Theory or a Law, according to Prathapan, 2014.

Analysis involving satellite imageries of years 1985 through to 2019, was carried out and supported with community mapping and ground truth activities for verification purpose for the year 2019. In addition, Normalized Differential Vegetation Index was applied particularly as related to the purpose of the study. Finally, Land Use Land Cover Change detection was made and way out provisions was proposed.

8.3 Recommendations

Today, climate change impacts and its effects has made it a much worse living experience to all living things on this planet earth than ever before, calling for an immediate and concerted response of all the community on the planet to cleverly address this issue at stake. WHO (2015) also advocates that as a result of the growing seriousness level of heat wave and accompanying damages to life there should be a coordinated move between and among sector and nations to address the crisis and that has to focus on the most affected segment of the society. It needs to be attended to in a manner scientifically planned, organized, and appropriate resources mobilized in line with the legitimate rules and procedures set forth. In addition, close monitoring and evaluation supported with a timely feedback and possible corrective actions should be undertaken in due course to contribute to the sustainability of the programs / projects functions. Revitalization of the watershed environment is not an option; it is a bottom line task requiring multiple actors and multiple nations. It is believed that integrated water resources management would support multiple engagements beyond just watershed locality based benefits including socio-economic and ecological sustainability in a more efficient and harmonious way. Integrated Water resources Management "seeks to manage the water resources in a comprehensive and holistic way" (Zaag & Savanije, 2015: 8).

Theoretical framework and Conceptual Framework Model (CFM) including Restoration Framework Model (RFM) employed in this study has culminated in drawing up an SPSP Model which would support formulate possible intervention mechanisms that could be waged against anomalies in the captioned watershed environment. The Model also can serve as a launch pad for large-scale application opportunities. The study would further highlight how research results would help in decision-making process; land management planning and policy implementation techniques.

Besides, in addition to the other findings' chapters, an emerging chapter pertaining to 'Findings on the Management and Responsibility Issues' was addressed to placing increased emphasis on sustained watershed natural resources management and environmental governance including responsibility for managing the natural resources of the watershed environment. Therefore, it is believed that particular attention must be devoted to these new and delicate areas of concern as well if programs / projects have to satisfy the intended outcomes and meet the envisaged impacts.

Moreover, as the PAR process model in this study, in its first instance, has witnessed that the result of comparison between satellite imageries and the community mapping are found to be the same, it attracted attention that it may be considered a Theory or Law. Therefore, it is worth considering that this approach may be part of 'a Theory' or 'a Law' (Prathapan, 2014).

This sub-chapter throws more light on policy issues, institutional structures, capacity building, community participation, funding arrangements, and follow-up and feedback provisions.

8.3.1 **Policy Options**

A review of current policy contents and operational performance status and associated likely gaps need to be sorted out including the provision of solutions of bridging the gaps involved.

Reconsideration of other particular issues relating to effective utilization of local resources, human participation and properly focusing on local conditions need to be given due regard. Administrative and managerial functions that should account for the shortcomings experienced needs to be attended to seriously. These include reconsideration of the institutional set-up, implementation and management capacity building. In addition, related funding arrangements including clear delegation of responsibilities at various stages in the government hierarchy and beneficiary communities should be addressed also seriously.

Other pertinent policy functions that require serious reconsideration and closer attendance of tasks to bringing an uncompromised and consistent enforcement of associated laws / bylaws into effect may include;

- Soil and water conservation practices need to be revisited advocating that physical and biological, including agronomic practices are diligently performed where agricultural extension services are continuously employed until such time when the farmers are placed in full control of the extension functions. Agricultural (climate-smart agriculture) intensification and agroforestry technologies should be integrated to meaningfully contribute to enriching nutrients, support soil and water conservation practices, and biodiversity management. A combination of forest as a land cover condition and terracing as a conservation practice is proposed as the best mechanism in conserving the soils resources. Moreover, this above approach may need to be included in the syllabus at all cycle education levels.
- Rules and regulations for tree plantation should be enacted, including say if one felled a tree one should replant 'x' amount of trees and also regular afforestation programs take place based on a declared date by the Government, including community based approaches where fruit trees are included to buttress economic and food benefits. Strategies and methods for law enforcement mechanisms should be clearly formulated and enacted. Continued dissemination of fuel wood-efficient stoves and fuel-shift stoves including electric and use of biogas has to be encouraged.
- Watershed protection approaches, including watershed restoration as a condition precedent to irrigation project development need to be regularly supported by government (local and national), pioneered by the communities, and NGOs. A buffer zone of a given strip width,

along each side of a river course, as shall be determined by the government shall be left undisturbed. Regulation of forest use and administration in a given land use situation need to be clearly put in place, enforced, and monitored.

- No community members that are non-compliant to the bylaws (for example JALWIB provisions which cross function with RFM model that deals with upstream watershed resources and downstream irrigation agriculture beneficiaries) shall be party to the functions and benefits of the watershed system. The developed Models including SPSP Model and JALWIB provisions would contribute an immense support to the environmental wellness, sustained irrigation development and improved community livelihoods.
- Declared watershed resources' administrative procedures, including irrigation projects, and associated tangible benefits need to be carefully / clearly formulated, detailed, defined and documented. The document that would contain project / program provisions including, joint rules and procedures, must be counter signed by all watershed beneficiary communities and irrigation developers. The resources / benefits, which are used legitimately among the beneficiary communities influence their interest and capacity to achieve goals and realize outcomes.
- The government involvement needs to be limited and the private sector contribution enhanced in the communities' programs and projects, with a view to benefiting the environment and thus the people as they draw closer to the communities by the nature of their missionary operations. The Government also needs to re-introduce, in consultation with the communities, appropriate land-use policies – tenure, property rights, if sustainable utilization, poverty eradication, and sustained environment have to come into effect.
- Decentralization process, including delegation through devolution to the involved communities, and coordination mechanisms in the project management hierarchies need to be seriously re-defined and implemented, putting people (the beneficiaries) and the environment first. FAO (2002: 8) agrees that: "Basin Agencies and basin councils where all stakeholders are represented have proven to be more effective than the traditional centralized institutions, when they are set-up in an appropriate manner".

- Without exception, planning, design, implementation including monitoring, and evaluation tasks would be fully undertaken in partnership with the both upstream and downstream beneficiary communities.
- Integrated Water Resources Management (IWRM) shall be given due focus where multi-sectoral institutions are involved that all uses of water are considered together starting from planning through to implementation ensuring a harmonious use of the water resources across all involved parties in the IWRM system. Legitimate and un compromised focus shall also be accorded to Integrated Watershed Management (IWSM) functions.

- Allocation of environmental water for forestry development from the watershed system should be put in place supported with research findings. Ali (2011: 149) argues that "Environmental flow is the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated". In this regard, World Development Report (2010: 142) states that "Even in a stable climate, sophisticated agencies find it difficult to determine in advance how much water can safely be allocated to different users, and how much should be set aside for environmental purposes". Integration of forest and water management to ensure sustained environmental functions should be a key task that forests are managed to securing sustainable environmental functions thereby support fight against climate change, and water resources are managed to supply domestic, agricultural and industrial needs of the society on a sustainable basis.
- Development of diversified income generating activities, including organization of community groups (the groups as a group can support one another in the related areas of intervention through for example traditional work parties system – Debo / Wonfel) into different associations such as development and promotion of local crafts, eco-tourism by enhancing capacities, micro-credits, and beekeeping activities should be put in place. This may absorb environmental shocks that would otherwise affect the watershed environment in terms of natural resource degradation (deforestation), for example, fuel wood harvest.

- Institute local fund raising arrangements to giving opportunity to re-utilizing the income generated in other areas of interest that would ensure the sustainability of income and the reliability of the project itself.

8.3.2 Institutional Structure

Policies, strategies, programs, and projects can be made effective use of if implementing and supervising institutions are carefully designed, put in place and at the same time empowered. Government structures (at various levels), community entities, NGOs, and the private sectors need to be there with defined list of mandates on watershed natural resources implementation, management, and governance issues. (Pradhan NS. et al., 2012: 31) concurs with this idea that "Weak institutional arrangements in the government sector combined with ill-defined functions have limited local adaptive capacity". These institutions should discharge their particular responsibilities in all project cycles for securing sustainable natural resources. These functions are undertaken through full adherence to and consistent with the mandates set forth under each institutions' list of mandatory of establishment including laws / bylaws, thus ensure that the project satisfies its intended objectives.

8.3.3 Capacity Building

A focused and mission specific training, which should be supported with practical fieldwork at various stages in the project cycles, would support and ensure a production of skillful beneficiaries. Marisol E. et al. (2000) states that there should be continued training in place to increase the skills of the beneficiaries and the ability to analyze and act on the lessons arising. This should be supported further with local resources utilization. The combined outcome of the two may guarantee sustainability in operation, management and administration of the system that would further ensure a lasting knowhow in the administration of the system. A continued site and beneficiary relevant (issue specific) training should include that all beneficiaries should come up with particular problems and should propose way out for joint debate during on the job training. Corresponding records should be captioned per event for subsequent review and evaluation process aiming at designing possible remedial measures.

8.3.4 Informed Community Participation and Benefits

Self-driven community participation is not just important for project making, it is a beacon function for nurturing the system and that would keep it sound and still active beyond normally expected design life. According to Samra J.S. et al. (2005), willingness and keen participation of the stakeholders in every activity of the program helped them achieve a great deal of success in the captioned program. Participation should include conceptualization of each cycle of the project making and maintaining scientific application procedures in various benefit harvesting techniques involved.

Participation in the project making and subsequent benefit drawing from the scheme would be based only on the collectively predetermined norms and standards supported with consented relevant laws. Mode of beneficiary participation in the community watershed projects shall be in accordance with the specific community work norm activities set in community based participatory watershed development guidance, Part 2 (Lakew D. et al., 2005). The communities should be able to derive permanent benefits that catalyze formation of strong (bondage) link between the system and the beneficiaries, which should result in the strong development of ownership mentality of the community that should further drive the beneficiaries toward safeguarding the scheme against any possible anomalies.

8.3.5 Funding Provisions

There should be an arrangement for funding by potential funding sources to start the community program/project and off course community participation is a key factor towards ensuring sustainability and engaging ownership of the project. Pradhan NS. et al. (2012), in this connection, argues that financial arrangement should be made through annual budgetary allocation plan to the target projects thus enhancing the adaptive capacity of the community involved. This will include government, NGOs and beneficiaries where government and NGOs would pull out, supposedly the capacity of the beneficiaries would have been built up, after the program had been set to full operation and the beneficiaries built confidence and made the exercise self-sustaining, leaving the rest of the journey to the beneficiary communities.

8.3.6 Follow-Up and Feedback Approaches

Once the system is put in place, it is like a baby in a cradle, it is a necessity exercise to carefully monitor operations, evaluate them, and take appropriate and timely remedial actions without any excuses. Adopted bylaws should be enacted without exception by all beneficiaries.

8.4 Prospects for Parallel use of Sustainable Environment & Irrigation

Research needs pertaining to technologies, knowledge, science, education, and practices that simultaneously increase productivity and resilience to climate change contributing to its mitigation is a necessary task, particularly relating to the diverse and vulnerable rain fed systems in the country, for achieving equitable and sustainable development while maintaining a sound ecosystem.

A research program must focus on local conditions and traditional knowledge that would help address the peculiarities of the local circumstances relatively more effectively. "Jacques M. et al. (2013: 173) support this observation that when carrying out a research program such as "PAR project, participation calls for research that is conducted by, for and with particular communities (i.e. collectivities defined territorially, organizationally or as communities of interests)", which helps address their circumstances. Relatively more attention, which is explicit, must be given to the poorer and disadvantaged farmers in marginal areas in a way they are all well involved and seriously engaged in the whole course of research activities with a view to tackling their particular issues affecting them. Chambers (1996:13) concurs with this that: "The realities, needs and priorities that should count most are those of local people, especially the disadvantaged - women, the poor, the marginalized, those who are physically and socially weak and deprived". Agricultural intensification where agroforestry functions are included would help enhance gains of the farmers' potential incomes.

This above task must be supported with the Forestry Research Center that is responsible for generating, testing, and disseminating appropriate technologies for development where the affected communities are actively involved in the whole course of making it happen.

Promotion and support to research projects on forest-water interplay involving alternative scenarios pertaining to varied climate and associated species of trees need to be given due consideration. Pradhan NS. et al. (2012: 22) addressed a study having a research objective to "examine the capacity of local institutions to adapt to changing climatic and environmental conditions" and tree crops as an adaptation to climate variability which resulted in local communities being the key role players in managing the meagre amount of water through local institutions adapting to local conditions.

However, the findings on the tree crops production systems called for re-examination of how resilience could be achieved against risk events and changes over time. This is because; the result of the study (performed on agro-climatic zone, crops and climate change stress pertaining to China, Nepal and Pakistan) showed "farmers are experiencing changes that may increase uncertainty and the risk of climate-related shocks" (Pradhan NS, 2012:36). In addition, researches relating to the mobilization and management of knowledge and skills in support of policies to increase production and productivity gains need to be looked at in a well-defined and organized way.

Studies that focus on the potential exploitation but balanced use of sustainable watershed natural resources pertaining to the development and simultaneous use of both sound environment and sustained agricultural operations are believed to be a matter of necessity than ever before in the history of human kind. In the course of the study therefore, it was felt quite important that all actors in the arena, needless to mention the necessity of participation of the end users, become party, without exception, to the whole cycle of making the project come to the fore.

As law, enforcement mechanisms are key to the success of programs and projects that due emphasis should be given to its particular applications at various stages in the implementation process. While setting watershed development strategies and projects involving the implementation of sound environmental and sustained agricultural (irrigation) functions, it is quite important that the two items are further researched as consisting of a single program operating in parallel. Studies need to focus on local peculiarities if tangible and meaningful benefits are to be achieved.

This approach would ensure a critical way forward in harnessing a friendly environment and sustainable agricultural development. The both upstream and downstream watershed communities would need to be convinced, have established a collaborative spirit and mobilized joint effort to operate together on both environmental and agricultural projects (upstream environmental project and downstream irrigation project) that would operate simultaneously towards delivering on sustained, multiple and common benefits.

9 References

(AHRQ) Viswanathan, M., Ammerman, A., Eng, E., Gartlehner, G., Lohr, K.N., Griffith, D., Rhodes, S., Samuel-Hodge, C., Maty, S., Lux, L., Webb, L., Sutton, S.F., Swinson, T., Jackman, A. & Whitener, L. (2004). Community-Based Participatory Research: Assessing the Evidence. Evidence Report/Technology Assessment No. 99 (Prepared by RTI University of North Carolina Evidence-based Practice Centerunder Contract No. 290-02-0016). AHRQ Publication 04-E022-2. Rockville, MD: Agency for Healthcare Research and Quality, July 2004.

Abiy, S. (2002). Perception and Response of Farmers to Impacts of Population Growth on the Environment.

Adam, P. et al. (2012). Local institutions, livelihoods and vulnerability: lessons from Afghanistan, HPG – Working Paper.

Agenda 21. (1992). United Nations –Sustainable Development, United Nations Conference on Environment and Development, Rio de Janerio, Brazil, 3 to 14 June 1992.

Ajzen, I., (1991). The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes 50:179-211.

Ajzen, I. (2001). Nature and operation of attitudes. Annual Review of Psychology 52:27-58.

Alemayehu, B. (2015). Gis and Remote Sensing Based Land Use/ Land Cover Change Detection and Protection in Fagita Lekoma Woreda, Awi Zone, North Western Ethiopia. A Thesis Submitted to School of Graduate Studies, Addis Ababa University.

Ali, A. (2011). Sustainability of Small Scale Irrigation Schemes: A case of Nedhi Gelan Sadi Small Scale Irrigation in Deder Woreda, Eastern Oromiya. A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements of the Degree Masters of Art at Institute of Development Studies.

Ali, MH. (2010:195). Practices of irrigation and on farm Water Management Volume-2, Springer Science + Business Media, LLC, 233 Spring Street, New York, NY 10013, USA.

Amacher Gregory, S., Lire Ersado, Donald Grebner and William, F. Hyde. (2001). ’Disease, Micro-dams and Natural Resources in Tigray, Ethiopia’, manuscript.

Amare, A. (2005). Study of sediment yield from the watershed of Angereb reservoir. Master's Thesis, Department of Agricultural Engineering, Alemaya University, Ethiopia.

Amissah-Arthur, A. Mougenot, B. Loireau, M. (2000). Assessing farmland dynamics and land degradation on Sahelian landscapes using remotely sensed and socioeconomic data. International Journal of Geographical Information Science 14: 583–599. Barbier EB. 1997. The economic determinants of land degradation in developing countries. Philosophical Transactions Royal Society B 352: 891–899.

Anonymous. (1990a). The Forest Resources of the Temperate Zones, Vol. II. FAO, Rome.

Anonymous. (2010). Global Forest Resources Assessment, 2010-Main Report. FAO Forestry Paper 163. Rome, Italy. 340p.

Antenucci, J. C, Brown, K., Croswell, P. L., Kevany, M. J. & Archer H. (Eds). (1991). Geographic Information Systems - A Guide to the Technology, Van Nostrand Reinhold, New York, USA.

Arnold Michael, Gunnar Kohlin, Reidar Persson and Gillian Shepherd. (2003). ’Fuelwood Revisited: What has Changed over the Last Decade?’, CIFOR occasional

Arowolo, O. O. (2010). Population Issues in National Development of Ethiopia. Center for Global Development Working Group on UNFPA’s Leadership Transition.

Atinkut, M. W. (2015). Module on Integrated Water Resources Management (WRIM2062) – College of Dryland Agriculture and Natural Resources, Department of Land Resources Management and Environmental Protection (LaRMEP)

Averill, M. Law. (2008). How to Build Valid and Credible Simulation Models, Proceedings of the 2008 Winter Simulation Conference S. J. Mason, R. R. Hill, L. Monch, O. Rose, T. Jefferson, J. W. Fowler eds.

Awlachew, S.B., Yilma, A.D., Loulseged, M., Losiskandl, W., Ayana, M., and Alamirew, T. (2007). Water resource and Irrigation Development in Ethiopia. Colombo, Sri Lanka:, International Water Management Institute. 78p (Working Paper 123)

Aynekulu, E., S. Atakilti and A. Ejersa. (2006). Small-scale reservoir sedimentation rate analysis for a reliable estimation of irrigation schemes economic life: A case study of Adigudom area, Tigray, Northern Ethiopia. http://www.zef.de/module/register/media/6bd3_siltation_Tigray_Ethiopia_Ermias.pdf.

Azeze, M. (2004). Development of Synthetic Unit Hydrograph for watershed in the Upper Awash and Upper Tekeze Basins. A Thesis Submitted to School of Graduate Studies, Addis Ababa University in Partial Fulfillment for the Degree of Masters of Science in Civil Engineering.

Aziz, S. (2001). Environment and Poverty, Nairobi: Global Ministerial Environment Forum, United Nations Environment Program. Kenya.

Banald, J. M. et al. (undated). The Environmental Impact of Poverty: Evidence from Firewood Collection in Rural Nepal.

Barbara, V. Koppen et al. (2007). 1 Community- based Water Law and Water Resource Management Reform I Developing countries: Rationale, Contents and Key Messages.

Barsi, J.A., Lee, K., Kvaran, G., Markham, B. L., Pedelty, J.A. (2014). The Spectral Response of the Landsat-8 Operational Land Imager. Remote Sens. 2014 6**,** 10232-10251. doi:10.3390/rs61010232.

Basson, G. R. (2009). Management of siltation in existing and new reservoirs. General Report Q. 89. Proc. of the 23rd Congress of the Int. Commission on Large Dams CIGBICOLD (vol. 2).

Baulies, X., Szejwach, G. (1997). LUCC Data Requirements Workshop Survey of Needs: Gaps and Priorities on Data for Land-Use/Land-Cover Change Research Organized by IGBP/IHDP-LUCC and IGBP-DIS. Barcelona, Spain, Nov. 11-14, 1997.

Baumgartner, M. F., et al. (1996). Remote sensing and geographic information system.

Bekele. (2016). Water Sector Reform: Implementation of IWRM in Awash River Basin, Ethiopia

Berhanu BK, Assefa MM, Seleshi Y. (2013). GIS-based hydrological zones and soil geo-database of Ethiopia. Catena 104: 21–31.

Binyam, A. Desale, K. (2014). The Implication of Integrated, Watershed Management for Rehabilitation of Degraded Lands: Case Study of Ethiopian Highlands.

Black, P. E. (undated). Watershed Functions SUNY College of Environmental Science and Forestry Syracuse, New York 13210.

Bloomberg, L. D., & Volpe, M. (2008). Completing your qualitative dissertation: A roadmap from beginning to end. Thousand Oaks, CA: Sage.

Bolep. (2008). Strategic Planning and Management of Oromiya, Unpublished material.

Boserup, E. (1981). Population and Technological Change. Chicago University Press, 1981.

Briassoulis, H. (2011). Factors Influencing Land Use Land Cover Change. Journal of Land Use, Land Cover and Soil Science I.

Brodie, R., B. Sundaram et al. (2007). An Overview of Tools for Assessing Groundwater-Surface Water Connectivity. Canberra, Australia, Department of Agriculture, Fisheries and Forestry: 133.

Brookfield, H., Stocking M. (1999). Agro diversity: Definition, description and design. Global Environ Chang 9(1): 77 - 80

Brooks, K. N.; P. F. Ffolliott; H. M. Gregersen and J. L. Thames. (1991). Hydrology and the Management of Watersheds. Iowa State University Press, Ames, Iowa.

Brown, L. and Clarke, J. (1976). Twenty – two dimensions of population problem. World Watch papers, NO 5 World Watch Institute, Washington, D.C.

Bryan B. (undated). Just Enough Organization: Water Users Associations and Episodic Mobilization.

Byron, I., Curtis, A. and MacKay, J. (2004). Planning in the Queensland Murray-Darling region. Social innovations in Natural Resource Management: a handbook of social research in natural resource management in Queensland. Department of Natural Resources and Mines.

Cabal, C. (2000). Household food energy intake of semi-subsistent households in integrated crop-livestock agricultural systems in the central highlands of Ethiopia. PhD dissertation, University of Hawaii, Manoa, USA, .177 PP.

Caldwell, L. K. (1993). Achieving the NEPA intent: new directions in politics, science and law. In: Hildebrand, S. G. and cannon, J. B. (Eds.), Environmental Analysis: the NEPA Experience (pp. 12 - 21). Lewis Publishers, Boca Raton.

Caldwell, L. K. and Shrader – Frechette, K. (1993). Policy for land: law and ethics. Rowman and Littlefield Publishers, Boston.

Cambell, J. B. and Wynne, R. H. (2011). Introduction to Remote Sensing, Fifth Edition – the Guilford Press – New York. London.

Cap-Net et al. (2008). Integrated Water Resources Management for River Basin Organizations, Training Manual

CARIAA. (2016). Review of Current and Planned Adaptation Action in Ethiopia, CARIAA Working Paper # 8, Daniella Echeverria and Anika Terton.

Carolyn, P. B. H. et al. (2015). Rural local institutions and climate change adaptation in forest communities in Cameroon.

Castellanet, et al. (2002). Participatory Action Research in Natural Resource Management: A critique of the method Based on five Years' Experience in the Transamazonica Region of Brazil.

Catherine, B. (2007). Understanding the role of informal institutions in social accountability, Ethiopia.

Catherine, M. (1997). Population and Environment Relationships in Developing Countries: A Selected Review of Approaches and Methods, Bergen Norway.

CCME (Canadian Council of Ministers of the Environment). (2016). Summary of Integrated Watershed Management Approaches Across Canada.

Chanson, H. and P. James. (1998). Rapid reservoir sedimentation of four historic thin arch dams in Australia. J. Perform. Construct. Facilities, 12: 85-92

Charles, F. Cannell, Robert L. Kahn. (1968). The handbook of Social Psychology, Volume 2, edited by Gardner Lindzey and Elliot Aronson

CIP-UPWARD & IDRC. (2005). Participatory Research and Development for Sustainable Agriculture and Natural Resources Management- Volume-2: Enabling Participatory Research and Development. A sourcebook Overview.

Colin, R. (2002). Real World Research, Second edition

Coppin, P., Jonckheere I, Nackaerts K, Muys B, Lambin E. (2004). Digital change detection methods in ecosystem monitoring: a review. Int J Remote Sens 25: 1565-1596

Creswell, J. W. (2007). Qualitative inquiry and research design: choosing among five approaches, John W. Creswell – 2nd editions, 2007:73.

Creswell, J. W. (2009). Research design: Qualitative, quantitative, and mixed methods approach. Thou-sand Oaks, Calif.: Sage.

CRGE. (2011). Ethiopia's Climate-Resilient Green Economy, Green Economy Strategy – Federal Democratic Republic of Ethiopia.

Crippa, M. et al. (2020). Fossil CO_2 emissions of all world countries – 2020 Report, EUR 30358 EN, Publications Office of the European Union, Luxembourg, 2020.

Cruz. (1999). Integrated Land Use Planning and Sustainable Watershed Management. A Journal of Philippine Development – Number 47, Volume XXVI, NO 1, First Semester 1999

Cruz, R. V. O. (1991). Biophysical Characterization of Critical Watersheds. In: Proceedings of the First National Symposium and Workshop on the Management of Critical Watersheds in the Philippines, 1991. HARRDEC. Baguio City, Philippines.

CSA. (2004). Statistical Abstract. Federal Democratic Republic of Ethiopia. Addis Ababa: office of population and housing commission.

CSE. (1997). The Conservation Strategy of Ethiopia, Volume II, Federal Policy on the Environment, Environmental Protection Authority in Collaboration with Ministry of Economic Development and Cooperation, Addis Ababa, Ethiopia.

Cunningham. (1993). The Coalition of Essential Schools, HORACE, "So Now What?" Managing the change process.

Daron, A., et al. (2008). The Role of Institutions in Growth and Development, Working Paper No. 10

David, L. Morgan, (1997). Focus Groups as Qualitative Research, Second edition.

Deepak, K. (undated). Resource Mobilization, SANDEEP Program, Save the Children, Training Paper.

Dejene, K. M. (2017). Research Paper Writing Principles and Concepts, Mega Publishing and Distribution P.L.C.

Dellink, R. J. B. and Ruijs, A. (2008). Economics of Poverty, Environment and Natural - Resources Use, Online version at http://library.wur.nl/frontis, Wageningen University and Research Center.

Delman, J. (2006). The Community-based Participatory Action Framework.

Demel, T. (2000). Status of Forestry Development, Conservation, and Utilization in Ethiopia: Proceedings of the First Meeting of Eastern and North Eastern Node of the African Forestry Research Network (AFORNET) in Kenya, 1999.

Denscombe, M. (2010). The Good Research Guide for small-scale social research projects. Fourth Edition - Open University Press.

Devi, R., T. Esubalew, L. Worku, D. Bishaw and B. Abebe. (2007). Assessment of siltation and nutrient enrichment of Gilgel Gibe dam, southwest of Ethiopia. Bioresour. Technol., 99: 975-979.

Dhankhar, R. (2018). Environmental Studies: Daya Publishing House – A division of Astral International Pvt. Ltd.

Diallo, G. Hu et al. (2009). Application of Remote Sensing in Land Use/Land Cover Change Detection " Journal of American Science (2009.,5(4)): 9.

DSE. (2001). Integrated Watershed Management Planning. Training Manual (unpublished).

E f a p. (1994). Ethiopian Forestry Action Program, Final Report, Volume II - The Challenge for Development. Transitional Government of Ethiopia. Ministry of Natural Resources Development and Environmental Protection. Addis Ababa, Ethiopia.

Easterling, W.E., Aggarwal, P.K., Batima, P., Brander, K.M., Erda, L., Howden, S.M., Kirilenko, A., Morton, J., Soussana, J. F., Schmidhuber, J. & Tubiello, F.N. (2007). Food, fiber and forest products. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of WG II to the Fourth Assessment Report of the IPCC, M. L. Parry, O.F. Canziani, J.P. Palutikof, P. J. van der Linden and C.E. Hanson, eds., Cambridge University Press, Cambridge, UK, 273-313.

Eastman, J. R. (2001). Guide to GIS and Remote Sensing – Volume 1, https://www.mtholyoke.edu/courses/tmillett/course/geog205/files/remote_sensing.pdf

EC. (2008). European Commission Non Paper, Guidelines on Agricultural Research for Development.

EHI and GEF. (2008). (Caribbean Environmental Health Institute) Integrated Water Resources Management (IWRM) Planning – What is an IWRM plan – why do we need one?

Ehrlich, P. and J. Holdren. (1971). The Impacts of Population Growth. Science Vol. 171, pp 1212 – 1217

Ehrlich, P. and J. Holdren. (1974). Human Population and the Global Environment, American Science, Vol. 62 pp 282 – 292.

Einar, B., Govind, S., Martin, J., Josef, K. (2010). Integrated Watershed Management – Perspectives and Problems

Elias, E. (2003). Environmental roles of agriculture in Ethiopia. ftp://ftp.fao.org/es/ESA/Roa/pdf/2_Environment/Environment_EthiopiaNA.pdf.

Elias, N. (2008). Dwindling Ethiopian Forests: The Carrot and Stick Dilemma

Ellis, F. et al. (2000). Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, Oxford. 2000:1-273.

Elsa Mendoza, Stephen Perz, César Aguilar & et al. (2007): The ‘Knowledge Exchange Train’: a model for capacity building for participatory governance in the south-western Amazon, Development in Practice, 17:6, 791-799

Engel, P. G. H. and Salomon, M. L. (1997). Facilitating innovation for development. A RAAKS resource box. Royal Tropical Institute, Amsterdam.

EPA. (2005). United States Environmental Protection Agency, Community-based Watershed Management, Lessons from the National Estuary Program.

EPA. (2007). Achievements in Stratospheric Ozone Protection, Progress Report.

EPG. (2011). Colby College, Environmental Policy Group, Environmental Policy Review: Key Issues in Ethiopia

ERA. (2013). Drainage Design Manual

Erba, T. B. (2010). Impacts of Deforestation on Rural Livelihoods: A case of Kuyu Woreda, Central Ethiopia. A Thesis Presented to Addis Ababa University School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Masters of Arts in Environment and Development Studies.

Erle, E. (2016). The encyclopedia of earth, land-use and land-cover change.

Estrella M. et al. (2000). Learning From Change, Issues and Experiences in Participatory Monitoring and Evaluation.

Ethiopian Constitution. (1995). Preamble, Constitution of the Federal Democratic Republic of Ethiopia.

Ethiopian Water Recourses Management Policy. (1999).

Fakhra, A. et al. (2016). Causes of Ozone Layer Depletion and Its Effects on Human: Review

FAO (Food and Agriculture Organization of the United Nations). (2004a). FAOSAT data. FAO, Rome, http://apps. fao. org

FAO and UN. (2009). Working Paper, Habitat.

FAO. (1986). Ethiopian Highland Reclamation Study: the Food and Agriculture Organization of the United Nations.

FAO. (2002). Water Resources Planning and Management for Drought Mitigation – Regional Workshop on Capacity Building on Drought Mitigation, in the Near East, Rabat, Morocco.

FAO. (2006). Livestock's long shadow; 00153 Rome, Italy

FAO. (2012). Climate Change Adaptation and Mitigation, Challenges and Opportunities in the Food Sector (Food and Agriculture Organization of the United Nations (FAO) Natural Resources Management and Environmental Department – Rome, September 2012.

Federal Negarit Gazeta. (1994). Ethiopian Proclamation NO. 94/1994, Ethiopian Forest Law Enacted

Federal Negarit Gazeta. (2002). Ethiopian Proclamation NO. 295/2002 – A proclamation provided for the establishment of environmental protection organs – 9th year NO. 7, Addis Ababa – 31st October.

Federal Negarit Gazeta. (2002). Ethiopian Proclamation NO. 299/2002 – Environmental Impact Assessment Proclamation – 9th year NO. 11, Addis Ababa – 3rd October, 2002.

Federal Negarit Gazeta. (2002). Ethiopian Proclamation NO. 300/2002 – Environmental Pollution Control Proclamation – 9th Year NO. 12 Addis Ababa – 3rd October, 2002.

Federal Negarit Gazeta. (2005). Proclamation NO. 456/2005, Forbidding farming and free grazing on rural lands with slopes exceeding 60% that devoted to tree planting, perennial crops, and forage production.

Federal Negarit Gazeta. (2007). Ethiopian Proclamation No. 542/2007, The Federal Democratic Republic of Ethiopia, A Proclamation to provide for the Development, Conservation and Utilization of Forests.

Federal Negarit Gazeta. (2007). Forestry Conservation, Development and Utilization Proclamation NO. 542/2007 of the Federal Democratic Republic Government of Ethiopia

Fishbein, M. and I. Ajzen. (2010). Predicting and changing behavior. Psychology Press, New York, New York.

Floress K. et al. (2015). The Role of Social Science in Successfully Implementing Watershed Management Strategies – Universities Council on Water Resources, Journal of Contemporary Water Research and Education, Issue 154, PP 85-105, April 2015.

Floyd, F.S. (1996). Remote Sensing, Principles and Interpretation – Published - W. H. Freeman and Company, New York

FMoH. (2018). Federal Ministry of Health, National Health Adaptation Plan to Climate Change (2018-2020), Addis Ababa, Ethiopia.

Forest and Water. (2014). Forest and Water – a five –year action plan, Increasing international action to address forest-water interactions in science, policy, economics and forest practices. An action plan of the international forests and water agenda

FSC (Forest Stewardship Council). (2013). The increasing importance of forests to the prosperity of people. Stockholm, March 2013.

Fuest, V., Haffner, S., Ampomah, B., and Tweneboah, E. (2005). Mapping the Water Sector of Ghana: an Inventory of Institutions and Actors. GLOWA – Volta research Documentation.

Gashaw et al. (2017). Climate Change Adaptation and Mitigation Measures in Ethiopia.

Gaventa, J. (1993). The powerful, the powerless, and the experts: Knowledge struggles in an information age. In P. Park, M. Brydon-Miller, B. Hall. & T. Jackson (Eds.) Voices of Change: Participatory Research in the United States and Canada. Westport, CT: Bergin, Garvey

Ge et al. (2016). Forest Management Challenges for Sustaining Water Resources in the Anthropocene.

Geist, H. J. and Lambin, E. F. (2002). Proximate Causes and Underlying Driving Forces of Tropical Deforestation. Bio Science, 140-150

Geist, H. J. and Lambin, E. f. (2002). Proximate Causes and Underlying Driving Forces of Tropical Deforestation. Bioscience 52(2): 144 – 150

Geist, HJ. (2005). The causes and progression of desertification. Ashgate Publishing, Aldershot, 258 pp

Gessese, A. (2008). Prediction of sediment inflow for Legedadi reservoir (using SWAT watershed and CCHE1D sediment transport models). Master's Thesis, Faculty of Technology Addis Ababa University, Ethiopia.

Gessese, B. H. (2018). Impact of Land Use/ Land Cover Change on Rural Communities Livelihood of Ethiopia – Department of Natural Resource, Mizan teferi Atvet College, Ethiopia.

GGWSSI (Great Green Wall for the Sahel and Sahara Initiative). (2012). National Strategy and Action Plan for the Implementation of the Great Green Wall Initiative in Ethiopia, Federal Democratic Republic of Ethiopia.

Gonzalez, P. et al. (undated). Forest and Woodland Systems – Chapter 21.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework Water Partnership, IWRM Implementation Project in Ethiopia, Final Project for mixed-method evaluation designs. Educational Evaluation and Policy Analysis, 11(3), 255–274.

GWP (Global Water Partnership). (2015). Integrated water resources management in Eastern Africa: Coping with 'complex' hydrology. Technical Focus Paper

GWP (Global Water Partnership). (2009). – Eastern Africa, Ethiopia Country Report. Project Supported by the United States Department of State [USDoS].

GWP (Global Water Partnership) et al. (2005). Integrated Water Resources Management Plans, Training Manual and Operational Guide.

Haboudane, D. Bonn, F, Royer, A, Sommer, S. Mehl, W. (2002). Land degradation and erosion risk mapping by fusion of spectrally-based information and digital geomorphometric attributes. International Journal of Remote Sensing 23: 3795–3820

Habtamu, T. (2001). Assessment of Sustainable Watershed Management Approach: Case Study Lenche Dima, Tsegur Eyesus and Dijjil Watershed.

Hagmann, J., Chuma, E., Murwira, K., Connolly, M. (1999). Putting process into practice: operationalizing participatory extension. Network-Paper-Agricultural-Research-and-Extension-Network, - ODI (UK), no. 94, 23 p.

Hailemariam A. (2003). Population Growth, Environment and Agriculture in Ethiopia; Prepared for Panel Discussion and Media Plan on the Occasion of the 10th Anniversary of the Launching of the National Population Policy of Ethiopia, June, 17, 2003.

Halcrow. (1989). Master plan for the development of surface water resources, in the Awash Basin for EVDSA vol. 4 Addis Ababa.

Hanson, W. E., Creswell, J. W., Plano Clark, V. L., Petska, K. S., & Creswell, J. D. (2005). Mixed methods research designs in counseling psychology. Journal of Counseling Psychology, 52(2), 224–235.

Haregewany, N., J. Poesen, J. de Wit, M. Haile, G. Govers and S. Deckers. (2006). Reservoirs in Tigray (Northern Ethiopia): Characteristics and sediment deposition problems. Land Degradat. Dev., 17:211-230

Hart, C. (1998). Doing a Literature Review – Releasing the Social Science – Research Imagination

Hathaway, T. (2008). What cost Ethiopia's dam boom? A look inside the expansion of Ethiopia's energy sector. International Rivers, People. Water. Life. http://www.internationalrivers.org/files/EthioReport 06Feb08.pdf

Hawando, T. (undated). Desertification in Ethiopian highlands, RALA REPORT NO. 200.

Heemskerk, W. (2005). Participatory Approach in Agricultural Research and Development, CTA, Knowledge for Development

http://pubs.wri.org/pubs_description.cfm?pubID=3764

Hunter, L. M. (2000). The Environmental Implications of Population Dynamics. Santa Monica: RAND

Hurni, H. (1982). Soil Conservation Research Program: Inception Report. Bern, Switzerland and Tokyo, Japan: University of Bern and United Nations University.

IAASTD. (2009). Agriculture at a crossroads.

IAN DEY. (1993). Qualitative data analysis – A user-friendly guide for social scientists.

ICRAF. (2014). Report to Irish Aid, Department of Foreign Affairs and Trade.

IDRC. (2010). Resource Mobilization – A Practical Guide for Research and Community-Based Organizations, Venture for Fund Raising

IDRC. (2012). The Application of Participatory Action Research to Climate Change Adaptation in Africa.

IEG. World Bank, IFC, MIGA, (2013). Managing Forest Resources, for Sustainable Development – An Evaluation of World Bank Group Experience.

IFAD. (2008). Improving access to land and tenure security - Policy

IFAD. (2009). Research and innovation for smallholder farmers in the context of climate change. IFAD's Governing Council Discussion Paper for Round Table 3, February 18-19, 2009, organized during the Thirty – second session of the Council.

IFAD. (2011). IFAD’s Environment and Natural Resource Management Policy: Resilient livelihoods through the sustainable use of natural assets

IFAD. (2011). Rural Poverty Report – New realities, new challenges: new opportunities for tomorrow's generation.

IFAD/GEF. (2008). Partnership on Climate Change: Fighting a global change at the local level.

IFPRI and ILRI. (2002). Policies for sustainable land management in the East African highlands, Summary of papers and proceedings of a conference held at the United Nations Economic Commission for Africa (UNECA), Addis Ababa, Ethiopia, 24-26 April 2002 – Socio-economics and Policy Research Working Paper 50 – IFPRI – International Food Policy

Research Institute, 2033 K Street, NW Washington, DC 20006, USA and ILRI – International Livestock Institute, P O Box 30709, Nairobi, Kenya.

IHP. (2017). VIII Technical Document No 37 –Latin America and the Caribbean: Forest Management and the Impact on water resources: a review of 13 countries

IIMI. (1990). Resource Mobilization for Sustainable Management, Proceedings of a workshop on Major Irrigation Schemes in Sri Lanka, held at Kandy, Sri Lanka - 22-24 February 1990.

Ilker, E. et al. (2015). Comparison of Convenience Sampling and Purposive Sampling, American Journal of Theoretical and Applied Statistics, Science PG, Science Publishing Group.

ILRI. (2000). Policies for Sustainable Land Management in the highlands of Ethiopia: Socio-economics and Policy Research Working Paper 30

IPCC. (2001). Climate change. Mitigation. Bert Metz, Ogunlade Davidson, Robert Swart and Jiahua Pan (Eds). Cambridge University Press, UK. pp 700.

IPCC. (2007). Working Group III Report on Mitigation of Climate Change, IPCC Fourth Assessment Report. Bert Metz, Ogunlade Davidson, Peter Bosch, Rutu Dave Leo Meyer (Eds.) Cambridge University Press, UK.pp841.

Israel, BA, Schulz, AJ, Parker, EA, Becker, AB, Allen, AJ, & Guzman, JR. (2003). Critical Issues in Developing and Following Community Based Participatory Research Principles. In M. Minkler & N. Wallerstein (Eds.). Community Based Participatory Research for Health (pp 53-76) San Francisco: Jossey Bass.

IWM. (2015). International Watershed Management, 2015, Policy brief No 2

IWMI. (2005). Irrigation Development in Ethiopia." International Water Management Institute

IWMI. (2005). Irrigation and River Basin Management, options for Governance and Institutions.

IWMI. (2005:152). Irrigation and River Basin Management, options for Governance and Institutions.

IWMI. (2007). Water Resources and Irrigation development in Ethiopia, Working Paper 123:4.

IWMI. (2016). Working Paper 170, An Assessment of Integrated Watershed Management in Ethiopia, IWMI, Bill and Melinda Gates foundation, AGWATER SOLUTIONS, Makelle University, CGIAR.

IWSM. (2015). Policy Brief: Pathways to effective integrated watershed management.

Jabulane, J. (2014). Quantitative Research: Methods and Designs – M&D Workshop, Polokwane/Durban, Dhlamini College of Education.

Jackson, P. T. (2006). A statistician strikes out: In defense of genuine methodological diversity. Paper presented at the meeting of the American Political Science Association, Philadelphia. (August–September).

Jacques, M. et al. (2013). Participatory Action Research – Theory and Methods for Engaged Inquiry – Downloaded by [University of South Africa] at 04:39 19 August 2015.

James, G. L. (2005). The forest service and the Greatest Good: A centennial History. The Forest History Society, 701 William Vickers Avenue, Durham, North Carolina 27701

Jean, B. (undated). The Sociological Approach in Watershed Management: from Participation to Decentralization – Proceedings of the African Regional Workshop on Watershed Management, Part 4, Social aspects of Watershed Management.

Jesson, J. et al. (undated). Doing a Literature Review – Traditional and Systematic Techniques

John, B. et al. (2010). Finding Practical Approaches to Integrated Water Resources Management

Johnson N. et al. (2001). User Participation in Watershed Management and Research, CAPRi Working Paper No. 9

JOHNSON, M. P. (undated). Watershed Function, Publication 8064; FWQP Reference Sheet 10.1, Oregan State University.

Julien, P. and S. Shah. (2005). Sedimentation Initiatives in Developing Countries Draft Report presented to UNESCO – ISI. Colorado State University.

Karin, R., et al. (2009). Ethiopia at a Crossroads: Demography, Gender, and Development, Policy Brief,

Katarina, M. et al. (undated). Impact of Informal Institutions on Economic Growth and Development.

Kebede, W. Wolancho. (2012). Watershed Management: An Option to Sustain Dam and Reservoir Function in Ethiopia.

Keller, M. (2009). Climate Risks and Development Projects – Assessment Reports for a Community-Level Project in Guduru, Oromiya, Ethiopia.

Keno B. Terfa. (2019). Urban Expansion in Ethiopia from 1987 to 2017: Characteristics, Spatial Patterns, and Driving Forces.

Kevin, T. et al. (undated). Community-Based Watershed Planning and Management Recommendations, Submission to the Environmental Advisory Board.

Kidanemariam, J. (2009). Participatory integrated water resources management (IWRM) planning: Lessons from Berki Catchment, Ethiopia – Reviewed Paper – Local, 34th WEDC International Conference, Addis Ababa, Ethiopia – Water, Sanitation and Hygiene: Sustainable Development and Multisectoral Approaches.

Klevin, R. J. T. and Nicholls, R. J. (1999). Assessment of coastal vulnerability to climate change. AMBIO 28(2) 182 – 187.

Kothari, C. R. (2004). “Research Methodology: Methods and Techniques", New Age International, pp: 123-124.

Kothari, C.R. (2004). “Research Methodology: Methods and Techniques ", New Age International, p: 95.

Kumar, Shubh K. and David Hotchkiss. (1988). ‘Consequences of Deforestation for Women’s Time Allocation, Agricultural Production, and Nutrition in Hill Areas of Nepal,’ International Food Policy Research Institute Research Report 69, Kumsa, A. (2015). Gis and Remote Sensing Based Analysis of Population and Environmental Change: The Case of Jarmet Wetland and its Surrounding Environments in Western Ethiopia. A Thesis Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Arts in Geography and Environmental Studies.

Kunming. (2014). Forest and Water – a five- year action plan, Increasing international action to address forest-water interactions in science, policy, economies and forest practices. An action plan of the International Forest and Water Agenda.

Lakew D., Carucci, V., Asrat Wendem-Ageňehu and Yitayew Abebe (eds). 2005. Community Based Participatory Watershed Development: A Guideline. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

Lambin, E. and Helmut, G. (2003). Land-Use and Land-Cover Change: Local Processes and Global Impacts. Springer-Verlag Berlin Heidelberg, Berlin, Germany.

Lambin, E., Geist, H. and Lepers, E. (2003). Dynamics of Land Use/cover Change in Tropical Regions. Annual Review on Environmental and Resources 28:205–241.

Lambin, EF, Geist, HJ. (2001). Global land-use/land cover changes: What have we learned so far? IGBP Global Change Newsletter NO. 46, June 2001, pp 27 – 30

Lambin, EF, Geist, HJ. (2001). Global land-use and land-cover change: what have we learned so far. Global Change Newsletter 46: 27-30

Lambin, EF. (2003). Linking socioeconomic and remote sensing data at the community or at the household level: Two case studies from Africa. In: Fox J, Rind fuss RR, Walsh SJ, Mishra V (eds) People and the environment: Approaches for linking household and community surveys to remote sensing and GIS. Kluwer Academic, Dordrecht Boston London, pp 223–240

Lambin, et al. (2006). Land – Use and Land – Cover Change, Local Processes and Global Impacts.

Lemessa A. (2008). Perception of People about the Effects of Population Growth on the Environment: The Case Jida Ayana Woreda, East Wollega (Oromiya Region)

Lillesand et al. (1994). Remote Sensing and Image Interpretation, John Wiley & Sons, New York .Chichester. Brisbane. Toronto. Singapore.

Lillesand, M. T., Kiefer, R. W. and Chipman, J. W. (2004). Remote Sensing and Image Interpretation. (Singapore: John Wiley & Sons, Pvt. Ltd)

Liu, Y., Guo H.C, Zhang Z., Wang LJ. Dai, Y. Fan Y. (2007). 'An Optimization Method Based on Scenario Analysis for Watershed Management Under Uncertainty', Environ Manage 39: 678-690.

Lunetta, R. S., J. F. Knight, et al. (2006). "Land Cover Change Detection Using Multi-Temporal MODIS NDVI data Remote Sensing of Environment (105). 2006): 12

M. A. Burton. (2010). Irrigation Management: Principles and Practices.

M. Ghorbani and M. Dehbozorgi. (2015). Sustainable Watershed Management – Gonenc, Wolflin and Russo (Eds): Analysis of policy network and institutional networks cohesion in sustainable management of watersheds, case study: Taleghan region, northern Iran.

MA (Millennium Ecosystem Assessment). (2003). Ecosystems and human-wellbeing: A framework for assessment. Island Press, Washington D.C., 245 PP

MA (Millennium Ecosystem Assessment). (2005). Ecosystems and Human Well-being: Synthesis. Washington, D.C.: Island Press.

Macleon, M. and Congalton, R. (1998). A Quantitative Comparison of Change Detection Algorithms for Monitoring Eelgrass from Remotely Sensed Data. Photogrammetric Engineering & Remote Sensing, 64:207–216.

MAF/DANIDA. (2002). Evolving Concept, Practice and Issues of Integrated Watershed Management in Lao P.D.R.

Mahi, P. (undated). Mobilization and Management of Financial Resources – A Study of Haryana State.

Maidment, D. R. (1993). Hand Book of Hydrology. McGraw-Hill, New York.

Mallick, A. (2015). Environmental Science and Management, Viva Books Private Limited

Malthus, Thomas Robert. (1798). An Essay on the Principle of Population; London

Maria, C. J. Cruz. (1991). Population Pressure, Deforestation, and Common Property Institutions: An Overview.

Markos, E. (1997). Demographic Response to Ecological Degradation and Food Insecurity, Drought Prone areas in the Northern Ethiopia PDOD publication.

Markos, E. and Dilnesaw A. (1998). Population, Environment, Resource and Sustainable development in Ethiopia. In ICDR, Hand book on population and family life education for secondary school in Ethiopia (p. 390). Addis Ababa: Institute for Curriculum, Development and Research.

Mather, AS. (2006a). Proximate causes. In: Geist HJ (ed) Our Earth's changing land: An encyclopedia of land-use and land-cover change, vol. 2 (L - Z). Greenwood Press, Westport, London, pp 490 – 495

Mather, AS. (2006b). Driving forces. In: Geist HJ (ed) Our Earth's changing land: An encyclopedia of land-use and land-cover change, vol. 1 (A - K). Greenwood Press, Westport, London, pp 179 -185

McMillan, J. H. and Schumacher, S. (2010). Research in Education: Evidence based inquires (7th ed) Boston: Pearson Education.

MCPFE (Ministerial Conference on the Protection of Forests in Europe). (2009). Workshop on Forest and Water: Sustainable Forest Management and influences on Water Resources –Coordinating Policies on Forest and Water.

MEDaC. (1999). Ministry of Economic Development and Corporation; Survey of the Ethiopian Economy: Review of Post-Reform development, 1992/93 – 1997/98, Addis Ababa.

Mengistu, D. A. (2008). Remote Sensing and gis-based Land use Land cover change detection in the Upper Dijo river catchment, Silte zone, southern Ethiopia. Working paper on population and land use change in Central Ethiopia, Nr. 17

MERILARK, et al. (2002). Watershed Function, Publication 8064, FWQP Reference Sheet 10.1., University of California, Division of Agriculture and Natural Resources.

Mesfin, T. (2009). Spatial Metrics and Landsat Data for Urban Land Use Change Detection: Case of Addis Ababa, Addis Ababa University, Addis Ababa.

Meyer, W. and Turner, B. (1992). Human Population Growth and Global Land-use/cover Change. Annual Review of Ecology and Systematics, 23:39–61.

Michael, Q. Patton. (2002). Qualitative Research & Evaluation Methods, 3 Edition, P: 305

Minkler, M., Blackwell, A. G., Thompson, M. & Tamir, H. (2003, August). Community-based Participatory Action Research: Implications for Public Health Funding. Am J of Public Health, 93(8), 1210-1213.

Misselhorn, AA. (2005). What drives food insecurity in southern Africa? A meta- analysis of household economy studies. Global Environ Chang 15(1): 33 – 43

Mncube. (2005). School Governance in the Democratization of Education in South Africa, PhD Thesis, Birmingham University.

MoA. (1998). Ministry of Agriculture, National Resource Management & Regulatory Department , in cooperation with German Agency for Technical Cooperation (GTZ), "Advisory Assistance to the Forest Administration": Monitoring of Forest Resources in Ethiopia.

MoA. (2007). Policy and Strategy for the Development, Conservation and Utilization of Forests: Translated from the Amharic Version.

MoFED. (2003). Rural Development Policy and Strategy, Ministry of Finance and Economic Development, Economic Policy and Planning Department, Addis Ababa

Monica P. et al. (1999). A Participatory Approach to Watershed Management: The Brazilian System – Journal of the American Water Resources Association, Vol. 35, No.3

Morie, N. D. (2007). Land Use and Land Cover Changes in Harena Forest and Surrounding Area, Bale Mountains National Park, Oromiya National Regional State, Ethiopia. MSc Thesis, Addis Ababa University, Ethiopia.

Moujahed, A. (2002). Forest and Water: Towards Effective Watershed Management – International Expert Meeting on Forest and Water – Forest & Water/PRSNT/01, Shiga, Japan.

Mourad, K. A. (2013). Can Integrated Water Resources Management contribute to sustainable peace in the Middle East?

MoWIE (Ministry of Water, Irrigation and Energy). (2018). Assessment of National Water use and Demand Forecast, Part 1 – Water Resources Potential Assessment, IA: Surface Water Resource Potential

MoWR (Ministry of Water Resources). (2002). The Federal Democratic Republic of Ethiopia, Ministry of Water Resources, Water Sector Development Program 2002 – 2016.

Mukherejee, N. et al. (undated). Sustainability Planning and Monitoring, Community Water Supply and Sanitation – A Guide on the Methodology for Participatory Assessment (MPA) for Community-Driven Development Program, IRC International Water and Sanitation.

Mule H. M. (undated: 9). Institutions and their Impact in Addressing Rural Poverty in Africa.

Mulugeta, L. (2004). Effects of Land Use Changes on Soil Quality and Native Flora

Muniu F. N. (2018). Community Participation in Resource Mobilization and Sustainability of community Water Projects in Kenya

Musa, A.S., S. El-Zein, S.M. Ei-sayed, M. Mirghani and S. Golla. (2005). Assessment of the current status of the nile basin reservoir sedimentation problems. Nile Basin Capacity Building Network-for River Engineering. Nairobi, Kenya.

Nancy, L. Leech · Anthony J. Onwuegbuzie. (2007). A typology of mixed methods research design

NAP. (2019). Ethiopia's Climate Resilient Green Economy – National Adaptation Plan, Federal Democratic Republic of Ethiopia

NAPA. (2007). Climate Change National Adaptation Program of Action (NAPA) of Ethiopia – The Federal Democratic Republic of Ethiopia, Ministry of Water Resources, National Meteorological Agency.

Natasha, M. et al. (2005). Qualitative Research Methods: A Data Collector's Field Guide – Family Health International – http://www.fhi.org, E- mail : publications @fhi.org - P. O. Box 13950 – Research Triangle Park, North Carolina 27709, USA.

NBAP. (2008). National Biodiversity Action Plan, Government of India, Ministry of Environment and Forests

NCS. (1994). National Conservation Strategy, National Policy on Natural Resources and the Environment, National Conservation Strategy Secretariat, Ministry of Natural Resources Development and Protection.

Nehemia, et al. (2015). Agriculture, Climate Change and Food Security.

NEPAD. (2003). New Partnership for Africa's Development (NEPAD) – Action Plan of the Environment Initiative

Nielsen TL, Zobisch MA. (2001). Multi-factorial causes of land-use change: Land –use dynamics in the agro pastoral village of ImMial, northwestern Syria. Land Degraddev 12: 143 – 161

NMSA (National Meteorological Services Agency). (1996). Assessment of drought in Ethiopia. NMSA, Addis Ababa, Ethiopia.

Ntiamoa-Baidu, Y., Souleymane, Z., Deo. Gratias Mboje, G. and Bonnehin, L. (2000). Principles in practice: Staff observations of conservation projects in Africa. Biodiversity Support Program, Washington, D. C. NW Washington, DC 20433.

Ojima DS, Galvin KA Tuner BL II. (1994). The Global impact of land-use change. Bioscience 44 (5):300 - 304

Oldeman, L. R., Hakkeling RTA, Sombroek WG. (1991). World map of the status of human-induced soil degradation: An explanatory note, revised ed. United Nations Environment Program, Nairobi; International Soil Reference and Information Centre, Wageningen, 34 pp (with maps) paper n◦ 39.

Oriabure, D. E. (2016). Importance of Forest and Trees in Sustaining Water Supply and Rainfall.

Oswal, M. C. (2018). Watershed Management (for Dry Agriculture): Associated Publishing Company – A Division of Astral International Pvt. Ltd. – New Delhi – 110 002, Printed at: Replika Press Pvt. Ltd

OV1. (2010). Integrated Water Resources Management (IWRM), China - UK, WRDMAP, Integrated Water Resources Management Document Series – CHINA WATER, DFID, Mott MacDonald.

Parry, J., (2003). Tree choppers become tree planters. Appropriate Technology, 30(4), 38-39 Retrieved November 22, 2006, from ABI/INFORM Global database.

PASDEP. (2005). Ethiopia: Building on Progress: A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) 2005/06-2009/10). Ministry of Finance and Economic Development, Addis Ababa, Ethiopia.

Pasquale, De M. et al. (2008). The role of institutions for human development.

Patra, P. (Undated). Remote sensing and Geographical Information System (GIS).

Pearson. (2013). Secondary Atlas, New Edition, Always Learning: Edinburgh Gate, Harlow, and Essex – CM20 UK.

Petticrew, M. and Roberts, H. (2006). Systematic Reviews in the Social Sciences: A Practical Guide, Oxford: Blacwell.

Pieter van der Z. et al. (2015). Principles of Integrated Water Resources Management – UNESCO – IHE, Institute for Water Education, Delft.

Polit, D. F. and Hungler, B. P. (1995). Nursing research: principles and methods. Lippincott, Philadelphia, B. P.

Polit, D. F. and Hungler, B. P. (1997). Essentials of nursing research. Lippincott, Philadelphia, PA. Population Census Commission (Addis Ababa, Ethiopia: UNFPA, 2008).

Ponelis, S. R. (2015). Using interpretive qualitative case studies for exploratory research in doctoral studies: A case of Information Systems research in small and medium enterprises. International Journal of Doctoral Studies, 10, 535-550. Retrieved from http://ijds.org/Volume10/IJDSv10p535-550Ponelis0624.pdf

Pradhan, NS; Khadgi, VR; Schipper, L; Kaur, N; Geoghegan, T. (2012). Role of Policy and Institutions in Local Adaptation to Climate Change – Case studies on responses to too much and too little water in the Hindu Kush Himalayas. Kathmandu: ICIMOD

Prathapan, K. (2014). Research Methodology for Scientific Research, I. K. International Publishing House Pvt. Ltd., New Delhi.

Pretty, J., Ward, H. (2001). Social capital and the environment, World Development, Vol.29, No.2, 209-227.Resources in the Awash Basin for EVDSA Vol. 4. Addis Ababa.

Probst, K., Hagmann, J., Fernandez, M., Asby, J. A. (2003). Understanding participatory research in the context of natural resource management: paradigms, approaches and typologies. Agricultural Research and Extension Network (ODI). (UK). 2003, no.130, 20p.

Puchra, et al. (2004). Assessment of Grassland Ecosystem Conditions in the Southwestern United States, Volume 1, United States Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Ramachandran, P. K. Nair. (1993). An Introduction to Agroforestry, Klgwer Academic Publishers, in cooperation with International Center for Research in Agroforestry (ICRAF).

Ranjan, K. A. (2016). Role of Geographic Information System and Remote Sensing in Monitoring and Management of Urban and Watershed Environment: Overview

Rattan, L. (2000). Integrated Watershed Management in the Global Ecosystem, CRC Press, Boca Raton London New York Washington, D.C.

Reis, S. (2008). Analyzing Land Use / Land Cover, Changes Using Remote Sensing and GIS in Rize, North-East Turkey.

Rekha, D. et al. (undated). Methodology for Participatory Assessment With Community, Institutions and Policy Makers – Linking Sustainability with Demand, Gender and Poverty. Water and Sanitation Program, The World Bank, Washington D.C., IRC International water and Sanitation Centre, The Netherlands.

Reston. (1998). American Institute of Aeronautics and Astronautics, Guide for the Verification and Validation of Computational Fluid Dynamics Simulations, AIAA-G-077-1998. Reston, VA, 1998.

Revenga, C. Murray S, Abram vitz J., Hammoud, A. (1998). Watersheds of the world: ecological value and vulnerability. World Watch Institute. Washington, DC.

Robert G. Sargent. (2011). Verification and Validation of Simulation Models, Proceedings of the 2011 Winter Simulation Conference S. Jain, R. R. Creasey, J. Himmelspach, K. P. White, and M. Fu., eds.

Robert, C. (1996). Participatory Learning Approaches and ZOPP Remarks to the GTZ Workshop "ZOPP Maries PRA?"

Robert, C. et al. (2005). Policy Arena, Revising the Paradigm: Quantification, Participatory Methods and Pro-poor Impact Assessment – Journal of International Development.

Ronald, J. Eastman. (2001). Guide to GIS and Image Processing, idrisi 32, Release 2, Volume 1, Manual Version 32.20

Rosegrant, M. (2002). Policies and institutions for sustainable water resource

Ross, N. et al. (1999). Using Stream Geomorphic Characteristics as a Long –term Monitoring Tool to Assess Watershed Function.

Rudel, T. and Roper, J. (1997). The paths to rain forest destruction: Cross national patterns of tropical deforestation, 1975 – 1990. World Development, 25(1), 53 – 65

Sahalu, G. A. (2014). Analysis of Urban Land Use and Land Cover Changes: A Case Study in Bahir Dar, Ethiopia. Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Geospatial Technologies.

Sahoo, A. K. (2012). Climate Mitigation and Carbon Finance – Global Initiatives and Challenges, New India Publishing Agency, Pitam Pura, New Delhi-110 088.

Samra J. S. et al. (2005). Participatory Watershed Management Programs for Sustainable Development: Experiences from IWDP

Santra, S. C. (2016). Environmental Science, New Central Book Agency (P) Ltd 8/1 Chintamoni Das Lane, Kolkata 700 009.

SARAH, J. TRACY. (2013). Qualitative Research Methods – Collecting Evidence, Crafting Analysis, Communicating Impact – A John Wiley & Sons, Ltd., Publication.

Savenije, H. H. G. & Van der Zaag, P. (2008). 'Integrated water resources management: Concepts and issues', Physics and Che-mistry of the Earth, Vol. 33, pp. 290–297.

Schlaepfer, R. (1997). Ecosystem-based management of natural resources: a step towards sustainable development. IUFRO occasional paper No. 6.

Seddeqy, M. Q. (2007). Sedimentation in reservoir. National Hydrology committee of Afghanistan. http://www.google.com.et/search?q=Mohammad

Seeme, M. and Naghmana, G. (2005). A Review of the relationship between Poverty, Population Growth, and Environment, The Pakistan Development review – 44:4 part II (Winter 2005) pp. 597 - 614

Shahin, M. M. A. (1993). An overview of reservoir sedimentation in some African River basins. International Institute for Infrastructural, Hydraulic and Environmental Engineering, The Netherlands.

Sharlene, N.H-B. (2010). Mixed Methods Research, Merging Theory with Practice, the Guilford Press.

Sharma, N. S., Denning and K. Cleaver. (1995). "Restoration of soil fertility In Sub-Saharan Africa, Concept paper and action plan". Africa Region, World Bank, Washington D.C.

SHWP. (2010). Storm water, Harbors and Watersheds Program, Proposed Integrated Watershed Management Program Plan, 625 Fisgard Street, Victoria, BC V8W 2S6

Simpson, E. L. & House, A. O. (2002). Involving users in the delivery of mental health services: systemic review. British Medical Journal, 325:1265- …..

Sing, A. (1989). Digital Change Detection Techniques Using Remotely Sensed Data. International Journal of Remote Sensing, 1000-1200

Singh, A. (1989). Review Article Digital change detection techniques using remotely-sensed data. International Journal of Remote Sensing, 10(6), 989–1003.

SMIS. (2016). (Small Scale and Micro Irrigation Support Project), Irrigation Agronomy Training Manual on Farm Water Management, Agriteam Canada Consulting Ltd, Hawassa, Ethiopia.

Sola, L. (2001). Impact of Poverty on the Environment in Southern Africa, Retrieved November 5, 2005, from http://www.sarpn.za.

Sonneveld, B. G. J. S, & Keyzer, M. A. (2003). Land under pressure: soil conservation concerns and opportunities for Ethiopia. Land Degradation and Development, 14,5-23

Springett, J. (2003). Issues in Participatory Evaluation. In Minkler, M. & Wallerstein, N. (Eds.), Community Based Participatory Research for Health (pp 263-288) San Francisco: Jossey Bass

Steven, C. Hackett. (1960). Environmental and Natural Resources Economics: Theory, Policy, and the Sustainable Society, 3rd ed.:326

Strand, K., Marullo, S., Cutforth, N., Stoecker, R., & Donohue, P. (2003a). Community-based research

Sujatha, G, Dwivedi RS, Sreenivas K, Venkataratnam L. (2000). Mapping and monitoring of degraded lands in part of Jaunpur district of Uttar Pradesh using temporal space borne multispectral data. International Journal of Remote Sensing 21: 519–531.

Sumit, C. et al. (undated). Deforestation: Causes, Effects and Control Strategies.

Tadesse G. (2014). Methodology and Writing up Research - A Handbook for Students & Supervisors, Mega Publishing & Distribution P. L. C. Addis Ababa.

Tailor, G. R. (Ed.). (2005). Integrating quantitative and qualitative methods in research. Maryland: University press of America Inc.

Ted, C. Sheng. (1994). Challenges and Strategies of Integrated Watershed Management in Developing Countries, Paper presented to the 8th International Soil Conservation Conference, New Delhi, India, December 4 to 8, 1994.

Thacker H. Ben, et al. (2004). Concepts of Model Verification and Validation, Los Alamos – National Laboratory-test. 1943, The World's Greatest Science Protecting America.

Thiam, AK. (2003). the causes and spatial pattern of land degradation risk in southern Mauritania using multi-temporal AVHRR-NDVI imagery and field data. Land Degradation & Development 14: 133–142.

Thomas, M. and Bekele. (2003). Role of Planted Forests and Trees Outside Forests in Sustainable Forest Management, Working Paper FP/29E, FAO, ROME (ITALY)

Thomas, M. L. and Ralph, W. K. (1994). Remote Sensing and Image Interpretation, Third Edition – John Wiley & Sons, Inc. - New York. Chichester. Brisbane. Toronto. Singapore.

Thomas, M. L. and Ralph, W. K. (2000). Remote Sensing and Image Interpretation, Fourth Edition – John Wiley & Sons, Inc. - New York. Chichester. Weinheim Brisbane. Singapore Toronto

Thomas, M. L., Ralph W. K. and Jonathan W. Chipman. (2008). Remote Sensing and Image Interpretation, Sixth Edition – John Wiley & Sons, Inc.

Tuckman. (1972). Objectivity of Strategic Ritual: An Examination of Newsmen's Notions of Objectivity, American Journal of Sociology, University of Connecticut.

Turner, B. Skole, D., Sanderson, S., Fischer, G., Fresco, L. and Leemans, R. (1995). Land-use and Land-cover Change Science/research plan. IGBP Glob. Change Rep. 35/HDP Rep. 7). Int. Geosph - Biosph. Program, Hum. Dimens. Glob. Environ. Change Program, Stockholm, Geneva.

Turner, BL Hyden G, Kates RW (eds). (1993a). Population growth and agricultural change in Africa. University Press of Florida, Gainesville.

Twenehboah, E. (2001). School governance in the democratization of education in South Africa, PhD Thesis – Bermingham University.

Twenehboah, E. (2009). The Role of Economic Values and Attitudes of Ghanaian Coastal Women in Natural Resource Management, PhD Thesis – Brandenburg University of Technology in Cottbus.

UN Population division. (1998). Regional Distribution of Population. New York: United Nations, Department of Economic and Social Affairs, Population Division.

UN Water et al. (2018). Progress on – Integrated Water Resources Management, 6 Clear Water and Sanitation, Global Baseline for SDG 6 Indicator 6.5.1, Degree of IWRM Implementation

UN. (1992). United Nations Sustainable Development, United Nations Conference on Environment & Development Rio de Janerio, Brazil, 3 to 14 June 1992 – AGENDA 21.

UN. (1994). Population and Environment in Developing Countries: Literature Survey and Research Bibliography.

UN. (2015). World Population Prospects – The 2015 Revision – Key Findings and Advance Tables, Department of Economics and Social Affairs - Population Division, ESA/P/WP.241.

UNDESA. (2019). World Population Prospects – Highlights.

UNDP Ethiopia. (2011). Framework for UNDP Ethiopia's Climate Change, Environment and Disaster Risk Management Portfolio

UNEP. (2002). Capacity building for sustainable development: An Overview of UNEP Environmental Capacity Development Activities.

UNFCC. (2008). Challenges and opportunities for mitigation in the agriculture sector Technical paper.

UNFPA. (2008). Central Statistical Authority (CSA) and United Nations Population Fund (UNFPA), Ethiopia, Summary and Statistical Report of the 2007 Population and Housing Census, Universitatis Agriculturae Sueciae. Silvestria Vol. 306.

UN-Water. (2015). The United Nations World Water Development Report: Water for a Sustainable World. United Nations Educational Scientific and Cultural Organization (UNESCO), Paris, France.

USAID. (2000). Amhara National Regional State Food Security Research Assessment Report. Available at: http;//crsps.Org/amhara-rpt. PDF.

USAID. (2006). From the American People, October, Issues in Poverty Reduction and Natural Resources Management.

USDA SCS. (1972). National Engineering Hand Book, USDA Soil Conservation Service, Washington DC.

Vanessa, U. (2013). The Management and Use of Natural Resources and their Potential for Economic and Social Development in the Mediterranean, IAI Working Papers 13/29 - October 2013.

Verheye, W. (2011). Land Cover, Land Use and the Global Change. Journal of Land Use, Land Cover and Soil Science I.

Vincent Oparah. (undated). AU-NEPAD Environmental Action Plan (EAP)

Wabekbon Development Consultant PLC. (2009). Final Study Report of Strengthening Multi-sectoral Development Planning in Oromia Region – JICA, Ethiopia Office

Wakena, T. O. (2008). Operational analysis of the cascaded Wadecha-Belbela reservoir system in Ada'a Liben. A Dissertation submitted to Arba Minch University in Partial Fulfillment of the Requirements of the Degree of Masters of Science in Hydrology and Water Resources Management Washington DC.

Walliman, N. (2011). Research methods: The Basics. New York: Rout ledge.

Wani, et al. (2011). Integrated Watershed Management in Rain fed Agriculture, CRC Press, Taylor & Francis Group, Boca Raton London New York Leiden

WCED (World Commission on Environment and Development). (1987). Our Common Future. Oxford University Press. New York. NY.

Weng, Q. (2012). Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends. Remote Sensing of Environment, 117, 34–49.

Wessels, KJ. Prince SD, Frost PE, van Zyl D. (2004). Assessing the effects of human induced land degradation in the former homelands of northern South Africa with a 1km AVHRR NDVI time-series. Remote Sensing of Environment 91: 47–67

White, A. T., Hale, L. Z., Renard, Y. and Cortesi, L. (Eds.). (1994). Collaborative and community-based management of coral reefs lessons from experience, Kumarian Press, Inc., West Hartford, Connecticut.

WHO. (2015). Climate change and health in the Western Pacific Region: synthesis of evidence, profiles of selected countries and policy direction.

Wiesmann, U. (1999). Integrated Management of Watersheds – Trans-disciplinary Approaches at Multiple Scales. A summary of presentations. In: Workshop Proceedings on Concepts and Methods for Institutionalizing Watershed Classification and Watershed Management in the Lower Mekong Basin, Vientiane, Laos, 16 – 17 November 1999. (Hardcopy)

Wijayadasa, K. H. J. (1997). Harmonizing Environment and Development in South Asia – A Publication of South Asia Co-operative Environment Program in Collaboration with UNEP and NORAD.

Wilkinson, S. (2004). Focus group research. In D. Silverman (ed.), Qualitative research: Theory, method, and practice (pp. 177–199). Thousand Oaks, CA: Sage.

William, F. W. (1991). Participatory Action Research

Wirtu, D. K. (2014). An assessment of soil degradation and conservation practices based on farmers perception in Toke – Kutaye District, West Shewa Zone, Oromiya Regional State, Ethiopia. A Thesis Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment for the Degree of Masters of Arts in Geography and Environmental Studies, Specialized in Land Resource Management.

Woldeamlak, B. & Stroosnijder, L. (2003). Effects of agro-ecological land use succession of soil properties in the Chemoga watershed, Blue Nile, Ethiopia. GEODERMA 111: 85–98.

Wood, A. and Lemma, K. with Konde, A. (2001). Conservation Strategy of Ethiopia (CSE 1996-2001), Phase III Project, Final Evaluation Report, Volume One.

Working Group on Watershed Management and Development, University of Minnesota. (1988). Working Paper 3, December, 1988. The Role of Watershed Management in Sustainable Development, by the Working Group on Watershed Management and Development, University of Minnesota.

World Bank. (1995). The World Bank Legal Department, Policy Research Working Paper, 1414; The World Bank and Legal Technical Assistance, Initial Lessons

World Bank. (2010). Economics of adaptation to Climate Change, Ethiopia. World Bank Group 1818 H Street,

World Development Report. (2010). Development and Climate Change, The International Bank for Reconstruction and Development / The World Bank.

World Resource Institute. (2003). World Resources 2002 – 2004: Decision for the Earth: balance, voice, and power. United Nations Development Program, United Nations Environment Program, World Bank, World Resources Institute.

Wouters, P. et al. (2007). Implementing Integrated Water Resources Management in Central Asia – Published in cooperation with NATO Public Diplomacy Division

Xu, JC. Wilkes A. (2004). Biodiversity impact analysis in northwest Yunnan, southwest China. Biodrivers Conserv 13: 959 – 983

Yirsaw, E.; Wu, W.; Temesgen, H.; Bekele, B. (2016). Effect of temporal land use/ land cover changes on ecosystem services value in coastal area of China: The Case of Su-Xi-Chang region. Appl. Ecol. Envion. Res. 2016, 14, 409 – 422. (CossRef).

Zamba, B. (2007). Fragile Environment, vulnerable people and sensitive society – KAIHATU-SHA Co., Ltd. (3-44-4 Minami-Otuka Toshima-ku Tokyo Japan).

Zazu, C. (2015). Guidelines for implementing IWRM at local level

Zegeye, H. (2018). Climate change in Ethiopia: impacts, mitigation and adaptation – International Journal of Research in Environmental Studies.

Zomer, J. R. (2009). Trees on Farm, Analysis of Global Extent and Geographical Patterns of Agroforestry – Published by the World Agroforestry center, United Nations Avenue P O Box 30677, GPO 00100

10 Annexures

Annex - 1: Focus Group Discussion

Focus Group Schedule for Respondents

Welcome all participants and thank you for coming. The purpose of the focus group discussion is to gather information/evidence about how natural resources in the area, specifically soil and vegetation/forest, are managed and how you, as primary resource users, interact with these natural resources.

We will have interactive discussion on possible benefits you may gain and challenges you encounter whilst managing the natural resources. Involvement level of government or NGOs, if exists, will be discussed, including policy support that may or may not involve irrigation development and environmental sustainability functions side-by side.

Please kindly be informed that opinions expressed will be treated confidentially and will be used only for academic purposes. All information will remain anonymous.

The session will be recorded electronically and notes will be taken during the session. Please let us know of any inconvenience or if there are any objections to the procedures.

- What benefits do the watershed communities obtain from the watershed system?
- What are the general environmental problems in the area?
- What are the impacts of natural resources degradation, vegetation/forest and soils of the watershed environment on the area and the community?
- Have access and use of the natural resources changed over the years?
- Do you think the shortage of fuel wood is being observed as getting worse over years or remains the same?
- What are some general socio-economic problems in the watershed environment?
- What are the impacts of irrigation development on the watershed ecosystem?
- What are the coping strategies being experienced in dealing with environmental degradation problems?

- What kind of measures do you use to control soil erosion?
- Would you tell us the experience of the watershed communities in protecting and preserving the natural resources of the area?
- What does the livelihood practices impact on the watershed ecosystem?
- Which organizations, government, local NGOs, are involved in managing natural resources in the Belbela-Wadecha watershed area?
- Do you have government policies in one, for both irrigable agriculture development and watershed management, reflecting on the indispensability of the both functions in terms of the sustainability and socio-economic benefits for both upstream and downstream communities of the area?
- Do you think policies on watershed natural resources management consider the livelihood of the rural poor?
- Do you have bylaws and how do you discharge environmental protection responsibilities?
- What are your perceptions about participation in program to manage the natural resources of the watershed area?
- Are you involved in planning, design, implementation and management of watershed natural resources of the area?
- What actions do you think should be taken in harnessing a healthy watershed environment of the Belbela-Wadecha ecosystem and maintain sustainable irrigation agriculture, both to function side by side in a sustainable way?
- Is there anything else you would like to mention?

Annex - 2: Focus Group Schedule

Focus Group Schedule for Government officials

- What are some of the general problems of environmental issues in Belbela-Wadecha watershed area?
- What benefits does the community of the area obtain from the watershed ecosystem?
- What are the livelihood practices of the community of the area on the watershed environment?
- Do these irrigation projects empower the people economically?
- What specific problems do you observe as environmental degradation problems in the area?
- What impacts does the irrigation development in the area reflect on the watershed ecosystem?
- How the communities in this watershed area are coping with the existing and current economic and social problems?
- What practice do the communities in the watershed have in protecting and preserving the natural resources of the area?
- Do you have government policies in one, relating to irrigation agriculture development and watershed environmental management, considering the indispensability of both functions with each other in terms of sustainability and socio-economic benefits for both upstream and downstream watershed communities?
- What strategies/policies/bylaws are in place in reducing/preventing general environmental degradation problems in the area? (What are the limitations to these approaches?).
- Were the local residents involved in these project activities? (If so how and at what level?).
- What is your follow up mechanism on whether or not the communities are discharging their environmental responsibilities?
- Any other relevant and related issues that have not been mentioned?

Annex - 3: Questionnaire

The information you will provide will be treated in confidence and will be used for academic purpose only. Please read through the questions and tick mark the appropriate box provided or write your response on the space provided. If you are unable to, I will be there to help. Thank you.

Section-A: Background Information

1. Name of Community --
2. Gender of household head ---
3. Respondent name---
4. Age in years
   - 4.1 22 -30 [ ]
   - 4.2 31-40 [ ]
   - 4.3 41-50 [ ]
   - 4.4 50 and above [ ]
5. Were you born in this area? If no, where were you born? ---------------------------------
   ----
6. What is your highest level education?
   - 6.1 No Education
   - 6.2 Middle school
   - 6.3 Primary
   - 6.4 Secondary
   - 6.5 Higher, please specify--
     ----
7. Occupation---

Section-B: Formal and Informal Institutions/Provisions for Environmental Management within the Study Areas

1. Do you have specific community /government organization in the area that deals with environmental/water conservation? If so please name them.------------------------------ -- -- --
2. Are you aware of any community/entity based natural resources program?
   Yes [ ] No [ ]
3. Which organization should take care of natural resources and the environment in the watershed area?
   Government [ ] NGO [ ] Community [ ]
   3.1 Explain your choice-- -- -- -- ---------------------
4. Is there are any binding laws to enforce environmental protection activities?
   Yes [ ] No [ ]
   4.1 If yes, who drafted it?_____________________________________
   4.2 How is it ratified?____
5. Is there a government policy in action?
   Yes [ ] No [ ]
   5.1 If yes, are you happy with it?
   Yes [ ] No [ ]
   5.2 If no, do you want one to support the bylaws?

Yes [ ] No [ ]

Section-C: Environment

1. Have you lived in the area since birth

   Yes [ ] No [ ]

   1.1 If no, why did you choose to come to the area?

   Looking for job [ ]

   To visit family/ friend [ ]

   Through settlement program [ ]

   Other, specify---

   ----

2. How are the surroundings of the place you leave?

   2.1 Very good [ ]

   2.2 Quite good [ ]

   2.3 Bad [ ]

   2.4 Very bad[ ]

   2.5 Don't know [ ]

3. In your opinion do irrigation schemes cause negative impacts on the watershed environment?

   Yes [ ] No [ ]

   3.1 If yes explain what, in terms of;

   Soil degradation and its impacts on vegetation and soil erosion---------------

   ----

Water storage in Belbela and Wadecha reservoirs------------------------------
----

Specify others, if any.--

----

4. Do you observe the problem of soil erosion and/or deforestation on your land and/or outside your land?

Yes [ ] No [ ]

5. Explain the type of farming practices you do and why you do them reflecting on its role for soil and water conservation activities.

Soil conservation ---

Water conservation ---

----

6. Do you want to protect soil erosion?

Yes [ ] No [ ]

6.1 If yes, why and how?---

6.2 If no, Why?--

----

7. Explain why, to your answer number 6 above---

----

8. How do you prevent soil erosion and water loss to conserve the watershed environment?--
----

----

9. What do you use as a control measure practice to control soil erosion?

9.1 Cultivation along the contour [ ]

9.2 Terracing [ ]

9.3 Strip cropping along the contour [ ]

9.4 Wind breaks [ ]

9.5 Vegetation and crop cover [ ]

9.6 Tree planting [ ]

9.7 Ditch [ ]

9.8 Other, specify____

10. What do you use for cooking?

10.1 Electricity [ ]

10.2 Kerosene [ ]

10.3 Fuel wood [ ]

10.4 Charcoal [ ]

10.5 Crop residue [ ]

10.6 Dry dung [ ]

11. What type of energy do you use for market?

11.1 Electricity [ ]

11.2 Kerosene [ ]

11.3 Fuel wood [ ]

11.4 Charcoal [ ]

11.5 Crop residue [ ]

11.6 Dry dung [ ]

12. Is the farm you own sufficient for sustaining your household life?

Yes [ ] No [ ]

13. If your answer to the question number 12 above is no, how do you like to increase your earnings?

13.1 By expansion of the agricultural land [ ]

13.2 By selling forest products [ ]

14. If your answer to the question number 13 above is 13.1 how do you obtain the additional plot of land?

14.1 Inheritance [ ]

14.2 Contract/Lease [ ]

14.3 Clearing forests [ ]

14.4 Government allocation [ ]

15. If your answer to question number 13 above is No, do you still sell forest products?

Yes [ ] No [ ]

If your answer to question number 15 above is yes, please state why.____

16. Do you rear cattle for economic purpose and hose hold consumption?

    Yes [ ] No [ ]

17. If your answer to question number 16 above is yes, where do you graze your livestock?

    17.1 Portion of your farm land [ ]

    17.2 Common grazing plot [ ]

    17.3 Forest area [ ]

18. Do you produce forest products relating to

    18.1 Market [ ]

    18.2 House hold consumption [ ]

    18.3 Others, please specify --

    ----

19. Put question number18 above in the order of priority.

    19.1 Market, household consumption [ ]

    19.2 Household consumption, Market [ ]

20. Do you use forest products as a main means of income?

    Yes [ ] No [ ]

21. If your answer to question number 20 above is yes, please state what you do with forest.____

    ____

22. What is the proportion of your community between those who sell forest products and those who do not?

    22.1 50% each [ ]

    22.2 Less than 50% for those who do not sell [ ]

    22.3 Less than 50% for those who do sell [ ]

    22.4 Greater than 50% for those who do not sell [ ]

    22.5 Greater than 50% for those who do sell [ ]

23. In your opinion, what is your order of priority that forest can mainly deliver?

    23.1 Rainfall source [ ]

    23.2 Regulate temperature [ ]

23.3 Soil erosion control [ ]

23.4 Improve biodiversity [ ]

23.5 Environmental sustainability [ ]

23.6 Market benefit [ ]

24. If you did area closure some Ten years back, do you think it would have impacted on question number 24 above?

Yes [ ] No [ ]

25. If your answer to question number 25 above is yes, which will benefit more than the other (order of benefits)?

25.1 Improve rainfall pattern [ ]

25.2 Improve biodiversity [ ]

25.3 Minimize soil erosion [ ]

25.4 Improve temperature [ ]

25.5 Regulate watershed environment [ ]

26. What impact do you observe on the socio- economic status of the community, as a result of forest/vegetation cover degradation and soil erosion (put them in the order of severity)?

26.1 Decline of forest product [ ]

26.2 Decline of agricultural produces [ ]

26.3 Environmental instability [ ]

27. What do you think is the main reason for forest/vegetation degradation?

27.1 Natural[ ]

27.2 Humans [ ]

28. If your answer to question number 27 above is 27.2, could you describe how?

28.1 Economic benefit – to sell to a market [ ]

28.2 House hold consumption [ ]

28.3 Resettlements [ ]

28.4 Grazing [ ]

28.5 Agricultural expansion [ ]

28.6 Others, please state --

----

29. Is there any community based natural resource management in your locality?

Yes [ ] No [ ]

30. Are you trained in natural resources conservation methods?

Yes [ ] No [ ]

If your answer to question number 30 above is yes, who trained you?

Government [ ] NGO [ ]

31. Who owns forest resources in your area?

Government [ ] NGO [ ]

32. Who should hold responsibility for forest resource conservation?

Government [ ] NGO [ ] Community [ ]

33. State your reasons why to your choice number 32 above.------------------------------------
----

Section-D: Economy

1. What kind of house do you leave in?
    1.1 Corrugated iron sheet [ ]
    1.2 Locally made grass top cover[ ]
    1.3 Other, please specify ---
    ----
2. Does your household has
    1.4 Electricity? [ ]
    1.5 Telephone? [ ]
    1.6 Television? [ ]
    1.7 Radio? [ ]
    1.8 Video deck? [ ]
    1.9 Refrigerator? [ ]
    1.10 An iron? [ ]
3. Do you own this house?
    Yes [ ] No [ ]
4. Is irrigation important to your living?
    Yes [ ] No [ ]

If yes, explain what impacts have been made to your living pattern, consisting of changes to:

4.1 Housing type including bedding [ ]
4.2 Incomes [ ]
4.3 Health [ ]
4.4 Schooling [ ]
4.5 Clothing [ ]
4.6 Feeding habits [ ]
4.7 All [ ]

If No, explain why.---

----

5. What is your livelihood practices like? Explain how you earn your living. Is it based on?

   5.1 Agriculture farming;

   Rain fed agriculture [ ]

   Irrigated agriculture [ ]

   5.2 Animal husbandry [ ]

   5.3 Logging [ ]

   5.4 Other, please specify ---

   ----

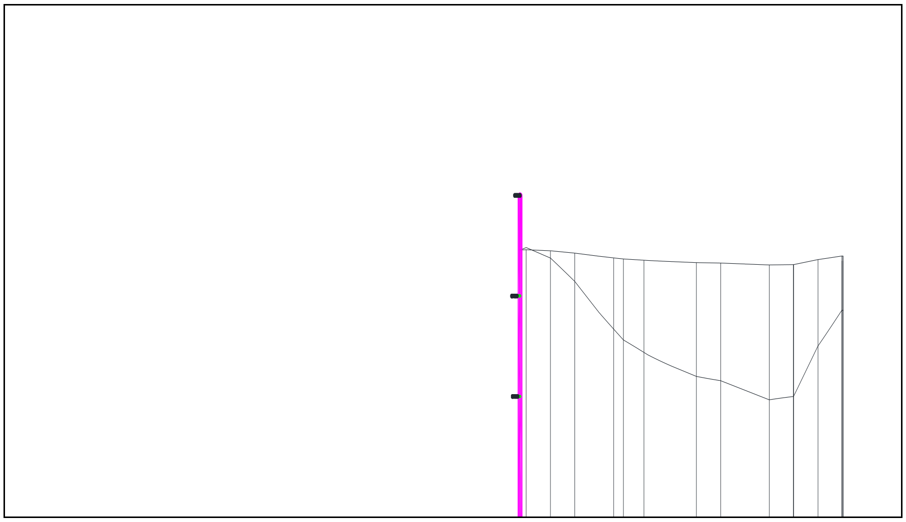
6. Do you benefit from the watershed ecosystem and/or face any challenges?

   6.1 Describe the benefits and how they are gained.-----------------------------------

   ----

Describe the challenges reflecting on the sources and ways to overcome them ____
____
____

Annex - 4: Pilot Scheme X-Section Elevations and Profile



504998.7	975602	1938.669	0.399501	96.7137808
504998.7	975602.4	1938.629	0.399452	97.11323292
504998.7	975602.8	1938.589	0.400451	97.51368392
504998.6	975603.2	1938.548	0.399501	97.91318486
504998.6	975603.6	1938.508	0.399452	98.31263698
504998.6	975604	1938.468	0.399452	98.71208911
504998.6	975604.4	1938.428	0.399452	99.11154123
504998.6	975604.8	1938.387	0.399501	99.51104217
504998.5	975605.2	1938.347	0.400451	99.91149316
504998.5	975605.6	1938.311	0.399452	100.3109453
504998.5	975606	1938.275	0.399501	100.7104462
504998.5	975606.4	1938.239	0.399452	101.1098984
504998.5	975606.8	1938.203	0.399452	101.5093505
504998.4	975607.2	1938.167	0.399501	101.9088514
504998.4	975607.6	1938.131	0.400451	102.3093024
504998.4	975608	1938.095	0.399452	102.7087545
504998.4	975608.4	1938.059	0.399452	103.1082067

504998.4	975608.8	1938.023	0.399501	103.5077076
504998.3	975609.2	1937.988	0.399452	103.9071597
504998.3	975609.6	1937.952	0.400451	104.3076107
504998.3	975610	1937.916	0.399501	104.7071117
504998.3	975610.4	1937.88	0.399452	105.1065638
504998.3	975610.7	1937.844	0.399452	105.5060159
504998.3	975611.1	1937.809	0.399452	105.905468
504998.2	975611.5	1937.773	0.399501	106.304969
504998.2	975611.9	1937.737	0.400451	106.70542
504998.2	975612.3	1937.702	0.399452	107.1048721
504998.2	975612.7	1937.666	0.399501	107.504373
504998.2	975613.1	1937.63	0.399452	107.9038252
504998.1	975613.5	1937.595	0.399452	108.3032773
504998.1	975613.9	1937.559	0.400451	108.7037283
504998.1	975614.3	1937.523	0.399501	109.1032292
504998.1	975614.7	1937.488	0.399452	109.5026813
504998.1	975615.1	1937.452	0.399452	109.9021335
504998	975615.5	1937.417	0.399501	110.3016344
504998	975615.9	1937.381	0.399452	110.7010865
504998	975616.3	1937.345	0.400451	111.1015375
504998	975616.7	1937.31	0.399452	111.5009896
504998	975617.1	1937.275	0.399501	111.9004906
504997.9	975617.5	1937.239	0.399452	112.2999427
504997.9	975617.9	1937.204	0.399452	112.6993948
504997.9	975618.3	1937.168	0.399501	113.0988958
504997.9	975618.7	1937.133	0.400451	113.4993468
504997.9	975619.1	1937.097	0.399452	113.8987989
504997.8	975619.5	1937.062	0.399452	114.298251
504997.8	975619.9	1937.026	0.399501	114.697752
504997.8	975620.3	1936.991	0.399452	115.0972041

504997.8	975620.7	1936.956	0.400451	115.4976551
504997.8	975621.1	1936.92	0.399501	115.897156
504997.8	975621.5	1936.885	0.399452	116.2966081
504997.7	975621.9	1936.85	0.399452	116.6960603
504997.7	975622.3	1936.815	0.399501	117.0955612
504997.7	975622.7	1936.779	0.399452	117.4950133
504997.7	975623.1	1936.744	0.400451	117.8954643
504997.7	975623.5	1936.709	0.399452	118.2949165
504997.6	975623.9	1936.674	0.399501	118.6944174
504997.6	975624.3	1936.638	0.399452	119.0938695
504997.6	975624.7	1936.603	0.399452	119.4933216
504997.6	975625.1	1936.568	0.4005	119.8938213
504997.6	975625.5	1936.533	0.399452	120.2932735
504997.5	975625.9	1936.498	0.399452	120.6927256
504997.5	975626.3	1936.463	0.399452	121.0921777
504997.5	975626.7	1936.427	0.399501	121.4916786
504997.5	975627.1	1936.392	0.399452	121.8911308
504997.5	975627.5	1936.357	0.400451	122.2915818
504997.4	975627.9	1936.322	0.399501	122.6910827
504997.4	975628.3	1936.287	0.399452	123.0905348
504997.4	975628.7	1936.252	0.399452	123.489987
504997.4	975629.1	1936.217	0.399452	123.8894391
504997.4	975629.5	1936.182	0.399501	124.28894
504997.3	975629.9	1936.147	0.400451	124.689391
504997.3	975630.3	1936.112	0.399452	125.0888431
504997.3	975630.7	1936.077	0.399501	125.4883441
504997.3	975631.1	1936.042	0.399452	125.8877962
504997.3	975631.5	1936.008	0.399452	126.2872483
504997.3	975631.9	1935.973	0.400451	126.6876993
504997.2	975632.3	1935.938	0.399501	127.0872003

504997.2	975632.7	1935.903	0.399452	127.4866524
504997.2	975633.1	1935.868	0.399452	127.8861045
504997.2	975633.5	1935.833	0.399501	128.2856054
504997.2	975633.9	1935.798	0.399452	128.6850576
504997.1	975634.3	1935.764	0.400451	129.0855086
504997.1	975634.7	1935.729	0.399452	129.4849607
504997.1	975635.1	1935.694	0.399501	129.8844616
504997.1	975635.5	1935.659	0.399452	130.2839138
504997.1	975635.9	1935.625	0.399452	130.6833659

X = 975633.9 – 975603.6= 30.30m

H = 1938.508 - 1935.798= 2.71m

Annex - 5: Pilot Scheme Soil Laboratory Test Results

Company Name: **Ethiopian Constraction Design & Supervision Works Corporation**
Research,Laboratory and Traning Center
Tel 0116 - 61 45 01 / 0116 - 61 01 05 ; Fax. 251 - 116 - 61 53 71/61 08 98; e-mail w.w.d.s.e@ethionet.et ; P.O.Box 2561

Title: **Soil Fertility Testing Report**	Document No: OF/RLTC/604	Issue No.1	Page No. 1of 1

Client:- Abiti Getaneh G/Meskel

Project:-

Source of Sample:-

Client Ref:-SF/030 & 032/2018

Location:- Koftu-Adindan

Date of Collection:- 02/12/2018

Date Received:-03/12/2018

Reported Date:-05/12/2018

Test Requsted:-Texture, & OC

Laboratory Number	799/2011			Test Method
Profile Code	N:505065 E:975626			
Sand (%)	39.82			Hydrometer
Clay (%)	25.79			
Silt (%)	34.39			
Texture Class	Loam			
Organic Carbon (OC) (%)	0.936			Walklay Black

REMARK: The Soil sample is collected and submitted to the laboratory by the client.

Reported by ______ Lab Expert

Checked by ______ Senior Soil Expert

Approved by ______ Soil Fertility Lab S/P Manager

Among the major services rendered by the Soil Fertility Laboratory Testing S Process of Ethiopian Construction Design & Supervision Works Corporation are: Testing Soil Fertility/ Agricultural Soil Testing and Plant Analysis. Sampling of soil, etc

Annex - 6: Pilot Scheme Soil Loss Estimates

The widely recognized method of soil loss estimation is the use of the universal soil loss equation (USLE), given by Wischmeter and Smith (1960), as

A = RKSLCP

Where, A = Average annual soil loss, t/ha

R = Rainfall erosivity factor

K = Soil erodibility factor

SL = Slope-Length factor

C = Cropping management factor

P = Conservation Practices factor

Descriptions of each factor and their value determination are explained below.

R- Rainfall Erosivity Factor

It is defined as one hundredth of the product of kinetic energy (KE) and maximum of 30 minutes rainfall intensity (I_{30}) of a rainstorm. Annual total of each storm value of EI_{30} is a measure of R and it can be expressed as:

$$R = \sum (KE x I_{30})/100$$

The KE is related with rainfall intensity by:

$$KE = 210.3 + 89 \log I$$

Where, KE = Kinetic energy (t/ha-cm)

I = Rainfall Intensity (cm/hr)

The rainfall intensity for the Pilot scheme is determined from Intensity-Duration-Frequency (IDF) curves for different Rainfall regions of Ethiopia, developed by the Ethiopian Road Authority, (ERA, Drainage Design Manual, 2013). Figure 10-1 shows the Rainfall Regimes of Ethiopia.

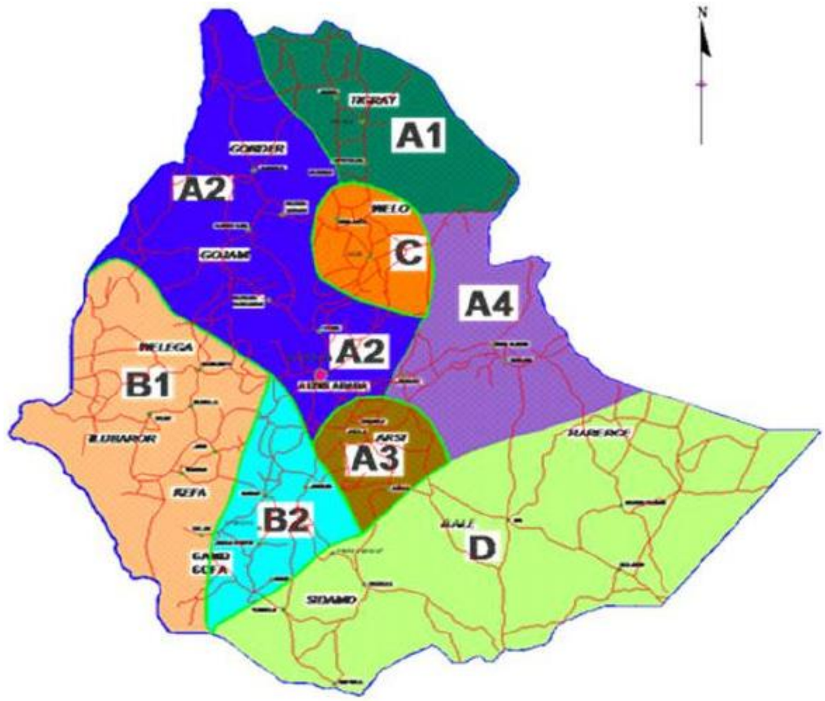


Figure 10-1: Rainfall Regimes of Ethiopia

Source: ERA, Drainage Design Manual, 2013

The Pilot Scheme is located in Region A2, and Figure 10-2 shows the corresponding IDF curves. For the rainfall duration of 30 minutes and for average year, the I_{30}, is 45mm/hr (4.5cm/hr).

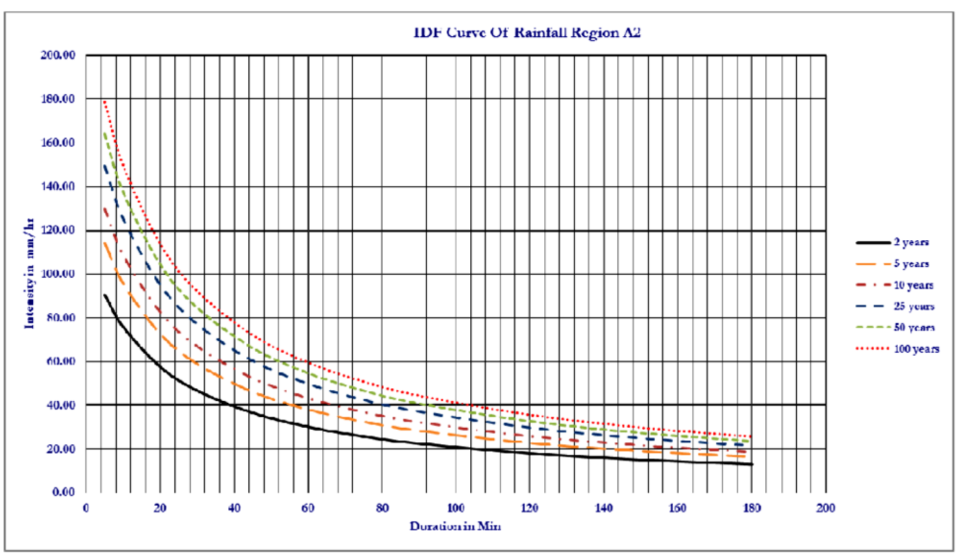


Figure 10-2: IDF Curve of Region A2

Source: ERA, Drainage Design Manual, 2013

Soil Erodibilty Factor (K)

This factor relates the rate at which different soils erode depending upon their inherent soil properties. The United States Soil Conservation Services developed a relationship of K with Soil Texture and organic matter. Table 10-1 reproduces this relationship.

Table 10-1: K Value in Relation to Soil Texture and Organic Matter

Source: Wischmeter and Smith (1960)

Texture class	Organic matter content, %		
	≤ 0.5	2	4
Sand	0.05	0.03	0.02
Fine sand	0.16	0.14	0.1
Very fine sand	0.42	0.36	0.28
Loamy sand	0.12	0.10	0.08
Loamy fine sand	0.24	0.20	0.16
Loamy very fine sand	0.44	0.38	0.30
Sandy loam	0.27	0.24	0.19
Fine sandy loam	0.35	0.30	0.24
Very fine sandy loam	0.47	0.41	0.33
Loam	0.38	0.34	0.29
Silt loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Clay loam	0.27	0.25	0.21
Sandy clay loam	0.28	0.25	0.21
Silty clay loam	0.37	0.32	0.26
Sandy clay	0.14	0.13	0.12
Silty clay	0.20	0.23	0.19
Clay	0.13	--	0.29

In order to determine the Soil Texture and Organic matter content of the soil, samples were taken and analyzed in the laboratory. The laboratory result shows that, Annex-5. The soil texture class is Loam and the organic matter content is 0.936%.

Slope-Length Factor or Topography Factor (SL)

Erosion increases with the increase in slope steepness and slope length due to their respective increase in velocity and volume of surface runoff. The Product of slope length and slope gradient is called topographic factor and is given by:

$$SL = \frac{(x)^m}{22.13}(0.065 + 0.045S + 0.0065S^2)$$

Where x = field slope length

S = slope gradient, percent

m = constant whose value varies with S as follows

m = 0.05 for S > 5%

m = 0.04 for S = 3- 5%

m = 0.03 for S = 1-3%

m = 0.2 for S < 1%

Topographic survey was carried out on the pilot scheme and the result shows that L = 30 m and Slope = 8.94 %.

Cropping Management Factor (C)

This term reflects combined effect of cover crop sequence, productivity level, and length of growing season, tillage practices and residue management on erosion control. Table 10-2 Table 10-2 shows the values of C for different land conditions.

Table 10-2: Value of C for Different Land Conditions

Source: Wischmeter and Smith (1960)

Land condition	C value
Fallow	1.0
Crop cover	0.4-0.3
Over-grazed grass	0.1
Thick grass	0.01
Forest (thick)/mulched	0.001
Pearl-millet	0.61
Pearl-millet followed by cowpea	0.39
Sorghum followed by pegeonpea	0.28
Rice	0.1-0.2
Palm tree	0.1-0.3

Conservation Practices Factor (P)

The erosion control practices are contouring, strip cropping and terracing. Table 10-3 shows the values of P for the three major practices.

Table 10-3: Conservation Practices Factor (P)

Source: Wischmeter and Smith (1960)

Land slope, %	Contouring	Strip cropping	Terracing
1-2	0.60	0.30	0.12
3-8	0.50	0.25	0.10
9-12	0.60	0.30	0.12
13-16	0.70	0.35	0.14
17-20	0.80	0.40	0.16
21-25	0.90	0.45	0.18

The amount of soil loss of the pilot scheme has been estimated for three major land cover condition namely, thick grass, forest and cropland with contouring, terracing and strip cropping conservation practices for each land cover condition. Table 10-4:_ shows the results.

Table 10-4: Average Soil Loss for Combinations of Different Land Cover and Conservation Practices

Items	Land cover condition	Conservation practice	P value	C value	Average Annual Soil Loss			Best Practice, Rank
					t/ha/yr	quintal/ha/yr	kg/ha/yr	
1	Thick grass	Contouring	0.6	0.01	0.0015	0.0151	0.1511	4
		Terracing	0.12	0.01	0.0003	0.0030	0.0302	3
2	Forest	Contouring	0.6	0.001	0.0002	0.0015	0.0151	2
		Terracing	0.12	0.001	0.0000	0.0003	0.0030	1
3	Crop cover	Contouring	0.6	0.35	0.0529	0.5289	5.2895	6
		Terracing	0.12	0.35	0.0106	0.1058	1.0579	5
		Strip cropping	0.3	0.35	0.0264	0.2645	2.6447	7

As it is evident from Table 10-4, the best land use practice that will reduce soil loss by erosion is Forestland cover with terracing conservation practice. The best land cover condition is Forest followed by Thick grass. Regarding the conservation practice, the best practice is terracing followed by contouring.

Annex - 7: Status of Energy Use of the Sample Communities.

		Name of the community		
		Godino	Qoftu	Total
		Count	Count	Count
Electricity	0	113	25	138
	1	0	49	49
	2	0	6	6
	3	0	1	1
	4	1	17	18
	5	9	8	17
	6	4	0	4
Kerosene	0	110	99	209
	1	0	3	3
	2	0	4	4
	5	13	0	13
	6	4	0	4
Fuelwood	0	0	59	59
	1	126	7	133
	2	0	13	13
	3	0	7	7
	4	1	12	13
	5	0	8	8
Charcoal	1	1	14	15
	2	27	38	65
	3	9	37	46
	4	89	17	106
	5	1	0	1
Crop residue	0	0	3	3
	1	0	5	5
	2	92	33	125
	3	9	41	50
	4	26	18	44
	5	0	6	6
Dry dung	0	0	1	1
	1	0	27	27
	2	8	12	20
	3	109	20	129

	4	10	31	41
	5	0	12	12
	6	0	3	3

Annex – 8: Ethical Clearance

Bul/Mootummaa Naannoo
Oromiyaa Go/Sh/Bahaatti
Waajjira Abbaa Taayitaa
Misooma Jallisii A/Ada aa

Ref no *ATMJ/256/2018*

Date *16/02/2018*

To Adugna Jabessa

Researcher on the Study of Belebela- Wadecha Watershed Environmental Degradation

Subject:- Request for Letter of Consent

With reference to your request in which you expressed you would like to undertake a research study relating to the Investigation of Nature, Causes and Effects of Long Term Environmental Degradation on Belbela-Wadecha Watershed Natural Resources, and would require our consent to carry on the study.

Your request states that the study will benefit the restoration process of a sound ecosystem and maintain sustainable irrigation agriculture where by the living pattern of the farming community will change for the far better style in terms of ensuring good social and economic status.

In this regard, our office should be grateful for the initiative taken and will support your study through providing the necessary assistance required to help you accomplish the study successfully.

Best wishes

Zannabach Alamuu Dhaabaa

Hojii Gaggeessaa

Godina Shaw... Bahaa Aanaa Ada'aatti
Ganda Q... Bulaa Godinoo

Ref no BU/G/Go/287/2018
Date 16/02/2018

To Adugna Jabessa

Researcher on the Study of Belebela- Wadecha Watershed Environmental Degradation

Subject: - Request for Letter of Consent

With reference to your request in which you expressed you would like to undertake a research study relating to the Investigation of Nature, Causes and Effects of Long Term Environmental Degradation on Belbela-Wadecha Watershed Natural Resources, and would require our consent to carry on the study.

Your request states that the study will benefit the restoration process of a sound ecosystem and maintain sustainable irrigation agriculture where by the living pattern of the farming community will change for the far better style in terms of ensuring good social and economic status.

In this regard, we, as a beneficiary of this initiative, not only express consent but also would like to engage ourselves in the research study process from the very beginning so that meaningful study can be put in place.

Best wishes

Abbabaa Alamuu
Gaggeesaa Ganda

Ref no Bu/G/Q/106/2018
Date 16/02/2018

To Adugna Jabessa

Researcher on the Study of Belebela- Wadecha Watershed Environmental Degradation

Subject: - Request for Letter of Consent

With reference to your request in which you expressed you would like to undertake a research study relating to the Investigation of Nature, Causes and Effects of Long Term Environmental Degradation on Belbela-Wadecha Watershed Natural Resources, and would require our consent to carry on the study.

Your request states that the study will benefit the restoration process of a sound ecosystem and maintain sustainable irrigation agriculture where by the living pattern of the farming community will change for the far better style in terms of ensuring good social and economic status.

In this regard, we, as a beneficiary of this initiative, not only express consent but also would like to engage ourselves in the research study process from the very beginning so that meaningful study can be put in place.

Best wishes

Damissee Gemmadaa
I/A/D/Talaa
Ganda Qoofttuu

CONSENT TO PARTICIPATE IN THIS STUDY

I, Ato Abrham Mulugeta confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the audio/video taping.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname – Abrham Mulugeta

Participant Signature………………………………………………Date 12/06/2018…………………

Researcher's Name & Surname - Adugna Jabessa Shuba

Researcher's signature………………………………………………Date 12/06/2018…………………

CONSENT TO PARTICIPATE IN THIS STUDY

I, Ato Sintayehu Desalegn, confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the audio/video taping.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname – Sintayehu Desalegn

Participant Signature...Date 12/06/2018....................

Researcher's Name & Surname - Adugna Jabessa Shuba

Researcher's signature...Date 12/06/2018....................

UNISA university of south africa

CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 03/12/2018

NHREC Registration # : REC-170616-051
REC Reference # : 2018/CAES/154
Name : Mr AJ Shuba
Student #: 61959626

Dear Mr Shuba

Decision: Ethics Approval from 01/12/2018 to 30/11/2019

Researcher(s): Mr AJ Shuba
61959626@mylife.unisa.ac.za

Supervisor (s): Prof S Shava
shavas@unisa.ac.za; 012-429-4782

Prof D Modise
dmmxo9@gmail.com; 072-751-0264

Working title of research:

An investigation of the nature, causes and effects of long term environmental degradation on watershed natural resources: A case of Belbela-Wadecha watershed ecosystem, Central Ethiopia

Qualification: PhD Environmental Management

Thank you for the application for research ethics clearance by the CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for a one-year period. After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 30 November 2019

Please note the points below for further action:

1. The researcher will obtain secondary data from various institutions. Is the secondary data available in the public domain, or does the researcher require permission to access the data? If permission is required, this must be obtained and submitted to the committee before data gathering may commence.

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Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
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www.unisa.ac.za

2. The questionnaire asks for the respondent's name. The researcher is cautioned that the anonymity of participants must be protected, and that he should consider using other means, such as allocating a number to each participant, to identify respondents.
3. The researcher indicates that photographs will be taken of the participants. He is cautioned that participants may not be identifiable in these images, and that their faces must be obscured to protect their anonymity.
4. GIS and remote sensing techniques will also be used as a data collection tool. Which of the objectives will this address?

*The **low risk application** was **reviewed** by the CAES Health Research Ethics Committee on 29 November 2018 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

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> *Note:*
> *The reference number **2018/CAES/154** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof EL Kempen
Chair of CAES Health REC
E-mail: kempeel@unisa.ac.za
Tel: (011) 471-2241

Prof MJ Linington
Executive Dean : CAES
E-mail: lininmj@unisa.ac.za
Tel: (011) 471-3806

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UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 25/11/2019

NHREC Registration # : REC-170616-051
REC Reference # : 2018/CAES/154
Name : Mr AJ Shuba
Student #: 61959626

Dear Mr Shuba

Decision: Ethics Approval Renewal after First Review from 01/12/2019 to 30/11/2020

Researcher(s): Mr AJ Shuba
61959626@mylife.unisa.ac.za

Supervisor (s): Prof S Shava
shavas@unisa.ac.za; 012-429-4782

Prof D Modise
dmmxo9@gmail.com; 072-751-0264

Working title of research:

An investigation of the nature, causes and effects of long term environmental degradation on watershed natural resources: A case of Belbela-Wadecha watershed ecosystem, Central Ethiopia

Qualification: PhD Environmental Management

Thank you for the submission of your progress report to the UNISA-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is renewed for a one-year period. After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 30 November 2020

*The **low risk application** was **reviewed** by the UNISA-CAES Health Research Ethics Committee on 29 November 2018 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

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1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:
The reference number ***2018/CAES/154*** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi
Chair of UNISA-CAES Health REC
E-mail: antwima@unisa.ac.za
Tel: (011) 670-9391

Prof MJ Linington
Executive Dean : CAES
E-mail: lininmj@unisa.ac.za
Tel: (011) 471-3806

URERC 25.04.17 - Decision template (V2) - Approve

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Protected Environment Generates Sustained Benefits Across Sectoral Institutions