Native Tree Species Based Afforestation/Reforestation For Carbon Sequestration: Contributions To Sustainable Development Through Clean Development Mechanisms In Ethiopia

by

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DECLARATION OF ORGINALITY

I, the undersigned, ASSEFA TOFU CHOFORE, student number 50790765, hereby declare that this thesis is my own original work with the exception of quotations and references, which are attributed to their sources. This thesis has not been previously submitted to any other university and will not be presented at any other university for a similar or other degree award. I also declare that I have complied with the rules, requirements, procedures and policies of the university.

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DEDICATION

I dedicate this work to my Lord Jesus Christ, who led me through my up and downs. Without Him, I might have passed away during a massive vehicle accident in 1991. Secondly, I express my gratitude to my beloved wife; Dr. Amarech Bekalo, for her unreserved love, encouragement and inspiration; and my daughter, Meklit, who has been my ‘face reader’, inspecting whether I was tired. When she was in high school she have been asking my about my progress and daily challenges, almost every day. Of course, my sons David contributed huge in formatting as well as checking grammar and the little Isaac for his understanding beyond his age deserve gratitude.

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ABSTRACT

The daunting tasks of responding to climate change and ensuring sustainable development (SD) are high on the political agenda among world leaders. From the onset, the clean development mechanisms (CDM) outlined in Article 12 of the Kyoto Protocol (KP), state that CDM activities should contribute to SD in the host country while reducing greenhouse gas (GHG) emission. Nevertheless, many scholars have criticized CDM for failing to deliver on its twin objectives. In Ethiopia in particular, there was lack of afforestation/reforestation (A/R) CDM research specific to the nation; specifically, research as to whether A/R-CDM met the stipulated twin objectives of SD and mitigation (reducing GHG).

This study was conducted in the Humbo district of Wolyaita Zone, Southern Nations - Nationality and People Regional (SNNPR) state of Ethiopia, where A/R-CDM was implemented in pursuit of these twin objectives. Humbo is located between 6°46'48.47 and 6°41'04.28N; and between 37°48'35.44 and 37° 55'14.51E, between altitudinal gradients 1200 and 1900 m.a.s.l. The climate of the study area is characterized by annual temperatures between 25°C and 28°C, and by total annual rainfall between 800 to 1000 mm.

The objectives of the study were to quantify the change of above ground and below ground carbon pools of native tree species; to assess the attractiveness of FMNR forestry practices; to examine A/R-CDM contributions to community level SD; and to assess the effectiveness of climate change mitigation policy founded on native tree species-based A/R-CDM.

Data regarding above ground biomass (AGB) and below ground biomass (BGB) carbon pools of native tree species was collected through non-destructive techniques to quantify the change in carbon sequestration and associated carbon trading. A multi-stage random cluster household (HH) sampling approach was used to assess the attractiveness of farmer managed natural regeneration (FMNR) forestry practice. To examine the contribution of A/R-CDM to community level SD, three dimensions of SD were evaluated,

namely; (local) environmental, social, and economic. Two indicators were considered per each dimension. With regard to local environmental SD, community access to natural resources, as well as changes to the local climate were considered. With regard to the social dimension, job creation and changes to social support structures were considered. With regard to the economic dimension, economic activities of the area and local skill development were considered. Focus group discussions and key informant interviews were used to triangulate the survey as well as to assess policy perspectives.

Results revealed that the Humbo native tree species based A/R-CDM, which employed FMNR forestry practices, sequestered a net total of 73,138; 84,848; 103,769 and 111,657 tCO2e along 2011, 2014, 2015 and 2016 years, respectively, across 2,728 ha. In terms of carbon leakage due to fuel wood collection activity displacement, a net zero was found since the average volume of fuelwood collected from the project area, after the area was closed off, was found to be 5.1 - 6.1 M^3, while before the area was closed off, that number was 4.3 M^3. This was due to the project employing FMNR forestry practices. Similarly, the leakage due to livestock grazing activity displacement also was found to be a net zero, since the number of animals grazing on land adjacent to the project area after four years of the area's being closed off reached 11,383 cattle, 429 donkeys and 4,108 goats, unlike 8,684 cattle and 2,288 goats before the project. In other words, the number of livestock owned by farmers on the land adjacent to the project site was not adversely affected by the closing off of the site, which prevented grazing on the area allocated to A/R-CDM. The livestock management training provided by project developer improved the farmers' rearing efficiency. Another expected leakage due to soil pitting for A/R was also found to be nil since soil disturbance did not take place because of FMNR practices. These results indicated that systematic regeneration of native tree species through FMNR forestry practices is an effective method to develop carbon sinks.

From the point of view of FMNR attractiveness, the results revealed that the practice improved land cover change. The use of FMNR avoided the projected eight years reforestation investment cost of US$ 2,751,312.00 which could have been used if plantation forestry was undertaken. This showed that Humbo A/R-CDM might not have happened if FMNR is had not been introduced, as CDM has no pre-finance mechanism.

With regard to community level SD contributions, the establishment of forest protection and development farmers' cooperatives, as well as the granting of communal land-user rights certification, resulted in legal ownership of the land to the community, whereas before, the land was considered "no man's land," and subject to open access. The land-user rights and carbon ownership in turn empowered the community to sign a contract with an international carbon credit buyer. In terms of the local microclimate, the regeneration of native tree species was correlated with increased rainfall in the area in June, July, August and September (JJAS) and March, April and May (MAM). This suggested that the native tree species based A/R-CDM project played a role in improving the local microclimate.

In terms of sociological SD, the study showed that new employment opportunities were created including tree pruning, thinning, forest guarding, and jobs at the community warehouse and community flourmill. The availability of employment opportunities was significantly higher for those who participated in the Humbo A/R-CDM, when compared to those who didn't. In terms of social support structures, in less than ten years, seven Humbo A/R-CDM project owner farmers' cooperatives, initially established as owners of the project, evolved into one forest protection and development Union. This enabled the institutionalization of grassroots organizations towards a common communal and international agenda of care for the environment.

In terms of economic effects, the project enabled a carbon credit contract worth a total of US$ 3,873,298.00, signed at the sell rate of US$ 4.4 per tCO_2^e, for a total of 880,295 tCO_2^e across a 30 year crediting period. This is a new business model for the community, the country, and global businesses, all doing their part in climate change mitigation - CDM. As of the first A/R-CDM verification, the community received a total of US$ 321,807.2 in 2011. Consequently, the community received 373,331.2 in 2014, 456,583.6 in 2015 and 491,290.8 in 2016. In terms of revenue from logging, selective harvesting is planned to take place in years 12, 24 and 36. The community is projected to earn at least US$ 15,150.00 per ha[1] (a total of US$ 3.9 million) from the first forest harvest in year 12 alone.

These benefits in emission reduction (ER) and SD suggest that massive cross-dimensional benefits were foregone due to the country's refusal to welcome A/R-CDM in its first commitment period, despite having 36,434,400 ha of land eligible for A/R.

The research results in the area of policy perspectives indicated that the Humbo A/R-CDM project, the only one of its kind in Ethiopia, was made possible by environment related constitutional provisions, especially those pertaining to land-user rights, and the existence of a nationally standardized definition of forest that complies with international range. Additionally, the timely ratification of the Kyoto Protocol (KP), the establishment of a designated national authority (DNA) and a letter of approval by the DNA to the project developer were found to be enablers. Yet, defining land use, clarifying carbon ownership rights and bringing an inclusive benefit sharing mechanism for forest carbon are among the key instruments the country has yet to put in place to prove local readiness for such development opportunities.

The Humbo A/R-CDM also undertook voluntary assessments to obtain additional certification in the form of the Climate Community Biodiversity (CCB) certification, and was certified to be of gold standard for its premium. However, there were no benefits to the host community and project developer from the CCB gold standard certification. Such ambiguity could have been cleared from the onset. This implied whenever going for market and/or result based climate change mitigation, it is necessary to understand the provisions.

This study revealed that the Humbo native tree species-based A/R-CDM via FMNR forestry practices met the CDM twin objectives as specified in Article 12 of the KP in 1997, namely the double aims of achieving mitigations of GHG emissions and assisting developing countries inSD. Yet, more research is needed to understand all eligible A/R carbon pools sequestered at Humbo A/R-CDM site.

Key words: Afforestation/reforestation, clean development mechanism, carbon sequestration, farmer managed natural regeneration, sustainable development and climate change.

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ABBREVIATIONS AND ACRONYMS

ADLI	Agriculture Development Industrialization
AFR	African Forest Landscape
AGB	Above ground biomass
AP	Advisory Panel
AR	Assessment report
A/R	Afforestation/Reforestation
Arc GIS	Aeronautical reconnaissance coverage geographic information system
A/R-CDM	Afforestation/Reforestation Clean Development Mechanism
BAU	Business as usual
BEF	Biomass expansion factor
BGB	Below ground biomass
BoANRM	Bureau of Agriculture and Natural Resource Management
C	Carbon
CCBA	Climate, Community and Biodiversity Alliance
CCB	Climate Community Biodiversity
CDC	Centres for Disease Control
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CH_4	Methane
CMP	Meeting of the Parties
CI	Confidence Interval
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent

COP	Conference of Parities
CRGE	Climate-Resilient Green Economy
CSA	Climate-smart agriculture
CSE	Conservation Strategy of Ethiopia
DBH	Diameter at breast height
DOF	Department of Forests
DME	Digital measuring device
DNA	Designated National Authority
DOE	Designated operation entity
EB	Executive Board
EFAP	Ethiopian Forestry Action Plan
EPA	Environmental Protection Agency
ER	Emissions Reduction
ERPA	Emissions Reduction Purchase Agreement
ERU	Emission Reduction Unit
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FDG	Focus Group Discussion
FDRE	Federal Democratic Republic of Ethiopia
FFMP	Forest Fire Management Plan
FMNR	Forest Managed Natural Regeneration
FMP	Forest Management Plan
GDP	Gross domestic product.
GHG	Greenhouse Gas
GoE	Government of Ethiopia

GPG	Good practice guidance
GPS	Geographic position system
GS	Gold Standard
Gt	Gigatonne
GTP	Growth and transformation program
Ha	Hectare
HH	Household
H_2O	Water vapour
ID	Identification
IETA	International emission reduction purchase agreement
INDC	Intended nationally determined contributions
INGO	International Non-Government Organisation
ITCZ	Inter Tropical Convergence Zone
IPCC	Intergovernmental panel on climate change
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
JI	Joint Implementation
JJAS	June, July, August and September
KA	Kebele administration
KII	Key Informant Interview
km	kilometre(s)
KP	Kyoto Protocol
LDC	Least developed countries
LNO	Letter of no objection
LOA	Letter of approval

LULUCF	Land use land use change and forestry
M	Metre
MAM	March, April and May
MoEFCC	Ministry of environment, forestry and climate change
MoFED	Ministry of finance & economic development
MRV	Monitoring, reporting and verification
MSD	Millennium Sustainable Development
NAPA	National Adaptation Program of Action
Nbs	Nature-based Solutions
NDC	Nationally determined contributions
NASA	National Aeronautics and Space Administration
NMA	National Meteorological Agency
NMSA,	National Meteorological Services Agency
N_2O	Nitrous oxide
NOAA	National Oceanic and Atmospheric Administration
NPNSP	National Productive Safety Net Program
NTFP	Non-timber forest product
O_3	Ozone
O^C	Degree Celsius or degree centigrade
OCHA	Office for the Coordination of Humanitarian Affairs
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PDD	Project Design Document
PIN	Project idea note
PoA	Programmes of activities
PPM	Parts Per Million

PRA	Participatory rural appraisal
PRD	Project Re-Design Document
PRSP	Poverty Reduction Strategy Paper
RCP	Representative Concentration pathway
REDD+	Reducing Emissions from Deforestation and Forest Degradation. The “+” signifies the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
R-PP	Readiness Preparation Proposal
RCP	Representative Concentration Pathway
SD	Sustainable development
SDP	Sustainable Development Plan
SDPR	Sustainable Development and Poverty Reduction Program
SF_6	Sulphur hexafluoride
SNNPR	Southern Nations’, Nationalities and Peoples’ Region
SPSS	Statistical Package for the Social Sciences
SROI	Social Return on Investment
SSA	Sub-Saharan Africa
tCER	Temporary Certified Emission Reductions
tCO_2e	tone carbon dioxide equivalent
TIST	International Small Group Tree Planting Program
UNEP	Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nation Convection to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
USD	United States Dollar

USAID	United States Agency for International Development
VCS	Voluntary Carbon Standard
WB	World Bank
WCED	World Commission on Environment and Development
WRI	World Resources Institute
WVA	World Vision Australia
WVE	World Vision Ethiopia

CHAPTER 1: INTRODUCTION

This chapter describes the research topic and its scope, which include background, problem statement, aims/objectives and significance of the study.

1.1 Background

1.1.1 Climate change

Adverse impacts of anthropogenic climate change are recognized as global issues because of their effects on livelihoods and ecosystems. The science behind global warming is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. That human influence on the climate system was the dominant cause of global warming between 1951 and 2010 is extremely likely (95-100% probability) (IPCC, 2020)

Addressing climate change is therefore among the major political, economic, social and environmental concerns of political leaders of the present day, as well as the public at large (IPCC, 2007). Climate change is characterized by the spatially and temporally increased frequency, as well as increased intensity, of extreme weather events including storms, floods, droughts and irregular rainfalls (FAO, 2006), which all lead to substantial loss of life-supporting systems and resources. Accordingly, over the past 30 years, the world has lost more than 2.5 million people and almost 4 trillion USD because of natural disasters associated with the adverse effects of climate change. More than three-quarters of these deaths were in developing countries, and almost half of them were in low-income, least developed countries (LDCs). The root cause of climate change in our time are increases in greenhouse gas (GHG) emissions from the extensive and intensive use of fossil fuels and extensive deforestation for commercially oriented intensive agriculture in the developed nations since the time of industrial revolution in 1750. Further extensive deforestation for fuel and expansion of crop and livestock farming in developing nations has also made a substantial contribution to the increase of the level of GHG concentration in the atmosphere. Human activities (industrial growth and land use changes in pursuit of a better lifestyle) account for 95% of the driving factors behind climate change (IPCC, AR5) while the remaining 5% is attributed to natural phenomena such as volcanoes, ocean currents and the earth's tilt (eclipse).

The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to (1986–2005) is likely to be 0.3 °C to 1.7 °C under representative concentration pathway (RCP2.6), 1.1 °C to 2.6 °C under RCP4.5, 1.4 °C to 3.1 °C under RCP 6.0 and 2.6 °C to 4.8 °C under RCP 8.59 (IPCC, 2014). On the other hand, studies suggest that if this natural phenomenon had not happened; or the extreme low level of atmospheric GHG concentration as low as that of during the ice age where the CO_2e concentration was as low as below 180 ppm. Besides, the earth's annual average temperature would have been as low as -ve18 ºC and life would exist hardly at such a low temperature (NMA, 2001). Various reports revealed that increased GHG in the atmosphere reduces the amount of solar radiation that is supposed to reach to the earth's surface and leads to regional/local cooling (global/local dimming); and this phenomena is known to cause drought on one part of the planet and strong rainfall and storms on the other part of the planet.

Such important functions of the atmosphere are impacted by GHG and are being threatened by the rapidly increasing concentration of GHGs in the atmosphere because of extensive use of fossil fuel resources. Among others (FAO, 2011) reported that about 7 billion tons of carbon are released annually into the atmosphere from burning of fossil fuels and deforestation. By 2050, the average annual global CO_2 is projected to be above 600 ppm, surface air temperature is predicted to increase between 1.1 º C and 6.4 º C, and the sea level is predicted to rise by between 18 cm and 59 cm (IPCC, 2007). These predicted climate change impacts are attributed to the accumulation of GHGs in the atmosphere resulting from increased level of intensive fossil fuel utilization.

Several studies have demonstrated that changes in the earth's climate affect developing countries like Ethiopia more severely because the largest share of their economy and livelihoods are based on rain-fed agricultural systems and land resources (water, soil and forest) that are less flexible in coping with such drastic changes (Stern, 2007). Other economic development sectors such as transport, energy, and manufacturing are also hampered by adverse impacts of climate change.

One of many inclusive efforts towards addressing the global climate change agenda was the development of the Kyoto Protocol (KP) in 1997; it set a framework for intergovernmental efforts to deal with GHG emission reduction mechanisms for climate change mitigation. The Protocol was adopted at the third session of the Conference of the Parties (COP3), and entered into force in 2005 in accordance with Article 23. The KP introduced legally-binding targets for the reduction of GHGs emissions from the countries listed in Annex-I to the Convention (this is the group of industrially developed countries, which historically have emitted large amounts of GHG since the 1750s and are referred to as “Annex-I countries”). The total cut in GHG emissions for Annex-I countries consists of a reduction by 5.2% from 1990 levels in the first commitment period, 2008-2012. Only Parties to the Convention that are also Parties to the Protocol (i.e. countries that have ratified it) were bound by the Protocol’s commitments (UNFCCC, 1997). During the first commitment period, 192 countries including Ethiopia ratified the Protocol excepting Afghanistan, Sudan, the U.S.A., and Canada who later withdrew.

Ethiopia, a country located at the Horn of Africa between 3 and 15˚ N and 33 and 48˚ E with a projected population growth exceeding 120 million by 2030 (FDRE, CRGE, 2011) is highly vulnerable to adverse effects of climate change impacts.

The 1973-74 and 1984-85 famines in Ethiopia caused millions of deaths and made millions more destitute (NMA, 2001). The drought disaster risk occurred mainly in farming and pastoral communities in the dry lands of Ethiopia, where low rainfall is reported. As a result, more than 6 million people needed emergency food aid and an estimated 7.5 million were receiving government aid for public work as part of the National Productive Safety Net Program (NPSP).

Because of the expanded droughts and floods across the East African region, about 23 million people were also affected during the second cycle of the widespread drought in 2012. In the years, 2015/16 Ethiopia had another drought while Kenya faced flood disasters. These continuous climate risk shocks experienced by East African countries (Ethiopia and East Kenya) were aggravated by the adverse effects of land resource degradation due to temporally and spatially increased deforestation in pursuit of various economic outcomes. Because of a combined effect of both climate change and anthropogenic land use changes, Ethiopia remained exposed to both slow and fast onset disaster events (droughts and floods) which are very frequent in the Sahel and Horn of Africa. The East African droughts have been known to be highly associated with El Nino events. Accordingly, in 2011 the situation worsened when climate change induced weather conditions over the Pacific, including an unusually strong La Niña, interrupted seasonal rains for two consecutive seasons in the Horn of Africa (OCHA, 2011). Particularly, in 2011 the rains severely failed in Ethiopia and the precipitation rate during the expected rainy season from April to June was less than 30 per cent of the average rainfall for 1995 - 2010 (OCHA, 2011).

1.1.2 Forests and climate change

Forests naturally sequester CO_2 from the atmosphere through photosynthesis and store C in soils and plant parts as above and below ground plant biomass. Climate change mitigation deals with reducing the causes of climate change (i.e. reducing GHG emissions), while adaptation deals with reducing the impacts/consequences (reducing droughts effects by providing sustainable water supplies such as irrigation).

Forests are both sources and sinks of carbon. Global forest vegetation stores 283 Gt of carbon in its biomass, 38Gt in dead wood, and 317 Gt in the soil (top 30 cm) and litter. The total carbon content of forest ecosystem has been estimated at 638 Gt for 2005, which is more than the amount of carbon in the entire atmosphere (IPCC, 2007). However, of the

2.6 billion tons of carbon that forests annually absorb, 60 per cent is emitted back into the atmosphere through deforestation, which accounts for 17 per cent of global GHG emission (Pearson et al., 2005).

The deforestation of tropical forests emitted 1.5 Gt C year^{1} while 8.4 Gt C year^{1} comes from the use of fossil fuels (Raupach et al., 2007; Canadell et al., 2007). According to Ralph and Lucas (2006) forest environmental conditions are affected by climate change, but investments in forest development for various purposes, including environmental quality improvement, can be used as part of as climate change mitigation strategy.

1.1.3 Forest coverage and the extent of degradation

One of the defining events of the past century was the astonishingly rapid decline in the coverage of tropical forests across the globe. An estimated 350 million hectares have been deforested, and another 500 million hectares of secondary and primary tropical forests have been degraded (ITTO, 2002).

In Ethiopia, the forest cover reported in the late 1960s was 16% of the land mass (EPA, 2003). During 1973 to 1976, forest cover was 6.08%, while during 1986–1990, it was estimated to be 4.75%. In 2000, it was reduced to 2.36% (Reusing, 2000). This rapid decrease in the country's forest cover at the rate of 13.6% during the last 40 years is attributed mainly to conversion of forestlands to small and large scale farmlands to meet the increased demand for food security and exports.

According to Tamirat (1993), the annual rate of Ethiopia's deforestation estimated at 88,000 ha year^{1}. Again, the EPA (1997) estimated that the annual deforestation in Ethiopia, mainly for expansion of rain fed agriculture varies from 80,000 to 200,000 ha per annum. Recent government reports show a decline in deforestation rates from 140,000 ha to 92,000 ha year^{1}.

According to MoEFCC (2016), the country's forest cover reached 15%. Debates are being had as to whether that the increase should be attributed to the adoption of a broader national definition of "forest" when the country's forest policy was declared, as opposed to the increase being a result of actual forest development efforts. However, no study provides evidence that either supports or refutes either side.

1.1.4 Native forest cover loses in Ethiopia and its consequences

Rapid decline of indigenous tree species have occurred such as *Podocarpus falciformis (Thunb.) Mirb., Juniperus procera Endl., Cordia africana Lam., Millettia ferruginea (Hochst.) Baker, Prunus africana (Hook.f.) Kalka and Croton macrostachyus (Del.).* They have been recently replaced by fast growing exotic species such as *eucalyptus, pines* and *cypress* (Legesse, 1995, Pohjonen and Pukkala, 1990). Although *Eucalyptus* plantations are thought to have adverse impacts on the environment, small scale farming communities are doing their best to expand *eucalyptus* woodlots in the Ethiopian degraded mountain landscape for their high economic return. These double-edged outcomes of eucalyptus plantations call for improving forest management practices that can harmonize the economic and environmental benefits of eucalyptus plantation/woodlots. One such improved eucalyptus plantation management technique is establishing a mixed stand where *Eucalyptus* is planted in a mix with slow growing valuable indigenous tree species such as *junipers* and *podocarpus*. Such type of mixed eucalyptus woodlots naturally established in mountain slopes that were originally covered by these native tree species.

Native tree species mainly existing under the natural forest category are ecologically more valuable than exotics for the conservation of native flora and fauna as well as for the conservation of water (Evans, 1992; Leggesse, 2007). These tree species are reported as less susceptible to serious damage from diseases, pests and climatic factors (Khan, 1987; Leggesse, 1995).

In Ethiopia, native forest degradation is frequently associated with depletion of water resources as deforestation increases surface run-off and reduces the amount of rainfall that infiltrates the soil and percolates into the ground water aquifers. This reduced level of water infiltration and storage affects the availability of water bodies (EFAP, 1994) that sustain the energy sector and food security. Water availability is especially critical to Ethiopia since, besides domestic use, urban energy supply and food consumption are dependent on hydroelectric and irrigation dams.

1.1.5 Interventions for restoring forest

There were three major responses against forest degradation. One was to expand networks of protected areas to help save the remaining biodiversity. In this response, the focus has largely been on making the selection of candidate sites as representative and comprehensive as possible. A second was to improve agricultural productivity on forest-abandoned lands in order to improve the livelihoods of communities living in these areas. The third approach has been to undertake some reforestation/afforestation. Much of the third type has been done using industrial plantations involving a limited number of fast growing exotic species from a remarkably small number of genera (particularly *Pinus, Eucalyptus, and Acacia*). Many of these reforestation plantations have been productive and generated goods such as pulpwood, timbers, medicines, and foods to the people living in these areas.

According to Evans (1992) if the choice of tree species lies between exotic and native species of comparable growth and quality, the native species is to be preferred, while, in contrast, exotic species are seen as covering the landscape and replacing the native species. Azene et al. (1993) also reported on the dangers of strong promotion of these exotic species to the rich indigenous flora of Ethiopia for reforestation purposes through extension programmes. However, the attractive short-term merits of exotic species expansion made its adverse environmental effects a necessary evil. Harmonizing the benefits of the exotic and native tree species through improved management practices such as mixed stand management by age and species is hardly practiced by the Ethiopian forest extension programme.

1.1.6 Forest regeneration

Among others, one way of increasing forest cover is to protect and manage the large areas of secondary or regrown forests since not all degraded lands are completely deforested. They vary in forest coverage, degree of fragmentation, and the extent to which biodiversity has been lost. They also vary in their capacity to recover unaided if further disturbances are prevented. Self-repair can be rapid at sites where forest clearance has occurred relatively recently, and some residual trees, seedling banks, and soil seed stores are present in the landscape. Although it is not impossible to determine the identities of missing plant species, the most common absentees are the large-fruited plant species because of the absence of appropriate dispersal agents. So, forest regeneration is one of options to restore. The same technique could be used to improve biodiversity by adding species that are otherwise unable to regenerate.

Nevertheless, the recovery is difficult where the system has crossed an ecological threshold and reached a new steady state condition. This might be the case when degradation led to topsoil loss and a reduction in soil fertility, complicating recolonization of these sites for many of the original species. Another threshold is grass occupation of sites.

Most deliberate efforts to overcome degradation involve tree planting. However, even traditional forms of timber plantation can be risky operations, and, where species selection or early stand management are inappropriate, plantations can fail. Planting to generate ecological services as well as goods is even more difficult, because trade-offs must be made between the productivity of most desired goods like timber and provision of ecological services such as biodiversity and the techniques to achieve these simultaneous goals are still being developed (David et al., 2005).

1.1.7 Ethiopia's position against climate change and Humbo A/R-CDM genesis

Ethiopia is one of the countries that ratified KP in 2005 and hence agreed to implement afforestation/reforestation Clean Development Mechanism (A/R-CDM)from 2006 for its twin objectives, namely carbon sequestration as off-set to Annex-I countries, as well as CDM associated SD benefits. The country has also been reported as one of the showcases in formulating a climate resilient green economy (CRGE) strategy to reach zero net GHG emission by 2030, and prioritizing increased forest area coverage as well as expansion of renewable energy as sectors of development worthy of special attention. The objective of this study was to assess the Humbo native tree species based A/R-CDM project in terms of: change in sequestered carbon, attractiveness of FMNR forestry practices and the contribution of A/R-CDM to community level SD. The study also set out to assess the policy aspects of climate change and to highlight policy recommendations as well as future research directions.

1.2 Statement of the problem

The daunting tasks of responding to climate change and ensuring SD are high on the political agenda among world leaders. From the onset, the clean development mechanisms (CDM) outlined in Article 12 of the Kyoto Protocol (KP), state that CDM activities should contribute to SD in the host country while reducing greenhouse gas (GHG) emission.

The validation and verification processes for CDM projects and the credits they produce rely heavily on the respective country DNA's approval of project compliance with host country definitions of sustainability. Yet, it appears that in some cases host country definitions of sustainability and host-country institutional arrangements allow project implementers to give little attention towards gathering socio-economic and environmental impact data beyond temporary employment figures and payments from credit markets.

Many scholars have criticized CDM for failing to deliver on one of its two mandates under Article 12 of KP, which is achieving SD in developing countries. Moreover, no country-specific empirical evidence as to whether the few registered A/R-CDM projects are delivering GHG mitigation as projected in the Project Design Document (PDD) is yet to emerge. In fact, one of the concerns about the performance of the CDM under international negotiations for the post Kyoto regime (2012) has been with its weak capacity to deliver on its environmental and SD objectives in countries where it is implemented, though the global political direction is still heading towards market based mechanisms.

As A/R based carbon sequestration mechanisms were the only activities recognized along the first commitment period within the LULUCF classification, registered A/R-CDM should be assessed for their actual returns to, and impacts on, local livelihoods (Arthur & Jon, 2010). Scholars have been questioning whether A/R-CDM is living up to its potential. If not, what changes need to be made in the framework in order to produce GHG mitigation and sustainable socio-economic and environment results when additional activities such as REDD+, agricultural and soil carbon sinks are part of climate change mitigation options?

In order to fill this knowledge gap, and to understand the actual contribution of A/R-CDM activities, this study assessed the performance of the only registered Ethiopian native tree species based A/R-CDM as to whether the stipulated socio-economic and environment outcomes as well as GHG mitigation had been achieved, or what constraints have hindered those outcomes.

Besides, A/R-CDM methodology allows application of appropriate forestry practices despite its pre-finance absence. In the case of the only Ethiopian A/R-CDM initiative, a forestry practice called FMNR was employed. FMNR as a practice has been praised for a number of merits such as low cost, scalability by farmers' level, its ability to bring back native tree species and biodiversity, especially when compared to the practice of plantation (Douglas et al., 2010). Yet, this technique had never been scientific assessed in relation to A/R-CDM performance in terms of forestry cost, project leakage and biodiversity.

Despite the first KP commitment period ending as of the COP21 agreement, there is a major absence of research conducted to find out whether A/R-CDM met the stipulated twin objectives as LULUCF and forestry in particular remained priority sectors for Ethiopia and even developed countries in the Paris Agreement. The absence of pre-financing for CDM requires assessing new forestry practices other than plantations which makes this study indispensable. Moreover, effectively tackling climate change is predicated on the availability of field-based evidence, which, at least in Ethiopia, is lacking, both for policy makers and potential private investors.

Nevertheless, Parties to the climate convention recognized the importance of the conservation and enhancement of forests as appropriate sinks and reservoirs of GHGs. What was concerning, however, was whether the implementation of LULUCF during the first commitment period delivered on its environmental and SD objectives in countries where A/R-CDM was implemented. Besides, nothing has been reported regarding the GHG mitigation performance of A/R-CDM base on Ethiopian native tree species. This research aimed at analysing the change in sequestrated carbon in terms of AGB and BGB carbon pools after employing FMNR forestry practices; and the contribution of native tree species-based A/R CDM to community level SD indicators. Another intention was to address the knowledge gaps regarding the impact of native tree species-based A/R-CDM by taking the only Ethiopian A/R-CDM as a case study.

1.3 Objectives of the study

General objective (aim) of the study was to evaluate the Ethiopian Humbo Afforestation/Reforestation Clean Development Mechanism (A/R-CDM) project of farmer managed natural regeneration (FMNR) practices in terms of the contribution of native tree species to changes in the carbon pools and sustainable development (SD) over a 10-year period (2006-2016).

The specific objectives:

This general objective was pursued through the following specific objectives:

1. Quantify the changes in above-ground biomass (AGB) and below-ground biomass (BGB) carbon pools over the 10-year period.
2. Assess the attractiveness of the FMNR forestry practices of the A/R-CDM project.

3. Examine the contribution of the A/R-CDM project to the set community level sustainable development indicators of Ethiopia.
4. Assess the contribution to policy perspectives of using native tree species in the A/R-CDM project towards climate change mitigation and sustainable development.

1.4 Significance of the study

The carbon sequestration initiative developers behind the project, investors interested in carbon sequestration using Ethiopian native tree species, carbon credit buyers, the Ethiopian DNA, the CDM executive board (EB) and/or market-based climate change mitigation organs would learn whether A/R-CDM generates the expected reduction in GHG and community level SD indicators on the ground.

The knowledge generated from FMNR forestry practice could make a better case for community managed reforestation as a better alternative to plantation forestry, as plantation forestry entails higher costs, risks of seedlings failing to survive, and emission leakage. The knowledge gain could increase the contribution of FMNR towards meeting the country's ambitious pledge of restoring 15 million ha land by 2030 within a constrained global carbon finance scenario.

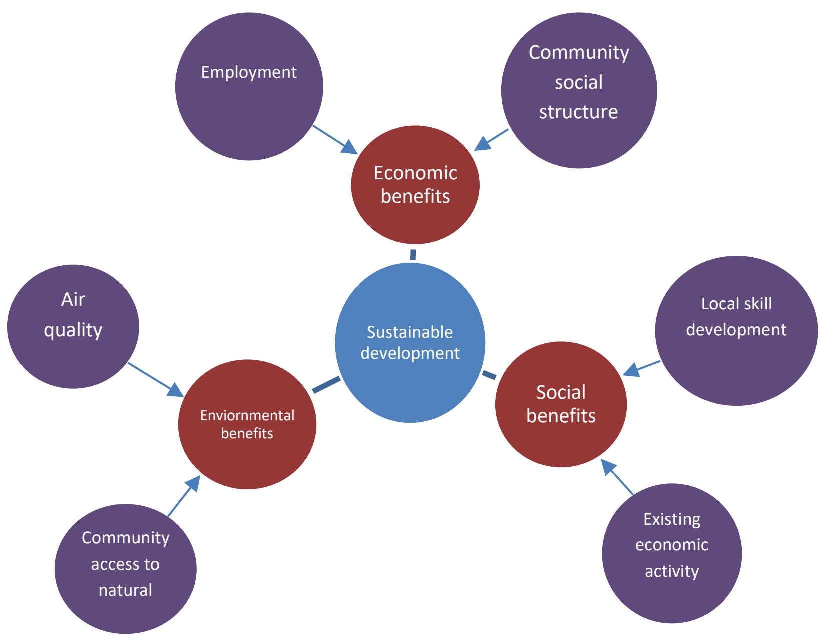
The findings regarding GHG reduction from native tree species-based A/R-CDM could contribute towards the realization of Ethiopia's CRGE and intended nationally determined contribution (INDC). The promotion of native tree species could benefit the degraded land-mass of the country. Policy formulators and also implementers would also pick up on the evidence and act accordingly.

1.5 Scope of the study

This paper's case study of interest is the implementation of A/R-CDM based on Ethiopia-native tree species in the Humbo district, Wolayita Administrative Zone, SNNPRS, Ethiopia, since 2006. The global concept behind the A/R-CDM use was to optimize GHG ER efforts through the most cost-effective solutions, where possible through the use of "better" technologies and even through the creation of a whole new market in terms CERs or tCERs while contributing towards sustainable development. One of the key issues discussed by the signatories at the COP meetings has been the effectiveness of the CDM as a tool in addressing the SD of communities at local level (Rusnok, 2004).

In the methodological literature there seems to be a consensus that SD encompasses at least three dimensions: the social, the economic and the environmental (Kolshus et al., 2001; Najam et al., 2003; Olhoff et al., 2004). When it comes to practical and concrete assessments of sustainability contributions of CDM projects there is no single, authoritative and universally accepted approach or methodology applicable to any CDM project regardless of the project's type and location. Each country's DNAs were delegated as authority to determine the CDM projects' contribution to SD. Actual definitions vary according to what host countries consider as their developmental priorities. Therefore, this research carefully examined those gaps.

Figure 1.1 Conceptual framework showing the contribution of A/R CDM to enhancing sustainable development



Specifically, this study considered the changes of two carbon pools of A/R-CDM, i.e above ground and below ground carbon pools in terms of carbon sequestration; attractiveness of FMNR forestry practices; the contribution of native tree species-based A/R-CDM to local level SD and the implemented mechanism policy aspects (Figure 1.1).

1.6 Outline of the study

The thesis is made up of eight chapters: **Chapter one** has introduced the study background and the statement of the problem, highlighting the thesis focus through its objectives, research questions, and the significance and the scope of the study. It also provides a background description of the study area. **Chapter two** gives a review of both theoretical and empirical literature on the issue of native tree species, issues of climate change, genesis of CDM and their links to forests, attractiveness of FMNR forestry practice, A/R-CDM's contribution to community-level SD and climate change mitigation. **Chapter three** provides details on research design, data collection strategies, and procedures. It also outlines the data analysis techniques employed in generating the research results. **Chapters four, five, six and seven** present the research findings. **Chapter eight** provides the thesis conclusions and recommendations. Suggestions are also provided for future research towards further enriching the body of knowledge regarding native tree species-based A/R-CDM's role in GHG mitigation and its contribution to community level SD.

CHAPTER 2: LITERATURE REVIEW

2.1 Climate change and international responses

The UNFCCC defines climate change in Article 1 as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Climate change caused by global warming is due to an increase in GHGs in the atmosphere, especially CO_2. Other scholars put climate change as the warming of the earth surface; which is caused by a layer of GHGs (water vapour, carbon dioxide, methane, nitrous oxide and fluorinated gases) which absorb heat and act as a blanket increasing the temperature on the earth's surface. Scientists overwhelmingly agree that pollution is the main cause of climate change.

GHGs are produced directly by human activities (such as deforestation, fossil fuel use in cars and factories); or directly by natural activities (such as volcanoes, ocean currents, the earth's tilt). Another sources of GHGs include energy supply (use of fossil fuels to generate electricity), industries (use of fossil fuels burned for energy), LULUCF (deforestation, land clearing to agriculture, and fires or decay of peat soils), agriculture (management of agricultural soils, livestock, and biomass burning), transport (petroleum-based fuels, largely gasoline and diesel), and waste (from landfills, incinerators). All human activities that induce climate change account for 95%of such change (IPCC, AR5) and the remaining portion is attributed to natural phenomena such as volcanoes, ocean currents and the earth's tilt.

Global climate change is recognized as one of the most significant environmental challenges in the world. The intergovernmental panel on climate change (IPCC) has indicated that global warming due to climate change could lead to many environmental threats, i.e. droughts, floods, sea level rise, decline in crops and animal production, and health hazards, among others (IPCC, 2007). The successive IPCC reports have described the worsening of climate change. As a result, after extensive negotiations especially in 2009, almost every part of the world expected that a deal would be sealed after the climate change negotiations at COP15 held in Copenhagen, Denmark. Unfortunately there was no such deal. The Parties to climate change in pursuit of the objective of the Convention and guided by its principles, including the principle of equity, and common but differentiated responsibilities and respective capabilities. The principle is in the light of different national circumstances, recognized the need for an effective and progressive response to the urgent threat of climate change based on the best available scientific knowledge. The Parties also recognized the specific needs and special circumstances of developing countries that are particularly vulnerable to the adverse effects of climate change, and took full account of the specific needs and special situations of the least developed countries with regard to funding and transfer of technology (CoP21).

One of the decisions of the Convention against climate change was that each country was to develop INDC. The Paris Accord also invited the IPCC to provide a special report in 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels and related global GHG emission pathways.

The Parties also urged those Parties whose INDC pursuant to decision 1/CP.20 contains a period up to 2025 to communicate by 2020 a new nationally determined contribution (NDC) and to do so every five years thereafter, pursuant to Article 4, paragraph 9, of the Agreement. These indicated that mitigation is a priority as climate change is a common concern of humankind.

The IPCC's AR1 was completed in 1990; the AR2 in 1995; the AR3 in 2001; the AR4 in 2007; the AR5 in 2014; and the AR5 was produced in 2015. The 4th IPCC report revealed that atmospheric concentration of CO_2 has increased from the pre-industrial value of 278 ppm to 379 ppm in 2005 and the average global temperature has risen by 0.74 °C. According to Earth's Bulletin (2016) earth's atmosphere reached 407.3 ppm of CO_2 in 2016, as measured at auna Loa, and stressed that various measures indicate that serious global warming is coming much sooner than expected. CO_2 as a GHG has risen more than 40 per cent since the beginning of the industrial age due to the burning of fossil fuels (coal, oil, and gas), the cutting down and burning of forests and agricultural interventions. It has been at least 800,000 years, and possibly 3-5 million years since earth last saw such high concentrations of this heat-trapping GHG (Deborah, 2013).

The (IPCC, AR5) finds beyond reasonable doubt that the earth's climate is warming. Since the 1950s, the rate of global warming has been unprecedented compared to previous decades and millennia. The IPCC AR5 report presents strong evidence that warming over land across Africa has increased over the last 50-100 years. Surface temperatures have already increased by 0.5-2 °C over the past hundred years. Data from 1950 onwards suggests that climate change has changed the magnitude and frequency of some extreme weather events in Africa already.

2.2 Greenhouse gases and its manifestation

GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infra-red radiation emitted by the earth's surface, the atmosphere, and clouds. This property causes the GHG effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), Sulphur hexafluoride (SF_6) and Ozone (O_3) are the primary GHGs in the earth's atmosphere (IPCC, 2012). The natural concentration of atmospheric carbon dioxide gas was not problematic, but the anthropogenic increase during the industrial era affected the balance and contributed to climate change. The prevailing development in the world has clear and present danger to all humankind and the ecosystem and the world is currently at a crossroad demanding far reaching efforts beyond either sustainable development or growth with a 'business as usual' (BAC) scenario. Sustainable development and climate change are two important and interlinked challenges facing humankind in the 21st century (IPCC, 2007).

GHGs absorb heat radiated from the earth's surface and in the past have been responsible for maintaining the temperature on the earth's surface. However, over the 20th century, increasing concentration of GHGs in the atmosphere has led to unprecedented changes in the earth's climate; since the 1950s, the global surface temperature has increased at an average of 0.1 °C per decade, making the 1990s the warmest decade and the year 1998 reported as the warmest year in the instrumental record. On January 20, 2016, scientists from NASA and the National Oceanic and Atmospheric Administration (NOAA) released their analyses of surface temperatures for the previous year and reported that globally averaged temperatures from January through December 2015 were 0.87 °C above the norm (defined as a 1951–1980 base period). So, for the planet, 2016 had the warmest temperatures since 1880, when consistent record-keeping began (NASA, 2016). Evidences reveal that there is a 10% decrease in snow cover since the 1960s and that there has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century.

The substantial increase in the concentration of GHGs in the atmosphere has the possibility of causing severe climatic changes such as rise in sea levels, frequent floods and landslides, health impacts (e.g. epidemics and spread of infectious diseases), loss to infrastructure, increase in soil erosion, pollution, increased desertification, and so on as reported by IPCC (2001). Apart from widespread loss of life, such unparalleled changes in climate threaten economic growth, particularly that of developing countries which may not have sufficient technical and financial capacity to adjust to these shocks., Indeed, climate change presents an extraordinary challenge to the global society and hence needs to be addressed as soon as possible.

Among all GHGs, CO_2, CH_4 and N_2O are considered as priority gases in the Ethiopian Green Economy Strategy (INDI, 2015). The same reportx stated that Ethiopia's per capita GHG emissions amounted to 1.8 tCO2ex, indicating its insignificant when compared to total global emissions. If Ethiopia's CRGE strategy is fully implemented, it would reduce per capita emissions to 1.1 tCO2e by 2030.

2.3 Contribution of forests to reduce GHG

Globally GHG emissions from deforestation and forest degradation are reported to account for 15% of total emissions. There is therefore a need to increase tree-covered landscapes to increase forest biomass productivity for enhanced carbon sequestration before the end of 2030 in the forestry sector. In Ethiopia in 2010 annual emission from forestry activities was estimated at 37% of the country's total emissions, which is almost 55 Mt CO2e (CRGE, 2010).

One method of climate change mitigation is market mechanism. Following the definition of the Kyoto target of 5.2% emission reduction for industrialized countries in 1997, it remains to be decided how to incorporate forests into the CDM in the first commitment period (2008-2012). On the operational side, a major concern has been the complexity of methodological approaches that are hardly practiced by developing nations. Such aspects of complex methodology include the topic of permanence – the potential threat that carbon effects accumulated over time are reversed, e.g. by fire. On the political side, negotiators were worried that "easy to earn" carbon credit forests would flood the markets and out-compete other project categories. These hurdles have overcome with the clarification that only A/R-CDM eligible land defined for the first commitment period. The definition of key methodological aspects and lengthy measuring, reporting and verification (MRV) procedures like baseline elaboration and PDD documents, approved methodologies, monitoring and the introduction of temporary and long-term carbon credits (tCER and lCER) were trusted to overcome the ambiguity.

2.4 Forestry under clean development mechanism

It is reported that 45% of the earth's terrestrial carbon is stored in forests. In 2005, forests covered four billion ha of the earth's surface; of this, African forests covered 635 million ha and accounted for around 16% of the world's forests (Pearson et al., 2005).

Growing evidence indicates that increased levels of CO_2 in the atmosphere are related to global warming (Houghton, 1994) and the risks of welfare losses associated with an increase in global temperatures have prompted several countries to consider options for offsetting current CO_2 emissions (UNCED, 1992). One such option takes the form of a tradable permits programme where units of carbon sequestered from the atmosphere in one location can be transacted to offset emissions in other locations. Forestry activities are among the initiatives that have received attention for their cost-effective CO_2 abatement, especially where rapid rates of tree growth are possible with high environmental benefits.

Following the definition of the Kyoto target of 5.2% emission reduction for the industrialized countries in 1997, it remained to be decided how to incorporate forests to the CDM in the first commitment period (2008-2012). Besides the definition of key methodological aspects such as baseline elaboration and monitoring (through PDD documents and approved methodologies) and the introduction of temporary and long-term carbon credits, tCER and lCER came up as way out in recognizing forests under CDM.

As a result, the UNFCCC has recognized the importance of the LULUCF sector for stabilizing concentrations of GHG in the atmosphere, and has included A/R as one of the 15 sectors that are eligible to generate emission reductions, offset credits and contribute to SD under the CDM. This might be due to deforestation and forest degradation accounting for 15% of GHG emissions. Additionally, tree species improvement, which can increase biomass productivity and carbon sequestration, is reported as a necessity in the forestry sector before the end of 2030.

After KP came up in the year 2006, the procedures for A/R-CDM projects have become operational. The first such registered project by the UNFCCC worldwide (10 November 2006) was the Guangxi Watershed Management project in the Pearl River Basin, China. This initiative comprised of reforestation of about 4,000 ha with mostly native species, and was supported by the World Bank's BioCarbon Fund.

After the 2009 Copenhagen climate change negotiations, Ethiopia studied the relative contributions of emission sources in the country. In 2010 Ethiopia estimated its annual emission from forestry activities alone to constitute about 37% of the country's total emissions, far higher than the relative contribution of forestry activities globally, which at 55 Mt CO2e, still contributes only 17% of total emissions (CRGE, 2010).

Between 2005, when the first CDM credits were issued, and by the end of 2012, the CDM is expected to generate 1 billion CERs. As of October 2012, there were 4,700 projects registered and another 247 were seeking registration. As of September 2017 the number of registered CDM projects reached 7,784 and the CERs and tCERs they generated amounted to 1.86 billion tCO_2e. In terms of PoAs, about 300 PoAs were registered and 10 million tCO_2e issued. Both CDM and PoAs attracted more than USD 3 billion. In terms of geographic distribution, both projects and PoAs were located across 125 countries with the majority being in China (Carbon Market Watch, 2013).

2.5 Kyoto Protocol and CDM

The KP was established by the international community in 1997 to tackle the problem of climate change by formalizing commitments for different groups of countries to reduce their emissions of GHGs. The ultimate objective of the Protocol is "to achieve stabilization of atmospheric concentrations of GHGs at levels that would prevent dangerous anthropogenic (human-induced) interference with the climate system" (UNFCCC, 2003). Despite the KP's emission targets being "legally binding" because of the written obligation, practical enforcement was limited to 'name and shame,' as illustrated by the Canadian withdrawal and the lack of credible sanctions. Furthermore, the seemingly binding nature of the KP may have led to a decreased coverage as illustrated by the non-ratification by the USA - or the non-participation of Japan in the CP2, for instance.

Nevertheless, one of many global climate change mitigation instruments; such as the KP has introduced flexible mechanisms that encourage carbon trading and promote forestry activities. However, use of A/R activities as a means of achieving reduction in carbon emissions has been a controversial issue and is heavily debated (Grace et al., 2003). While political and technical issues have dominated such debates, it is felt that analysis of the potential of such forestry activities to support local livelihoods could make an opportune contribution to the clarity of this debate (Smith and Scherr, 2002).

Yet, the CDM under the KP is a first of its kind carbon market instrument that advanced following a 'learning by doing' pattern. According to Fennhan (2009), CDM has spurred the development of 4,586 projects in 76 developing countries. The author indicated that these projects are expected to reduce global GHG emissions by up to 2.91 Gt CO_2e by 2012. Emily et al.'s (2009) analysis of the projects registered up to February 2009 found that they were unevenly distributed across regions in Asia and Latin America, with each region hosting 67% and 28% of the projects, respectively. Sub-Saharan Africa (SSA) hosts only 28 registered projects as of February 2009, accounting for 2.97% of registered CER volume up to 2012. Brazil, Mexico, India, China, South Africa and Israel have benefited the most within their respective geographical regions. For Ethiopia, the Humbo A/R CDM project is the only registered project under the CDM.

At the COP20 climate conference in Lima in late 2014, the decision made indicated that each of the 195 states would have to set out their roadmap to limit the effects of global warming to less than 2 °C by 2100. Before the COP21 conference, 188 countries committed to reducing their GHG emissions. On other hand, the least developed countries were asked to play their part instead of only expecting advanced countries alone to do so.

Hence, many forested countries, including those which are among the least developed economically, have planned to stem – or even reverse – deforestation trends. Ethiopia plans to restore 15 million ha by 2030 (Reij and Dennis, 2016) as part of AFR100 commitment.

As part of global communities, many of the countries agreed to set mitigation objectives (i.e. the reduction of GHG emissions) at the economic level. Thus, all sectors – energy, industrial processes, agriculture, waste as well as forests and land use – were considered by many countries. All developed and G20 countries have chosen commitment in many of these areas.

In the COP20 and 21 conferences, developed countries have shouldered their responsibilities and reported that they maintained 'leadership, particularly the European Union with at least 40% reduction by 2030 compared to 1990, and the United States with 26-28% reduction by 2025 compared to 2005" (COP, 21).

Important to the process is transparency in measuring progress and achievement in hitting GHG emission targets. To monitor emission reductions, a reference baseline is necessary. Hence, the baseline setting identified will have far-reaching consequences for the measurement of the emission reductions. Most importantly, if the baseline is not set conservatively, excess CERs get reported and the Kyoto abatement targets remain unmet. A baseline is expected to model the situation likely to take place if the project activity is not undertaken under the CDM. This scenario can of course be equivalent to the historical situation if no change is expected. As the baseline scenario is hypothetical, it implies a certain percentage of uncertainty. Since the baseline directly affects the numerical measurement of achieved emission reductions (ie, the number of carbon certifications), a high-quality baseline considered a prerequisite for maintaining the integrity of the KP. However, developing and (initially) applying a more refined baseline methodology is considered more costly.

2.6 Carbon sequestration

Carbon sequestration is the process of transferring and securing storage of atmospheric CO_2 into other long-lived carbon (C) pools that would otherwise be emitted or remain in the atmosphere (Lal, 2008). This scholar further described carbon sequestration as the transfer of atmospheric CO_2 into other long-lived global pools including oceanic, pedologic, biotic and geological strata to reduce the net rate of increase in atmospheric CO_2. Reducing CO_2 concentration in the atmosphere is an important step in mitigating climate change. Sequestering CO_2 from point of source or the atmosphere through natural techniques is one strategy to mitigate climate change (Schrag, 2007).

Carbon stock refers to the mass of carbon contained in a carbon pool. Biomass density refers to changes in time of vegetation biomass per unit area and can be used as an essential climate variable, because it is a direct measure of sequestration or release of carbon between terrestrial ecosystems and the atmosphere. Therefore, when using the term ‘biomass’ one refers to the vegetation biomass density, that is, mass per unit area of live or dead plant material. Carbon is a term used for the C stored in terrestrial ecosystems, as living or dead plant biomass (above ground and belowground) in the soil.

$$C = (0.50)*biomass$$

This indicates that about 50% of plant biomass consists of carbon.

Improved methods of land use (especially forests) offer significant potential for carbon sequestration (IPCC, 2001). Biotic sequestration, using managed intervention of higher plants and micro-organisms in removing CO_2 from the atmosphere is reported to be cost-effective. Such a strategy should be considered as it would entail sequestering almost all anthropogenically generated CO_2 through safe, environmentally acceptable and stable techniques with low risks of leakage (Lal, 2008). Terrestrial C sequestration is often termed as a win-win or no-regrets strategy (Lal et al. 2003). Terrestrial ecosystems constitute a major C sink owing to photosynthesis and storage of CO_2 in live and dead organic matter (Lal, 2008). Likewise, Jindal et al. (2008) reported that carbon sequestration through forestry and agroforestry could help in mitigating global warming.

In 2004/5, WVE and WVA selected forestry-based carbon sequestration as a potential means to stimulate community development while engaging in environmental restoration. After two years of consultation, planning and negotiations, the Humbo community-based assisted natural regeneration project began implementation as an A/R CDM - Ethiopian’s first carbon sequestration initiative (Douglas et al., 2011).

2.7 Role of native tree species based A/R in carbon sequestration

Reforestation in the tropics has received considerable attention in the last decade due to increased interest in expanding markets for timber as well as for environmental services such as carbon storage and biodiversity conservation (Chazdon, 2008). Yet, it has been dominated by mono-specific plantations because of their apparent economic and managerial advantages, such as the concentration of resources dedicated to the growth of a desired species, the simplicity of seedling production and stand management, and a uniform harvest with regular rotation cycles (Evans and Turnbull, 2004). Likewise, FAO (2001) reported that reforestation efforts have predominantly used exotic species plantations, such as *Acacia, Eucalyptus, Pinus, and Tectona*).

In Central America, the use of native tree species was previously limited to rural development and domestic wood production. In recent times, that use has expanded to include other purposes such as industrial wood production and commercial-scale carbon sequestration (Lam et al., 2010). As a result, demand has increased for information about the long-term performance of native tree species, silvicultural systems for timber and biomass production, and the economic viability of reforestation in the region.

In Western Sudan, the Community-Based Rangeland Rehabilitation for Carbon Sequestration Project has helped improve local rangelands, which happen to be the mainstay of Sudan's economy, covering about 60% of the country and providing fodder for one of Africa's largest concentrations of livestock. The same project reported restoring 700 ha of community rangeland by planting grasses and leguminous crops. Among others, planting *Acacia Senegal* and *ZiZiphus* trees was found to have created windbreaks over a stretch of 108 km. Besides, *Acacia* and *Panicum* plantations were found to be stabilizers of sand dunes, and by formulating long-term management plans with the local village councils (Dougherty *et al.*, 2001). Similarly, the Western Kenya Integrated Ecosystem Management Project, which focused on native tree species, also reported success in improving the ecology of Lake Victoria Basin by taking up erosion control and watershed management activities on 900 km^2.

On the other hand, (UNEP, 2002) reported that sequestration projects, particularly if they focus on single species plantations or fast growing exotics, are effective in storing carbon, but create other adverse effects. Single exotic plantations have been reported to cause substantial losses in stream flow, and increased salinization and acidification (Jackson et al., 2005). According (Farley et al., 2005) exotics specie trees such as *Eucalyptus* and pine, do not support undergrowth, and other plants can suffer to coexist with them.

2.8 Attractiveness of FMNR forestry practice for A/R-CDM

Effective forest resource regaining and management requires interrelated technical practices and social arrangements that are appropriate to a region's biophysical characteristics and that address the protection and sustainable management of resources. Creating new second growth forests through FMNR has been shown to protect and systematically manage natural regeneration, both on and off farms, across many countries, and since 2004, in Africa (e.g., Niger, Burkina Faso, Mali, Senegal, and Malawi) (Reij and Dennis, 2016). FMNR is a systematic reforestation, which involves identification of areas with live tree seed, stump and other reproducible tree parts, area closure for a minimum of two years, followed by farmer training on thinning and pruning of rootstock selected to grow into trees. In Niger alone, where the annual rainfall is between 400-600mm, five million ha of land has been restored back to forest status through FMNR (Abasse et al., 2009). The authors reported that FMNR adoption in farmland and community forest areas in Niger raised the annual gross income of the region in Niger by between 17 and 21 million USD.

Brown et al. (2011) reported that the application of FMNR forestry practice to regenerate degraded native forests is inexpensive, replicable and provides significant short-term benefits. The authors further highlighted that FMNR restored the natural forest without the effort of replanting by emphasising the regeneration of native vegetation, avoiding the negative consequences of some exotic species and addressing concerns about the reduced biodiversity associated with new plantations. The technique was further praised because within a year of project initiation, communities were able to harvest fodder and firewood, and within three years, wild fruits and other non-timber forest products. For small-scale CDM projects, Brunt and Knechtel (2005) reported that financial investments in small-scale CDM projects are often insufficient to cover the high CDM transaction costs.

In the case of Humbo A/R-CDM project, FMNR forestry technique was reported (Brown et al., 2011) for its advantage in bringing back indigenous tree species from live stump and soil seed bank in cheaper and ecologically friendly ways than by plantation. In Ethiopia, like many other developing countries, there is a scarcity of research on carbon sequestration potential of indigenous tree species. The use of FMNR for A/R-CDM as a low cost technique in Ethiopia is a world-wide first.

2.9 CDM projects and their contribution to sustainable development

The completion of the first commitment period of the KP (2008-2012) marks a turning point in the history of the CDM. This junction posed questions like: did the CDM fulfill its initial dual aim of assisting developing countries in achieving SD and assisting industrialized countries in achieving compliance with their GHG emission reduction commitments? The SD dimension was not merely a requirement of the CDM; but also was the main attraction for developing countries to participate in CDM projects. This is so since, apart from GHG emission reductions, CDM projects were anticipated to have developmental impact on host countries' economic, social, and environmental situations.

Furthermore, the selection of criteria for SD and the assessment of the SD contributions were sovereign matters of the host countries in the operationalization of the KP. National authorities have used the SD dimension to evaluate key linkages between national development goals and CDM projects, with the aim of maximizing synergies with local development goals. So as to assist the CDM projects process a number of CDM projects, guidelines and manuals have been published to cater for a broad audience of emitters, host countries, project developers, stakeholders, carbon credit buyers and others, mainly during the early 2000s. Some examples are UNDP (2000) and Rosales and Pronove

(2003). These guidelines view SD as an integrated part of the legal framework of the CDM and emphasis that SD is a purpose of the CDM on equal terms with the reduction of GHG emissions. However, due to the ambiguousness of the concept of SD and the lack of consensus regarding an operational definition, the choice of SD criteria and procedures for assessing these criteria has been by no means straightforward.

In contrast to emission reductions, the contribution to SD is not subject to a generally applicable evaluation procedure. As the KP requires a CDM project activity to contribute to SD, many sets of criteria and evaluation approaches have been developed (Markandya and Halsnaes, 2002 and Begg et al., 2003); however, so far they have not been widely applied. Scholars (Arens et al., 2014) reported that a successful achievement of keeping global warming below 2 °C could be accompanied by development that ensures sustainable economies, healthy environments and sustainable societies. Indeed, CDM was created with the double mandates of GHG emission reduction and SD, because SD is a crucial to creating a world that can be enjoyed by all —the end goal of a successful fight against climate change.

Historically, the links between climate change and SD are rarely defined primarily as lying between mitigation and development. Nonetheless, climate change adaptation is now often associated with SD in the literature (Klein et al., 2007). A number of studies highlight the benefits of adopting more sustainable practices leading to increased economic efficiency in the longer term (Epstein and Roy, 2003). The development paths and adaptive capacity are intrinsically linked (Yohe et al., 2007). This becomes true when economic development achieved in the sense of sustainability, and economic development regarded as an adaptation in itself.

The concept of SD has become an important objective of policy makers in the industry. Various reports define SD as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). In fact, SD is a broad concept that encompasses a range of issues related to economic, ecological and social/human dimensions. There exist several hundred definitions of the concept, and an early definition by Pearce et al. (1990) suggested that SD should imply that no generation in the future will be worse off than the present generation. Implicitly, society should not allow decreases in welfare over time. As Yohe et al. (2007) stated, vulnerability to climate change impacts will be most severe when they are experienced together with other stresses. These stresses include components of SD such as access to resources, poverty, and food security.

Nevertheless, it is commonly agreed among scholars that the CDM has been very successful in many ways, among which is that it has generated carbon markets to stimulate emission reductions. but at the same time the CDM has faced a number of challenges and weaknesses: complex governance procedures, unequal distribution of projects worldwide, questionable environmental integrity and technology transfer (Austin et al., 1999; Ritchie and Lewis, 2003 and Taayab, 2006).

On other hand, the CDM has been criticized for not delivering one of its main goals: SD. In fact, one of the growing concerns about the performance of the CDM under international negotiations for the post Kyoto regime (2012) has been its weak capacity to deliver on its environmental and SD objectives in countries where it got implemented and its continuity is yet to be decided. Several international assessments of the CDM and its impact on SD have begun to rise since the beginning of the KP commitment period, and all studies point to the fact that the SDM, if left only to market forces, fails to comply with its important aim of contributing to SD. Hence, the main question arises: Is the CDM fulfilling SD—one of its *raisons d'être*? And if so, to what extent?

The CDM has the dual goals of reducing overall GHG emissions, as well as promoting SD (Austin et.al., 1999). Although the CDM holds considerable potential for the realization of SD benefits, it is reported to have failed to deliver projects that offer high levels of SD. However, a number of projects have indirect benefits for the overall economy, as many projects create employment and indirectly improve the infrastructure or at least provide CER revenues to the economy.

The Marrakech Accords (UNFCCC, 2001) emphasised that it is the host country's prerogative to define whether a CDM project contributes to SD. In most countries, this has meant that a governmental DNA evaluates project documentation against a set of pre-defined criteria, which tend to encompass environmental, social and economic aspects of sustainability (Schneider and Grashof, 2007).

Besides, the difficulty of clearly presenting SD and the issue of sovereignty have also resulted in the decision to allocate to host governments the responsibility for setting SD criteria, which has meant in some countries SD has been overlooked because of the considerable economic value of CDM finance (Cole, 2007). Subsequently, many proposals were put forward to improve the CDM for the post-2012 climate policy framework, or to adapt it to new arrangements in the post-Kyoto round agreement.

Sixteen registered CDM projects were assessed (Sutter and Parrenro, 2007) for the integrity of ER and their SD contributions. To bring out the SD contributions, the authors examined local job creation, the distribution of carbon revenue (based on the project's ownership structure), and local air-quality effects. They found a stark contrast between the projects' contributions to GHG emission reduction, and their contribution to SD: 72% of reported GHG reductions are reliable in scientific terms, while less than 1% of projects contributed significantly to SD. The review revealed that direct benefits are considered to be those that arise directly from the project; indirect benefits reflect the case where there is an improvement in environmental and social conditions locally. This study considered the benefits irrespective CDM project types, while Jindal et al. (2008) reported that carbon sequestration CDM projects are considered as an opportunity to fund SD for Africa through financial inflows.

Cole (2007) compared CDM projects in Brazil and Peru and concluded that these countries have established different social development goals, with Brazil emphasising employment and income distribution objectives, and Peru pursuing more general local community needs. They have also chosen contrasting regulatory approaches. Peru has chosen an ad-hoc regulatory approach whereby the DNA visits project sites and asks local communities about their needs and their potential contribution to the project. Brazil, similar to India and South Africa, developed a set of generic criteria, and applied a desk based 'checklist' approach. In many cases, this resulted in PDDs where project developers' existing (business-as-usual) activities were sufficient to meet the prescribed criteria.

As a result, scholars have been critically systematizing the SD contribution of CDM projects. For example, Sirohi (2007) examined 65 PDDs for CDM in India. In his final analysis, Sirohi concluded that the PDDs offer just lip service regarding expected contribution to socioeconomic development of the masses, particularly in rural areas. Another study suggested that CDM's contribution to 'local' SD has been limited (Olsen, 2007; Lohmann, 2006).

In some large-scale CDM projects with very limited benefits to local people, however, developers have committed to use a percentage of CER revenues to fund local development projects (Capoor and Ambrosi, 2006; Ellis et al., 2007). On the host-country level, China, for instance, instituted a 65% CER tax on revenues from HFC decomposition projects, which is supposed to fund SD activities.

Specifically from the forestry sector side, Andrew et al. (2003) reported that climate change mitigation and policies encouraging the conversion of agricultural land to forest may generate additional environmental benefits such as reducing soil erosion, nitrogen, and atrazine pollution from an afforestation programme in Wisconsin. Likewise, Joshua (1998) reported carbon sequestration forestry projects are increasingly valued more for their environmental benefits than their timber yield.

According to Jindal et al. (2008) carbon sequestration represents an opportunity to fund SD for Africa through financial inflows. The same scholars reviewed 23 projects of 14 Africa countries. The reviewed initiatives expected to sequester 26.85 million tCO_2 beyond the baseline situation. This implies an income of 107.4 million USD considering 4.00USD per ton of CO_2e.

After ratification of KP Ethiopia opened a DNA office within EPA, following which the DNA office developed three core criteria (economic, social and ecological) to assess the contribution of the proposed CDM project to SD in Ethiopia (Table 2.1). The Ethiopia DNA office CDM projects should answer: does the project contribute to national economic development; does the project contribute to social development in Ethiopia and does the project contribute to SD? Each of the three criteria are given seven to eleven different impact indicators. To implement the regulation, the Ethiopia DNA set up the CDM Advisory Panel (AP). The AP is given CDM PDD so as to conduct desk assessment as to whether the CDM projects PDD meet SD criteria or not. Based on the AP recommendation, the DNA office approves the CDM projects for registration. However, there is no formally communicated mechanism in place to monitor the CDM projects' direction towards promised SD.

The Humbo, Ethiopia A/R-CDM project aimed to regenerate 2,728 ha of degraded native forest so as to bring social, economic and ecological benefits - facilitating adaptation to a changing climate and generating tCERs under the CDM (Brown et al., 2011). The Humbo A/R CDM project is expected to sequester 880,296 tCO_2e across a 30 year fixed crediting period.

In the first verification period which was from 2006-12-01 to 2011-12-01, the TÜV NORD JI/CDM Designated Operation Entity (DOE), verified and confirmed that the project has achieved emission removals of 73,339 tCO_2e. A validation exercise undertaken by the Climate, Community and Biodiversity Alliance (CCBA) rated the project Gold Standard, which gave confidence to carbon buyers that the project will deliver GHG reductions as well as both community and biodiversity benefits.

2.10 Sustainable development policy of Ethiopia

In the 1980s and early 1990s, the Ethiopian economy was on a downward trend, with an average GDP growth of 2.3% and per capita GDP growth of -0.4%. A global conference focused on SD took place in Rio in 1992. Right after Rio 1992, Ethiopia developed a

National Conservation Strategy also referred to as the Conservation Strategy of Ethiopia (CSE); it was adopted in 1993. Among others, CSE was followed by an Environment Policy in 1997 which again encapsulated SD principles. As a result, during the early 2000s Ethiopia registered growth, with an average total real and per capita GDP of 3.7% and 0.7% annum[1], respectively (MoFED, 2002). The country developed another strategy called the Sustainable Development and Poverty Reduction Program (SDPRP) in 2002 and commenced implementation in years 2002/03 and continued up to 2004/05. During SDPRP, the country began to register better economic performance, with average GDP growth of 6.7% year[1] and an average annual per capita income growth rate of 3.65%. SDPRP was followed by Agriculture Development Industrialization (ADLI), Poverty Reduction Strategy Paper (PRSP), a Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) formulated and executed across 2005/6 - 2009/10.

In 2010 Ethiopia unveiled a Growth and Transformation Plan (GTP-I) for the period 2010/11-2014/15. At the same time a CRGE strategy was developed in 2011 and launched at the COP17th to the UNFCCC in Durban as a long term strategy that set out to develop a climate resilient green economy that would result in a middle income country by 2025. The continuously improving integration of environmental concerns into successive long term economic plans during periods of economic growth signals that the government has understood and internalized the SD concept.

Among all of the medium and long-term plans prepared in Ethiopia, the CRGE is considered the most ambitious. It envisaged that the country’s GDP per capita would grow from 378 USD in 2010 to 1271 USD in 2025 (MoFED, 2010). The CRGE explicitly recognizes that the environment is a vital and important pillar of sustainable development, and states that building a ‘Green Economy’ and the ongoing implementation of environmental laws are among the key strategic directions to be pursued during the plan period.

The CRGE strategy of Ethiopia has been completed for seven sectors that are expected to offer the highest GHG abatement potential: power supply; buildings and green cities;

forestry (REDD+); agricultural/soil-based emissions; livestock; transport; and industry. In terms of costs, the investment needed to implement CRGE is expected to be upto USD 150 billion by 2030 (CRGE, 2011).

Specifically, the EPA of Ethiopia was created in 1994 as a regulatory organ. This authority was restructured as the Ministry of Environment & Forestry in 2013 and again restructured as the Ministry of Environment, Forestry and Climate Change in 2015 so as to shoulder the growing demands of deliverables. Tracking the recent two and half decade's journey of Ethiopia, clearly there has been political will, leadership and commitment.

As part of the global process, Ethiopia has also made important decisions and taken various measures to minimize the effects of climate change. It is party to both the UNFCCC (ratified in 1994) and the Kyoto Protocol (ratified in 2005) in its Proclamation No. 439/2005 for its twin objectives. So as to endorse KP, the country assigned the EPA office to serve as the DNA office too, and the office developed three core criteria (economic, social and ecological) used to assess the contribution of the CDM project to SD in Ethiopia (Table 2.1). As per the Ethiopian DNA office, CDM projects should answer: does the CDM project contribute to SD in terms of the economic, social and environment? Each core criterion is defined into 7 criteria and 26 indicators. To implement the regulation, the Ethiopia DNA set up the CDM AP. The AP needs PDD from the CDM project developer so as to conduct desk assessment whether the CDM project's PDD meet SD criteria. Based on the AP recommendation, the DNA office approves the CDM projects for registration or rejects them. However, there is no mechanism in place to monitor the CDM projects during the implementation period.

2.10.1 Ethiopia and A/R-CDM

Despite Ethiopia having been keen about SD and becoming active in climate change negotiation forums across the first KP crediting period (2008-2012), Ethiopia presented merely one A/R-CDM project, which was developed by the International Non-Government Organisation (INGO) called World Vision (WV).

In 2004/5, WVE, in collaborating with WVA, happened to read about A/R-CDM and seemed excited by the new instrument and initiated Humbo A/R-CDM as a project developer. As a result, the degraded hills of Humbo underwent efforts to restore native tree species through A/R-CDM in pursuit of the twin objectives of GHG reduction and SD. The World Bank Bio Carbon Fund played the role of trustee. This project anticipated indirect flow-on social, economic and environmental benefits for local communities, while generating temporary certified emissions reductions (tCERs) under the CDM (World Vision, 2008).

The Humbo Ethiopia A/R-CDM, which commenced in 2006, registered at UNFCCC in 2009, after being vetted against the complicated requirements for the Ethiopian DNA's letter of no objection and letter of approval, as well as being vetted against requirements from a UNFCCC-accredited independent auditor and the UNFCCC-EB. This project used a forestry practice called FMNR instead of plantation with intention to reforest with Ethiopia-native tree species.

The fundamental structure of the CDM as a market mechanism results in a preference for low cost emission reductions over SD effects, since the latter remain un-priced on the global market (Ellis et al., 2007). The lack of significant SD effects in the various meaning of the term may also be explained by conscious decisions by host countries DNAs to let one of the dimensions (primarily economic development) override the others.

Assessing the contribution of A/R-CDM projects towards local-community-SD is therefore crucial. As the global developmental consensus heads towards the Millennium Sustainable Development (MSD) goals and a result-based mitigation regime against climate change, understanding the extent to which an A/R-CDM project fulfils the goal of SD becomes all the more relevant.

2.10.2 Ethiopia DNA SD criteria being used to approve CDM

The three SD cross-checking core criteria, namely economic (with three criteria), social (with one criterion), and ecological (with three criteria) are further substantiated with some indicators developed by Ethiopia DNA (Table 2.1).

The Humbo A/R-CDM project being the first of its kind in Ethiopia means that there has not been any studies regarding the contribution of native tree-based A/R-CDM projects along the dimensions of carbon sequestration and SD, making this study all the more critical.

2.10.3 Carbon market and Ethiopia

Across the world, the carbon market showed continuous growth: it was worth 0.7, 11, 31, 65, 135, 144 and 146 billion USD during the years 2004, 2005, 2006, 2007, 2008, 2009 and 2010 respectively (World Bank, 2011). Mid 2017, finance transacted along carbon financing reached 3 billion USD.

As of 1st January 2014, the 7,418 CDM and 603 JI projects that were registered had issued 1,419 million CERs and 830 million Emission Reduction Units (ERUs) respectively (UNEP Risoe, 2014). Total CERs represent additional allowed emissions equivalent to 2.4% of base-year emissions for the CP1. Both CER and ERU supplies are largely concentrated in advanced developing countries and transition economies respectively. Indeed, over 90% of all issued CERs are from the five largest CDM countries: China, India, South Korea, Brazil and Mexico, while African countries account for less than 2%. Similarly, over 90% of all issued ERUs come from Russia and Ukraine, while Western Europe accounts for only 3% (Figure 2.1).

Such a concentrated distribution of CDM and joint implementation (JI) projects can be primarily explained by larger absolute and relative levels of GHG emissions in advanced developing countries and in transition economies which make for a larger, economically attractive, emissions reduction potential. Moreover, in the case of the CDM, advanced developing countries in Asia and South America provided relatively strong institutional capacity and a relatively favourable investment climate compared to less developed countries in Africa (Shishlov and Bellassen, 2012).

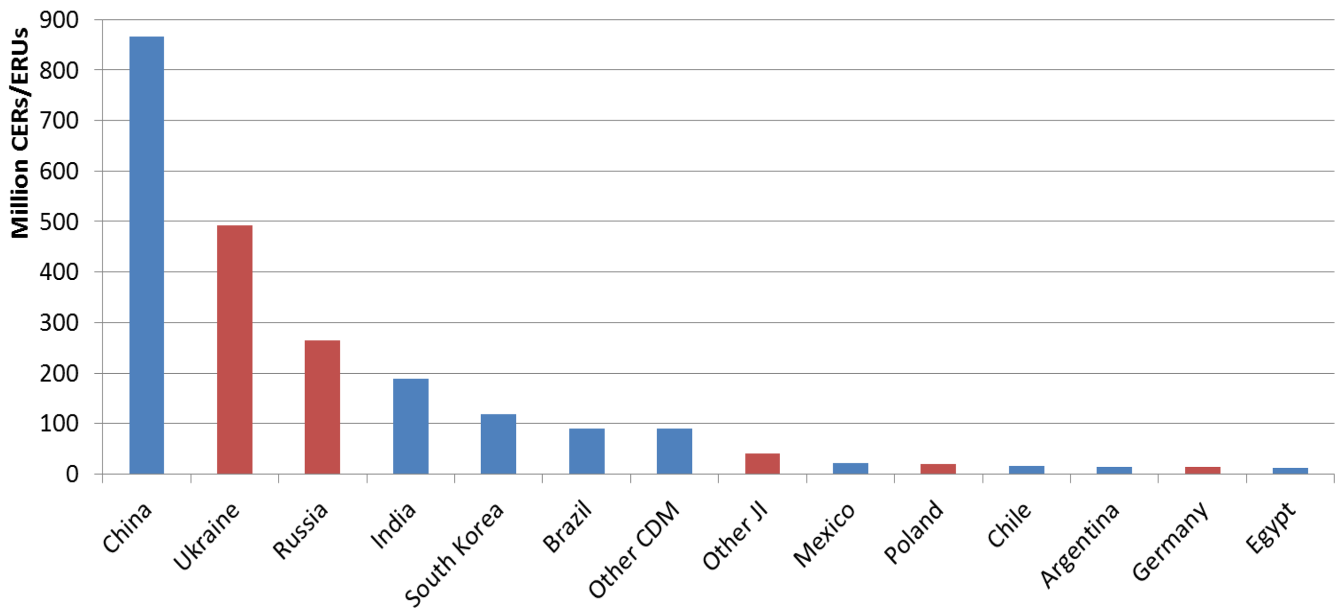
Table 2.1 Ethiopia DNA SD criteria being used to approve CDM projects

Pillars	Criteria	Indicators
Environmental	Impact on local environmental Quality	• Contribution on local climate • Impact on water pollution • Impact on the generation or disposal of solid waste • Any other positive or negative environmental impacts on noise, safety, visual impacts, or traffic
	Change in usage of natural Resources	• Contribution in community access to natural resources • Contribution to the sustainability of use of water, minerals or other non-renewable natural resources • Contribution to the efficiency of resource utilization
	Impacts on biodiversity and Ecosystems	• Changes in local or regional biodiversity
Economical	Economic impacts	• Contribution to foreign exchange requirements • Contribution to existing economic activity in the area • Contribution to the cost of energy • Contribution to foreign direct investment
	Appropriate technology transfer	• Positive or negative implications for the transfer of technology to Ethiopia • Contribution to local skills development • Demonstration and replication potential
	Alignment with national and local development priorities	• How aligned with provincial and national government objectives • How is aligned with local developmental objectives • Contribution to the provision of, or access to, basic services to the area

		• Contribution to the relocation of communities if applicable • Contribution to any specific sectoral objectives
Social	Social equity and poverty Alleviation	• Contribution to employment levels (specify the number of jobs created/lost; the duration of time employed, distribution of employment opportunities, types of employment, categories of employment changes in terms of skill levels and gender and racial equity) • Contribution to community social structures • Contribution to social heritage • Contribution to the provision of social amenities to the community in which the project is situated • Contribution of the project to the development of previously underdeveloped areas or specially designated development nodes

During the first commitment period, Ethiopian stakeholders were party to carbon market transactions amounting to only USD 360,000 and 40,000, from Humbo A/R-CDM and Sodo AR Voluntary Carbon Standard (VCS) projects, respectively (WVE report, 2016). Explanatory factors for such little share are found in many reasons: institutional capacity for host countries to receive CDM projects, domestic legal frameworks, investments laws (CDM projects are easy to implement where existing regulatory trade frameworks are already in place), and infrastructure, among others. Besides, participants in CDM projects have to face several difficulties before implementing CDM projects. Political and economic risks associated with investments are also other constraints. Ethiopia seems to be working towards targeting carbon markets like REDD+, A/R, soil carbon and energy efficient technologies so as to access carbon finance and contribute towards global emission targets. Yet, Ethiopia missed a carbon market opportunity during the KP period, which is ironic since the country often hosts climate change negotiations as the third diplomatic hub after New York and Brussels.

Figure 2.1 CER and ERU issuance by host country as of 1st January 2014



Source: CDC Climate research UNEP Risoe, 2014

2.10.4 Overview of forest and tree-based mitigation and adaptation options in line with NDCs toward sustainable development

Nature-based Solutions (NbS) are increasingly regarded as a critical elements in the fight against the causes and consequences of climate change (Seddon et al. 2019ac). Globally, ecosystems capture and store significant amounts of carbon and thereby can help slow global warming (Andersen et al. 2019, IPCC 2019). Recent estimates suggest that these natural climate solutions can provide around one-third of the cost-effective climate mitigation needed between now and 2030 to stabilise warming to below 2°C (Griscom et al. 2017). Therefore, efforts to avoid ecosystem loss or degradation and sustainably manage the world's ecosystems can ensure that nature continues to provide these important benefits to society. While countries are in the midst of revising and strengthening their NDCs under the Paris Agreement on climate change, further guidance is needed to help streamline and strengthen the inclusion of NbS in the NDCs.

Acting at the interface between natural resources and human activities, forests, trees and agroforestry provide numerous NbSs towards adaptation, mitigation and NDCs. The first group of reasons common to all other agricultural subsectors pertain to their particular vulnerability to climate change. A second group of reasons are based on the multiple ecosystem goods and services provided by forests and trees, most of which will be threatened by climate change. The third and often under-estimated group of reasons is that forestry and the ecosystem of goods and services provided by forests. Trees can be called on to play a critical role in the adaptation of most of the other sectors, i.e, in the adaptation of systems identified as vulnerable such as crop, livestock, water systems, and of vulnerable people and populations. This is why forests and trees are an essential component of NbS that are defined as actions that use ecosystems to help societies address a variety of environmental, social and economic challenges in sustainable ways. NbS are explicitly considered as alternatives to human-made technologies, engineering and infrastructures. They integrate conservation and protection of biodiversity as a basic objective. Hence, NbS have been increasingly promoted to address climate change and other societal challenges (MacKinnon et al., 2008; IUCN 2009). The role of forests and trees is envisaged and managed best at the landscape level, which calls for a landscape approach to adaptation, mitigation and NDCs, since forests and trees—including agroforestry, orchards, trees outside forests, urban and periurban forests—must be appropriately integrated into the formulation and implementation NDCs.

Ethiopia also clearly indicated in its NDC the significance of A/R, agroforestry and restoring degraded areas for their economic and ecosystem services, while sequestering significant amounts of CO_2 and increasing the carbon stocks in landscapes (NDC, 2015).

2.11 Constraints in Ethiopia in promoting CDM for SD

The UNFCCC EB 70th meeting in Doha approved a new tool that CDM project participants could use to describe SD co-benefits on a voluntary basis, in order to ensure that the CDM makes a growing contribution to the SD of all host countries, and to safeguard the reputation of the CDM as a mechanism for low carbon development. The EB decided that host countries are responsible for attesting to the SD requirements in a letter of approval.

The entity further highlighted to Parties to take important decisions on the next commitment period of the KP and make progress on a broader climate change agreement to take effect in 2020.

The existing research reports focuses on different types of registered CDM PDD assessments than actual analysis, as the CDM is relatively new, and A/R-CDM projects specifically are relatively fewer. Arthur & Jon (2010) assessed registered A/R-CDM projects PDD and recommended that research should focus on evaluating the performance of individual A/R-CDM projects for stipulated outcomes; and to utilize criteria and indicators to analyse the contributions of implemented A/R-CDM projects for their twin objectives.

Therefore, this research found it indispensable to assess native tree species based A/R-CDM as a study to answer the question "Is A/R-CDM delivering on its twin objectives, namely carbon sequestration and contributing to sustainable development claim set out at the UNFCCC?"

2.12 Conclusion

Climate change is defined as a change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods. Climate change caused by global warming is due to increase GHGs, especially CO_2. The IPCC has indicated that global warming due to climate change could lead to many environmental threats, i.e. drought, floods, sea level rise, decline in crop and animal production, and health hazards, among others.

Climate change mitigation and adaptation are complementary as mitigation deals with the causes while adaptation deals with the consequences of climate change. Both are needed to treat the effects of previous emissions and mitigate current and future causatives. The KP was established by the international community in 1997 to tackle the problem of climate change by formalizing commitments for different groups of countries to reduce their emissions of GHGs. The ultimate objective of the Protocol was to achieve stabilization of atmospheric concentrations of GHGs at levels that would prevent dangerous anthropogenic (human-induced) interference with the climate system. The CDM under the KP identified as the first of its kind carbon market instrument. Forests are recognized as both sources and sinks of carbon. Hence, forestry activities are considered initiatives that promise cost-effective CO_2 abatement, especially where rapid rates of tree growth combine with high environmental benefits. As a result, the UNFCCC has recognized the importance of the LULUCF sector in stabilizing concentrations of GHG in the atmosphere, and has included A/R as one of the 15 sectors that are eligible to generate emission reductions, offset credits and contribute to SD under the CDM.

The concept of SD is explained as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. In fact, SD is a broad concept that encompasses a range of issues related to economic, ecological and social/human dimensions. A/R is selected as eligible to CDM anticipating ER and SD.

Over the last decades, mono specific plantations—because of their apparent economic and management advantages such as the simplicity of seedling production and stand management, and a uniform harvest with regular rotation cycles—have dominated reforestation in the tropics. On other hand, the most popular exotic tree species employed in plantation do not comply with CDM SD requirements, and entail an unacceptable trade-off between the cost of reforestation and the size of the reforestation area. Besides, the CDM mechanism does not offer pre-finance to establish forests. So, one option for countries like Ethiopia is searching for native tree species-based low cost reforestation technology to implement forestry based CDM. FMNR forestry practice has been identified as a remedy to go for A/R-CDM through native tree species regeneration. Furthermore, FMNR was found to be a low cost reforestation practice.

The CDM delivers on its ER promises, but not its goal of SD in developing countries. Several international assessments of the CDM and its contribution to SD have been conducted since the beginning of the KP commitment period, and all studies pointed out that the CDM, if left only to market forces, fails to comply with its important aim of contributing to SD. Hence, the main question arises: Is the CDM fulfilling one of its *raisons d'être*, and to what extent?

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Study area description

Location: this study was conducted during 2013-2017 in Humbo Woreda[1] (District). The Humbo District is one of the twelve districts in Wolaita Zone, which is one of the thirteen zones of Southern National Nationalities People Region (SNNPR). It is located 360km southwest of the capital city, Addis Ababa, and eighteen kms from Soddo town, which is the administrative seat of Wolaita Zone. The Woreda is composed of forty-one Kebele[2] administrations, of which thirty-nine are rural and two are urban (Wolayita Zone FEC, 2015). It is situated from 6° 46'48.47 to 6° 41'04.28N and longitudinally ranges from 37° 48'35.44 to 37° 55'14.51 E. The total land area of the district is about 859.4km^2. The district had a total population of 144,739 (72,729 males and 72,011 females) in 2013. The overwhelming majority of the inhabitants belong to the Wolaita ethnic group, but there are also those belonging to Amhara, Sidama, Gamo, and other ethnic groups. Mixed agriculture, mainly crop and livestock production, constitutes the most important economic sector in Humbo, like other non-pastoral parts of Ethiopia.

Climate: the temperature of Humbo varies from the mean maxima range 18 to 24 °C and minima ranges from 12 to 15 °C. The elevation ranges 1200 - 1900 m.a.s.l. Total annual rainfall is between 800 mm and 1000 mm.

Natural vegetation: The main native tree species of the study area are *Terminalia brownie, Steganotaenia araliaceae, Opilia amentacea, Eritrena abisinica, Combretum molle, Tecalea nobili, Grewia bicolour, Combretum collinum, Combretum molle, Balanites aegyptica, Dodonaea angustifolia,* Schrebera alata *(Hochst.) Welw.* Maytenus undata *(Thunb.) Blakelock, Croton macrostachyus, Schrebera alata, Acokanthera schimperi, Maytenus undata, Faurea speciose, Acacia brevispica, Psychotria orphirebsis, Carissa*

[1] Woreda is an administrative division which is equivalent to a district
[2] Kebele are lower level administrative units (division) or farmers or peasant associations in rural Ethiopia

eduli, Euclea divinorum, Terminalia laxiflora, Rhus vulgaris, Otostegia fruticosa, Maytenus senegalensis *(Lam.) Exell* and others.

Socio-economic conditions: in the mid-1970s, after the fall of the Emperor H/Silasse's government, there was a reversal of the land policy and a proclamation encouraging redistribution of land to the landless proclaimed tenants. The Humbo area land was then distributed to all the landless in the vicinity, and mountainous forest areas were kept as open access land. According to Kamara et al. (2008), within a short period, large areas that were formerly covered by the forest were without a forest cover. The community blamed this on the increased population pressure and the occurrence of the 1984 drought in tandem with high poverty levels, which compounded forest degradation. The stumps of the remnants of trees became lucrative in the processing of charcoal and wood fuel.

As a result, the Humbo district is one of districts of Ethiopia facing deforestation, environmental degradation and associated loss of livelihood. As the population pressure surged in the late 1980/90s coupled with the 1984 drought, the remaining vegetation cover was completely destroyed, exposing the land to the current visible effects of soil erosion and the land was left almost barren. As trends evolved, the community's coping mechanisms also evolved, leading them to uproot tree stumps for charcoal - a coal-like fuel from wood which became brisk business in the area. This desperate action coupled with over-grazing and cyclical droughts that followed the 1984 drought episode halted the natural regeneration of the trees exposing the land to hostile weather elements that left the land bare and barren. In 2005, WVE in partnership with WVA, identified forestry based carbon trading as a means to stimulate on-going community development and to test new funding streams such as the A/R-CDM. Following two years of consultation, planning and negotiations, the Humbo A/R-CDM project was born; and became World Vision's (and Ethiopia's) first carbon trading initiative.

Hence, the Humbo A/R-CDM was selected as a case study for this study site since it is the only and biggest A/R-CDM in Ethiopia and Africa, respectively. Moreover, it is the first A/R-CDM project in getting tCER issuance in Africa and second in the world. The permission for the study area was secured from WVE with written consent. The forest area considered for this research is a natural regeneration area of 2,728 ha.

3.2 Research design

In Africa, carbon in living biomass is predominant, accounting for about 60%, followed by soil carbon, whereas in Europe soil carbon is the predominant fraction, i.e. reaching up to 64%, and living biomass accounts for only 25% of the carbon. Thus, the proportions of living biomass and soil carbon vary with the region but together account for more than 90% of the total biomass. The share of deadwood and litter together is less than 11% in all regions. Carbon in the litter pool is less than 5% in all regions[3].

For this research ABG and BGB carbon pools data was collected in 2006, and subsequent monitoring data was collected in 2012, 2014, 2015 and 2016 by the project developer, WVE. The data was collected using Pearson et al.'s (2005) non-destructive technique. With regard to the ex-post biomass calculation, the amended UNFCCC guideline allowing allometric equation for A/R-CDM was used, and the *0.2035*(DBH^2.3196* was found to reflect better the regional climatic growth conditions of the tropical dry forest. BEF method and equation (66)-(73) in Section III.5.1 of the approved baseline and monitoring methodology (AR-AM0003/version 03) followed to account and monitor the verifiable carbon stock changes in the above-ground and below-ground living biomass within the project boundary.

To assess FMNR attractiveness and A/R-CDM contribution to local level SD contribution, a multi-stage random cluster sampling method was used to maximize the efficiency of data collection for a household survey. To this end the calculated sample size (n=366) was divided into 30 clusters (366/30 = 12.2) and then conservatively rounded up to 13 HH per cluster for a total sample size of 390. Population clusters were identified using a

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[3] www.climate-policy-watcher.org/carbon-stocks/distribution-of-different-carbon-pools.html

comprehensive list of gotes—or sub-kebeles—in the project area. The survey was also implemented in the nearby non-project sites.

The household interview questionnaire contained questions on household demographics and gender. For sample size decision, the formula set by Bartlet et al. (2001) was employed. The sample size was calculated to keep the confidence interval (CI) within 95% and 5% error. The sample of 'n' households was divided into 30 clusters, while the villages were selected by systematic sampling from a complete list of all villages in the project area. Individual households were selected using systematic selection from a complete list of households in each village. Control households were selected from the area adjacent to the project.

So as to gather qualitative data on the experiences and perceptions of the benefits of FMNR and A/R-CDM approach to ensure SD, 18 key informants were interviewed. Key informant interviewees were selected from among the staff of WVE, government offices ranging from the federal to the kebele level, and finally, staff and forest development and protection cooperative leaders. 14 FDGs were conducted with cooperative members, cooperative non-members, youth, and elders.

Transect walks and site inspections were also conducted to determine the extent of forest regeneration. Data sources from UNFCCC web sites such as PDD, DOE, as well as reports on: (1) the social and ecological context; (2) community characteristics and project status and (3) carbon stock were used as baseline data.

3.2.1 Hypothesis

Null hypothesis

The native tree species-based Ethiopia Humbo A/R-CDM achieved the twin objectives in reducing emission while contributing to sustainable development in terms of improving local climate; increasing ownership of natural assets; in creating employment; improving community level social structures; improving local development skill and improving exiting economic activities.

Alternate hypothesis

The native tree species-based Ethiopia Humbo A/R-CDM project failed to achieve the anticipated socio-economic and environmental benefits to build SD as it was not managed well or the period of intervention was too short.

3.3 Materials and methods

3.3.1 Materials

3.3.1.1 Materials used to measure tree biomass

The materials used to measure the above ground tree biomass were diameter tape, calliper, clinometer, digital measuring device (DME) and ARC GIS. To reach each plot, Global Positioning System (GPS) used. To calculate belowground biomass, the shoot to root ratio formulas (Table 3.1) were employed.

3.3.1.2 Materials for socio-economic survey

The sampling tool that was used in the socio-economic survey was a semi-structured and open-ended questionnaire that helped capture the attractiveness of the FMNR forestry practices, the historical trend, and the current community-level sustainable development conditions vis-à-vis A/R-CDM. A checklist was used for the focus group and key informant discussions.

3.3.2 Methods

3.3.2.1 Methods for tree biomass

The biomass and carbon stocks of trees are estimated using appropriate equations. For practical purposes, tree biomass is often estimated from equations that relate biomass to diameter at breast height (DBH). Although the combination of DBH and height is often superior to DBH alone, measuring tree height can be time consuming and will increase the expense of any monitoring programme. Furthermore, databases of trees from around the world show that highly significant biomass regression equations can be developed with very high accuracy using just DBH. In forestry, breast height is defined as 1.3 meters above the ground (Pearson et al., 2005). Slightly adjusted equations may exist for individual species or groups of species. The original location of the equation should be considered before its application. This is because trees in a similar functional group can differ greatly in their growth form between geographic areas.

Table 3.1 Parameters used to calculate non-woody biomass carbon stock at baseline

Parameters	Value	Unit	Source
Root to shoot	2.8 d	dimensionless	Table 3.4.3 GPG IPCC 2003. R:S ratio for the vegetation type shrub land
Above ground biomass	2.3 t	d.m./ha	Table 3.4.2 GPG IPCC 2003 Peak aboveground live biomass for the climate zone tropical-dry
Carbon Fraction	0.5	tC/t d.m.	IPCC

3.3.2.1.1 Stratification and re-stratification

Stratification of the delineated area was done in 2006 using vegetation cover. Based vegetation cover, the total area was stratified into five strata. A stratum was assigned one after the other. After stratification, permanent sample plots were assigned systematically with a random start according to encouraged practice in GPG-LULUCF. This activity was accomplished using a GPS coordinates, and the first plot was randomly located after crossing the forest boundary and moving 500 meter into the forest. The same distance was used between successive plots. The circular plots were used to gather data and for subsequent monitoring and measurement. The centres of the circular permanent sample plots were marked to facilitate the measurement of trees located in the plot at each inventory and subsequent inventories. The location of the plots is recorded, as they would need to be identified at the subsequent verification. Slope in percent of each plot was used to estimate the actual plots using a conversion factor as needed to adjust the plot dimensions. Distance between plots was measured by tape and compass for bearing. Stratum and sub-stratum series numbers of each plots were recorded and archived. The sampling plots were distributed randomly and evenly. With respect to the numbers of permanent sample plots having the desired precision, the mean carbon density in each strata and the coefficient of variation in each strata and standard deviation were needed. To get variance, preliminary data from the respective stratum required. After this step, baseline tree biomass data was collected in 2006.

After five years of intervention, significant changes in the growth of vegetation were observed within the same strata (2, 3, and 4). To address these changes, the pre-verification stage monitoring process led by the designated operation entity (DOE) advised the project developer to re-stratify using the same strata definitions. As a result, some parts of stratum two moved to stratum three. Some areas of stratum three covered with rocky and scattered vegetation area removed and included into stratum four. The fifth stratum, which is considered an enrichment planation area, was estimated to span 500 ha in the beginning, and was later reduced to 50.7 ha because of change in vegetation growth during the five years (Table 3.2).

The re-stratification at pre-verification time was supported by the provisions as the minor amendments endorsed by the CDM EB at meeting EB 63, documented in Annex 27 paragraph 3. This guideline lowered the minimum diameter at DBH of the forest inventory from ≥4 cm to ≥2 cm.

Permanent plots are considered as statistically more efficient in estimating changes in forest carbon stocks when compared to temporary plots, because there is high covariance between observations at successive sampling events (Avery and Burkhart, 1994).

Table 3.2 Total size of each stratum before and after re-stratification

S/N	Strata	Strata at project inception	Strata after re-stratification (after 4 years)
1	stratum 1	234	233.48
2	stratum 2	745	630.71
3	stratum 3	1154	1698.71
4	stratum 4	95	114.41
5	stratum 5	500	50.7
	Total	2728	2728.01

Data source: WVE

3.3.2.1.2 Number of permanent sample plots calculation steps

To calculate the number of plots in accordance with Pearson et al. (2005), the project developer (WVE experts) employed the following steps:

Step1: Identifying the desired precision level. The level of precision required for a carbon inventory has a direct effect on inventory costs. Accurate estimates of the net change in carbon stocks achieved at a reasonable cost to within 10% of the true value of the mean at the 95% confidence level (Brown, 2002).

Step 2: Identifying an area to collect preliminary data. Preliminary data is required in order to calculate variance. Between 6 and 10 plots is usually recommended as sufficient to calculate variance. The same was utilized for Humbo A/R-CDM.

Step 3: Estimating carbon stock standard deviation and variance from preliminary data.

Step 4: Calculating to get the required number of plots.

Finally, for 'n' strata the following formula was employed to determine number of plots per stratum as follow[4]:

$$n = \frac{(N_1 * s_1)^2 + ... + (N_n * s_n)^2}{\frac{N^2 * E^2}{t^2} + N_1 * V_1 + ... + N_n * V_n}$$

For stratum 1, stratum 2 through to the nth stratum

Where,

E: is the desired half-width of the confidence interval, calculated by multiplying the mean carbon stock by the desired precision (i.e. mean carbon stock * 0.1 (for 10 % precision) or 0.2 (for 20% precision),

t: is the sample statistic from the t-distribution for the 95% confidence level - t is usually set at 2 as sample size is unknown at this stage, and p-value denoting level of statistical significance is 0.005 and below.

N: represents the number of sampling units in the population (= area of the project or stratum in hectares / area of the plot in hectares),

s: represents the standard deviation,

V: represents the variance.

3.3.2.1.3 Mean carbon stocks and standard deviations for each stratum estimation

Once re-stratification was done and map production completed, the preliminary six sample plots from each stratum were laid out and required tree data collected in order to calculate mean carbon stock and standard deviation.

Preliminary sample plots were located in the respective stratum randomly using software called 'Hawth's analysis tools' working in an ArcGIS applying the following procedures:

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[4] Source: http://www.winrock.org/ecosystems/tools.asp

a) A grid of points with a size equivalent to sample plots size (0.0625 ha) was created throughout the map of the project site.
b) A sequential identification (ID) assigned to each point of grids inside the stratum starting from north to south and west to east.
c) Using software operating in ArcGIS, preliminary sample plots locations (six from each stratum) fixed.
d) Nested circular (Figure 3.1) sample plots were used to capture all the trees sizes grown for the smallest circle being with 1m; the second 4m, the third 14m and the fourth 20 m radius. Since there were no trees found in diameter class ≥50 cm during baseline, the fourth circle was practically omitted at the initial stage which was used when tree diameters reach the required size and above. In one meter radius, every tree less than 5 cm DBH, trees having a DBH of 5-20 cm have been measured in 4 m radius circle, in 14 m radius the eligible trees measured were only those trees having a DBH of 20-50 cm at a height of 1.3 m. All other trees having a DBH more than 50 cm were measured in a circle with a radius of 20 cm.

The DBH data collected from 24 preliminary sample plots, the mean density per each stratum was calculated (Table 3.3) using the formula (Biomass = $_{10}$(-0.535+log10basal area) developed for tropical dry lands by Pearson et al. (2005). Standard deviation was also calculated for each stratum. As a result, mean carbon density 8.78, 6.69, 9.71 and 9.45 was obtained from strata 1, 2, 3 and 4 respectively.

3.3.2.1.4 Determination of the number of permanent sample plots

Using the data (Table 3.4), the number of total sample plots laid out in each stratum and the whole project site were calculated with 95% confidence interval and ±10 precision level using the formula (Pearson et al., 2005).

Figure 3.1 Nested circular plot of Humbo A/R-CDM project

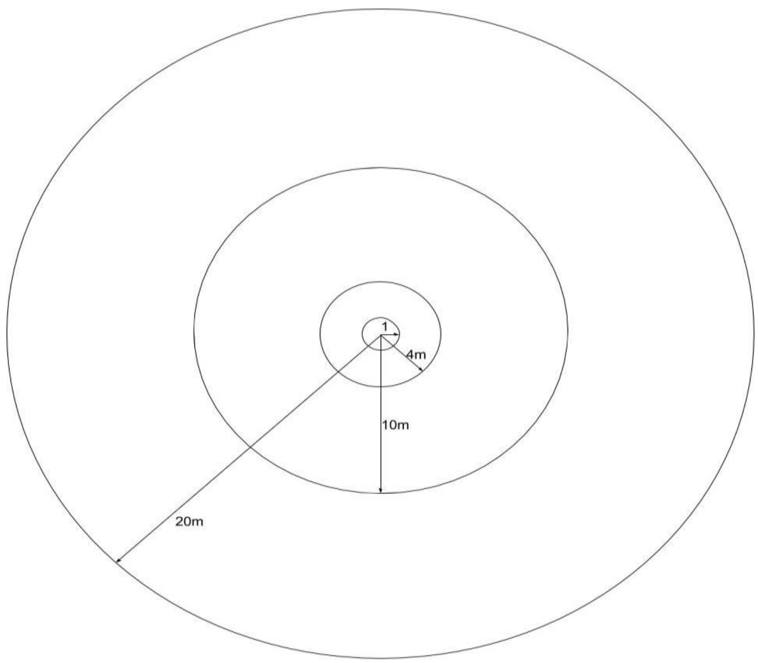


Table 3.3 Mean carbon density and standard deviation of each stratum

	Strata 1	Strata 2	Strata 3	Strata 4	Strata 5	Total
Area of each stratum (ha)	233.48	630.71	1698.71	114.41	50.7	2728
Plots size	0.062	0.062	0.062	0.062	0.062	
Mean carbon density (tC/ha)	14.28	5.89	46.03	26.67	8.51	20.3
Standard deviation (S)	8.76	6.698	9.71	9.45	8.08	6.92
Desired precision (%)						10
E						2.03

$$\eta = \frac{\left(\sum_{h=1}^{L} N_h * s_h\right)^2}{\frac{N^2 * E^2}{t^2} + \left(\sum_{h=1}^{L} N_h * s_h{}^2\right)}$$

Where,

E = allowable error or the desired half-width of the confidence interval. Calculated by multiplying the mean carbon stock by the desired precision (that is, mean carbon stock x 0.1, for 10% precision, 0.2 for 20% precession),

t = the sample statistic from the t-distribution for the 95% confidence level, t is usually set at 2 as sample size is unknown at this stage,

N_h = number of sampling units for the stratum b (= area of stratum in hectares or area of the plot in hectares),

n = Number of sampling units in the population $(n = \sum N_h)$

S_h = standard deviation of stratum *h*

As a result, the total number of sample plots distributed over the entire project site was computed to be 77. By including a10% contingency, the total number of sample plots was fixed to be 85. Once the total number of sample plots required from the project site to meet the targeted precision were calculated, the next step was calculating the number of sample plots distributed to each stratum. This was done again by employing the same formula (Pearson et al., 2005).

Number of plots for each stratum:

$$n_h = n \times N_h \times S_h \Big/ \sum_{h=1}^{L} N_h \times S_h$$

Where:

n= the total number of plots,

n_h= the number of plots in stratum h,

N= the number of sampling units in the population,

N_h= the number of sampling units in stratum h,

S= the standard deviation,

s_h= standard deviation in stratum h

Hence, there were 8 plots in stratum 1, 14 plots in stratum 2, 57 plots in stratum 3, 4 plots in stratum 4 and 2 plots in stratum 5.

3.3.2.1.5 Permanent sample plots

To maintain statistical rigor and avoid a subjective choice of plot locations, the permanent sample plots were located systematically with a random start using the ArcGIS randomization tool in ArcMap, as random points were generated for each of the strata using a 25 x 25 m grid. This was accomplished in the field with the help of a GPS device. The GPS coordinates, stratum number, and series number of each plot and respective grid number were recorded. The sampling plots were evenly distributed and plot locations overlaid on the map as is seen from Figure 3.1. The first plot in each stratum was randomly located using software called 'Hawths analysis tools" operating in ArcGIS, and the next sample plot was systematically located maintaining equal interval between successive sample plots. The following steps depict all the procedures followed.

1. A grid of points with a size equivalent to sample plots size (0.0625 Ha) was created over the map of the project site (Figure 3.1).
2. A sequential ID was assigned to each point of grids on the map starting from north to south and west to east.
3. The total possible sample plots number in each stratum was identified by archiving from the ArcGIS; or by dividing the area of each stratum by the area of sample size (Table 3.4).
4. The interval between each successive sample plots was identified by dividing the total sampling grid points in each stratum by the number of required sample plots.

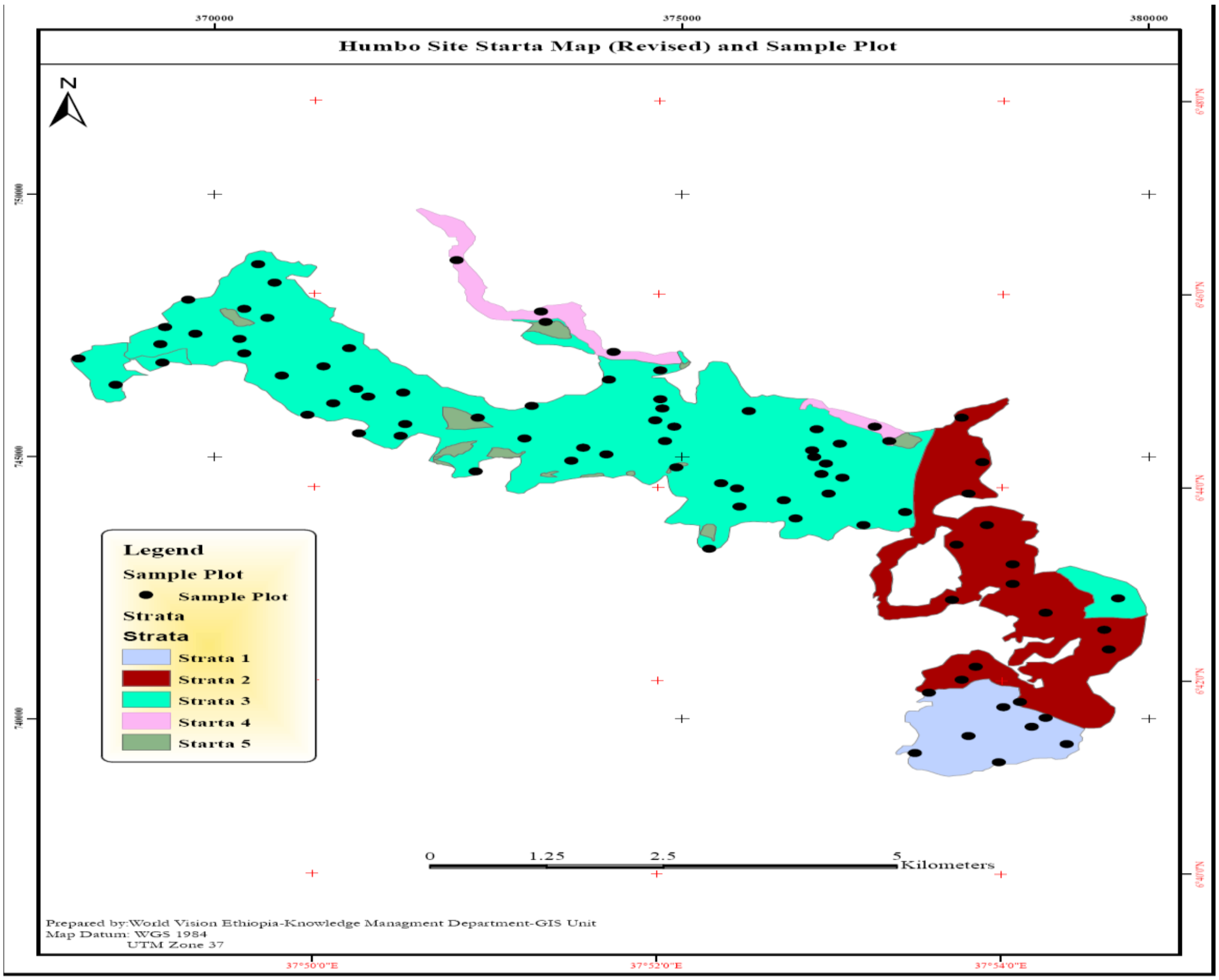
5. Using ‘’Hawths analysis tools”, a software operating in ArcGIS, the first sampling point in each stratum was randomly selected and a respective grid ID number as well as corresponding GPS point recorded.
6. The next sampling point in each stratum was identified systematically by adding or subtracting the interval to or from the grid ID number randomly selected as a first sample point and this was continued until the locations of all the required sample plots were identified.
7. Finally, locations of the sample plots were identified from the whole project site displayed on the map using their corresponding geographic coordinates. These GPS points recorded were fixed on the ground through a navigation technique after the sampling design approved by DOE (Figure 3.2).
8. Once the coordinates of each sample plot were identified in the ground, the DBH and tree height within each nested circular sample plot was measured to estimate the carbon stock change over time. The centre of each circular sample plot was fixed with metal bar. The metal bar was buried 5-10 cm below the ground to be detected by magnet during subsequent monitoring.

Table 3.4 Sample plots, interval between sample plots, required number of sample plots

Strata Number	Possible grids per stratum	Interval between sample plots	Required sample plots number per stratum	Area of each stratum (ha)
1	3737	467.1	8	233.48
2	10079	719.9	14	630.71
3	27090	475.3	57	1698.71
4	1819	454.8	4	114.41
5	919	459.5	2	50.7
Total	43644		85	2728.01

In brief the sample plots were established in accordance with the sampling design procedure in the Sourcebook for LULUCF projects, approved methodology AM0003 version 4 and the monitoring manual developed by Pearson et al. (2005). The data were recorded in the Humbo A/R-CDM data management template developed by project developers with the trustee.

Figure 3.2 Permanent sample plot locations, dots are location of circular sample plots



Source: WVE Humbo A/R-CDM project site sample lay out report

3.3.2.1.6 Ex-post biomass calculation

The project developer used the amended UNFCCC guideline, which allowed employing the allometric equation for the project site tree species rather than using IPCC default value. As a result, for ex-post estimation of tree biomass a species-specific or group-of-species-specific allometric equation derived from trees growing in edaphic-climatic conditions similar to Humbo A/R-CDM area was considered appropriate, and hence employed for ex-post estimation.

Below ground tree biomass was measured by applying a regression model to determine belowground biomass from knowledge of AGB. The regression models utilized was:

$$BGB = exp(-1.0587 + 0.8836 \times in\ ABG)$$

Where BGB = belowground biomass density in tons per hectare and ABG = aboveground biomass density is also t/ha according to Pearson et al. (2005). The equation used for above ground biomass was;

$$AGB = 0.2035*(DBH^{2.3196}).$$

3.3.2.2 Methods for socio-economic survey and sample size

A household (HH) survey was implemented to collect quantifiable data on HH characteristics, behaviours, and perceptions related to the social, environmental and economic contributions of native tree species based A/R-CDM to community level SD, and FMNR forestry practice attractiveness.

A multi-stage random cluster sampling approach was used to maximize the efficiency of data collection. The calculated sample size (n=390) was divided into 30 clusters (390 into 30) and gave 13 HH per cluster, for a total sample size of 390. Population clusters were identified using a comprehensive list of 'gotes' or sub-kebeles, ('kebele' being the lowest administrative structure) in the project area. The survey was also implemented on two non-project sites located in close proximate to the study area.

At non-project area the survey was administered to the same size households. Both project and non-project area surveyed HHs found 780. Target kebeles and clusters in the non-project area were selected purposively to: (1) ensure they did not include any population centres larger than those found within the project area; and (2) capture the different levels of remoteness vis-à-vis a paved road and large population centre.

Additionally, 18 KIIs and 14 FDGs were conducted to gather qualitative data about the experiences and perceptions of FMNR forestry practice utilized A/R-CDM project stakeholders, project and government staff, and other persons involved or affected by the initiative. KIIs were held with WVE staff, government officials from the kebele to federal levels and cooperative leaders. FDGs were pooled from cooperative members, cooperative non-members living in the project area, youth living in the project area, and elders from project communities and managed by the researcher.

3.3.2.3 Methods for climate data

3.3.2.3.1 Climate change trends

The long-term (1975-2016) meteorological data for rainfall and temperature of Humbo station obtained from Ethiopian NMSA was analysed to find out the trend.

3.3.3 Data analysis

Quantitative data collected during the household survey entered into a formatted Excel spread sheet. The raw data were cleaned and coded in preparation for frequency of distribution analysis. Then the data were imported into SPSS, version 24, and summarized into tables, charts and graphs. Crosstabs and t-tests were also used to explore significant differences between project and non-project households. The interview data were transcribed and coded into themes identified in the literature review and the conceptual framework. Data summaries that emerged as communality and difference were categorized. Patterns that are consistent with scholarly works and policy implementation results were identified and analysed and issues of differences were substantiated for empirical understanding and further study. In the process of analysis, the systematic survey results and the qualitative summaries supported the triangulation of the authenticity of the responses and evidence.

Qualitative data collected from FGDs and KIIs recorded by hand and typed into text documents. Analysis used descriptive statistics (frequency, percentiles, means, and measures of central tendency, percentage, proportion) and appropriate testing was undertaken where appropriate.

3.4 Ethical considerations

Ethics imply norms for conduct that distinguish between acceptable and unacceptable behaviour, and help researchers grapple with ethical dilemmas by providing important insights, concepts, tools, principles, and methods that can be useful in resolving these dilemmas (Lincoln and Guba, 1985; King et al., 1994).

During this study, ethical considerations were taken into account in order to protect the subjects of the research (human and non-human), and to prevent the researcher from prying into topics or events that may be unsafe or may make either party feel uncomfortable.

Among the critical steps in the researcher’s endeavour for ethical considerations was the need to seek written consent and authority from the international NGO called World Vision Ethiopia to accesses the selected case study area and database. The written consent in this regard was successfully issued. Concerning the consent of households, the Humbo District Administrator, as the gatekeeper to the rural district, issued the researcher with the assurance for the necessary support and cooperation through the Humbo Forest Protection and Development Union in the study area. The researcher was, therefore, granted access to, and cooperation from, the community leaders and different government sector offices under the district.

Once approval was granted by the UNISA’s College of Agriculture and Environmental Sciences Ethics Committee, the researcher and assistants arrived at the study area, reached out to targeted grassroots participants for the study and, accordingly, their individual consent was solicited and granted for the study which was carried out from 2013 to 2016.

Given the high regard accorded to the need to guarantee anonymity and confidentiality to the participants in order to enhance the willingness of the human subjects to participate in the survey (Bryman, 2012), the study was committed to this research principle. While it is this particular researcher's belief that most (not necessarily all) of the data and information collected is hardly classified as sensitive, confidentiality in particular and anonymity to a certain level have been a matter of serious consideration to the entire research process.

With regards to anonymity, a 'strictly anonymous' study design is considered as one in which it is impossible to trace data or information back to the research subject from whom it was obtained (Bryman, 1988; 2012). In an effort to address the anonymity dilemma, the data collection instruments in the survey did not require the personal names of the human subjects. In the case of key informants, names of offices or organizations have been noted whilst for questionnaires and historical profiling, code numbers were adopted. This was intended to sustain some degree of anonymity to the human subjects in the study, whilst at the same time allowing the possibility of a revisit to the study area and the intended participants whenever academic need arose.

The study was therefore committed to 'utmost confidentiality' with regard to research participation. In addition the study was strictly committed to the privacy of human subjects and the information attributable to them. Guarantee was therefore ascertained to protect all identifiable information about a person (such as notes or photo of the person) and to agreements about how data were to be handled in keeping with subjects' interest in controlling the access of others to information about themselves.

The study made sure that fears and concerns of participants were positively considered and respected. Balance was established between the concerns for the integrity of data on the one hand, and risk to privacy or confidentiality and anonymity on the other.

In terms of gender sensitivity, the need for a gender balance in the survey was taken seriously, particularly based on the argument that women's and men's perceptions of climate change and environmental degradation varies (UNEP, 2002). In the face of climate variation and climate change, when floods strike or droughts persist, women are among the first to feel the impacts on their livelihoods and daily lives. As a mother of household resources, they often struggle to secure water, fuel and food. The rural man on the other hand should not be overlooked as he is also equally in constant struggle, interacting with, and dependent on, the climate-sensitive natural resources to meet his everyday needs. Both sexes share a fair share of importance in terms of representation in the survey on the attractiveness of FMNR and sustainable development impacts observed due to the Humbo A/R-CDM initiative.

3.5 Expected outcomes

Expected outcomes from this study were that the study would provide evidence whether the UNFCCC market-based climate change set up mitigation A/R-CDM achieved its twin objectives: specifically, emission reduction and SD.

CHAPTER 4: NATIVE TREE SPECIES BASED CARBON SEQUESTRATION IN HUMBO, ETHIOPIA

4.1 Introduction

Plants, particularly perennial vegetation such as forests, are serving as sources and sinks of carbon dioxide. Globally, forest vegetation stores 283 Gt of carbon in the biomass, 38 Gt in dead wood, and 317 Gt in the soil (top 30 cm) and litter layer. The total carbon content of the forest ecosystem has been estimated to be 638 Gt for 2005, which is more than the amount of carbon in the entire atmosphere (IPCC, 2007). The annual carbon sequestration that the forests absorb/sequester annually is estimated to be 2.6 billion tons, and 60% of which (about 1.56 billion tons) is emitted back into the atmosphere through deforestation and biomass burning. Annual carbon emission from deforestation accounts for 17% of the global GHG (Pearson et al., 2005).

Several reports indicated that the major sources of CO_2 emissions are from the use of fossil energy sources amounting to annual emission of 8.4 Gt carbons (Raupach et al., 2007; Canadell et al., 2007).

The deforestation of tropical forests alone contributes 1.5 Gt C year^{1} to the global anthropogenic emission, suggesting that large parts of deforestation induced emission (96%) is from tropical forest deforestation versus 8.4 Gt carbons year^{1} from the use of fossil energy sources (Raupach et al., 2007; Canadell et al., 2007).

In Ethiopia, several reports on historical forest cover trend estimates report results that are not in close agreement. Some reports and text books suggested that some 87% of the Ethiopian highlands had forests and this amounts to about 40% of the total land mass of the country (Lemenih and Woldemariam, 2010), and that this was reduced to 14-16% in the 1960's. Others reported a decline of forest cover to 5.6% by 1980 and 2.4% by 1990 (Sayer et al., 1992).

Estimates of the FEPA (1994) indicated that the closed natural forests have been reduced to 2.7% of the country, and these are found mainly in the south-western highlands (NMA, 2001). Yet, the 40% of the forest cover and the 80% of highland forest cover were not confirmed by survey data and by other proxies of paleo vegetation history. The discrepancy among the later reports may arise from differences in the methodological approaches and forest cover definition used to estimate the forest cover. Whatever discrepancies among the reports on the historical size of the Ethiopian forest cover exist, the country has experienced severe deforestations and land degradation.

Recent government reports indicated that Ethiopia's forest cover is progressing to 15.5% of the total land mass (MEFCC, 2016). This revealed the effort of the government to keep increasing forest cover and ensure sustainable forest management so that the country can anticipate opportunities from carbon financing via REDD+, and avoid deforestation including forest conservation or sustainable forest management besides the in-country efforts.

Scholars (Robert et al., 2008) conducted a global analysis of land suitability for A/R-CDM carbon 'sink' projects and identified large amounts of land (749 million ha) as biophysically suitable and eligible as per A/R-CDM criteria. Out of this amount, 46% of all the suitable areas were found in South America and 27% in sub-Saharan Africa. Coming to Ethiopia, Yitebitu et al. (2010) reported 36,434,400 ha as eligible land for A/R in Ethiopia. This implies that if Ethiopia develops these forest resources by accessing carbon finances, it might be possible to mitigate the release of 2.76 billion tons of carbon year^{1} into the atmosphere. The opportunity found in Ethiopia alone is almost greater than the global annual carbon sequestration potential estimated to be 2.6 billion tons. As a result, reforestation in the tropics has received considerable attention in the last decade due to increased interest in expanding markets for timber and environmental services such as carbon storage and biodiversity conservation (Chazdon, 2008).

However, the reforestation in the tropics has been dominated by mono-specific plantations because of their apparent economic and management advantages, such as the concentration of resources dedicated to the growth of a desired species, the simplicity of seedling production and stand management, and a uniform harvest with regular rotation cycles (Evans and Turnbull, 2004). Furthermore, the establishment of exotic species plantations, such as *Acacia, Eucalyptus, Pinus, and Tectona* (FAO, 2001), has dominated the reforestation efforts. Exotic plantations have high potential to sequester atmospheric CO_2 at a rapid rate, and this potential needs to provide other environmental services by introducing mixed stand management practices in a manner that exotic tree species are mixed with indigenous tree species. The Humbo A/R-CDRM forest project, where this study was conducted, is dominantly characterized by occurrence of diverse native trees stand.

Until recently, the use of native tree species in Central America was promoted exclusively for rural development and domestic wood production. In this region, the use of native tree species has now expanded to include other purposes such as industrial wood production and commercial-scale carbon sequestration (Lam et al., 2010). Hence, the demand has increased for the long-term performance of native tree species in terms of timber and biomass production and the economic viability of reforestation in the region.

In Western Sudan, for example, the Community-Based Rangeland Rehabilitation for Carbon Sequestration project has helped improve local rangelands, as rangelands are a mainstay of Sudan's economy, covering about 60% of the country and providing fodder for one of Africa's largest concentrations of livestock. This initiative has helped to protect more than 300 local farms from wind erosion by planting *Acacia Senegal* and *ZiZiphus* trees as windbreaks over a stretch of 108 km.

Similarly, the Western Kenya Integrated Ecosystem Management Project is reported to improve the ecology of Lake Victoria Basin by taking up erosion control and watershed management activities on 900 km^2. On other hand, it is reported that some sequestration projects may actually be harmful, particularly if they focus on single species plantations or fast growing exotics that are effective in storing carbon but create other adverse effects (UNEP, 2002). Such plantations can often result in substantial losses in stream flow, and increased salinization and acidification (Jackson et al., 2005). Some exotics tree species are known for threatening local biodiversity and destroying native species.

Ethiopia biodiversity loss has been reported as one of the consequences of natural forest degradation despite the country being reported to be one of the most important centres of biodiversity (Vavilove, 1997). For instance, Eshetu Yirdaw (2002) placed Ethiopia as the fifth largest flora in tropical Africa. However, these immense biodiversity resources have been under continuous and severe threats of destruction. Massive habitat loss or habitat degradation is accompanied by large erosion of genetic resources (Legesse, 1995; Lemenih and Tektay, 2004). This is because large numbers of terrestrial organisms found in the natural forests (Taye Bekele et al., 1999) are being affected. For instance, 129 endemic plant species of Ethiopia and Eritrea were threatened due to forest destruction (Kelbessa et al., 1992). Many other scholars (Kelbessa et al., 1992; Legesse, 1995; Lemenih and Tektay, 2004) remarked that threatened endemic species require special attention because they are in the only habitats in which they are found. It is obvious that when their habitats are destroyed, those plants and organisms will be lost forever; and with them a wealth of indigenous flora and fauna, which would be very difficult to replace.

The damaging consequences of native forest degradation includes the loss of ecological services such as biodiversity and watershed protection, the loss of many goods like timber and non-timber forest products, and also the loss of means of existence for forest dwelling people. These losses have fallen particularly heavily on the rural poor in tropical countries, where the livelihoods of at least 300 million tropical forest-dependent people now depend upon these degraded or secondary forests (ITTO, 20002).

Specifically, the natural forests of Ethiopia have been declining rapidly due to their conversion into arable lands and continuous illegal logging. These conditions are coupled with rapid population growth. Centuries (and even decades) ago, large numbers of indigenous tree species such as *Podocarpus falciformi* (Thunb.) Mirb.*, Juniperus procera* Endl., *Cordia africana* Lam.*, Millettia ferruginea* (Hochst.) Baker*, Prunus africana* (Hook.f.) Kalkm and *Croton macrostachyus* (Del.) used to thrive within the natural forests of Ethiopia (Legesse, 2002). Because of better quality timber from native trees, illegal logging and smuggling of forest products from natural forests was rampant since there have been few commercially exploitable forests in the country (Mesfin T,1992). In addition to deforestation, indigenous species are also affected by the introduction of exotic species. Among many, *Eucalyptus* tree species is the one taking over significant parts of Ethiopia (Pohjonen and Pukkala, 1990). *Eucalyptus* tree species affect the Ethiopia environment by disturbing the water and nutrient balance of the soil and accelerating erosion by preventing the growth of ground vegetation.

Broadly in Ethiopia, the declining trend of natural forests has been most drastic in the past 100 years. In the beginning of 1900, it was estimated that about 35% of Ethiopia's land mass, which is about 110 million ha, was covered with high forests. By the early 1950s, the cover of high forests was reduced to 16% of the total land area (EFAP, 1994). The warning of EPA was if that rate of deforestation continued, the area covered by natural forests in 2010 may be reduced to scattered minor stands of heavily disturbed forests in remote parts of the country (EFAP, 1994). The good thing is that this warning might helped all concerned to take action and save some natural forest since the Ethiopia Ministry of Environment, Forestry and Climate Change of Ethiopia reported that the out of all forests coverage reached 15.5% close to 3% are still natural forest (MoEFCC, 2015).

In Ethiopia one of the serious consequences of native forest degradation is associated with water resources of the country as deforestation increases surface run-off and reduces the amount of rainfall that infiltrates the soil and percolates into the ground water aquifers. This reduced level of water infiltration and storage affects the availability of water (EFAP, 1994). Obviously, the negative consequences of water availability and quality affect the country's overall social, economic and political wellbeing.

As a result, indigenous tree species are found ecologically more valuable than exotics for the conservation of native flora and fauna as well as for the conservation of water (Evans, 1992; Legesse, 2007).

The report by Evans (1992) disclosed that if the choice of tree species lies between exotic and native species of comparable growth and quality, the native species is to be preferred.

In many instances, native tree species could not surpass the exotic by some desirable attributes farmers motivated. Because of the fast economic benefits obtained from woodlots of exotic tree species, Azene et al. (1993) reported the danger of strong promotion of exotic species to the rich indigenous flora of Ethiopia for reforestation purposes in the extension programmes. High public attention to the economic values of exotic woodlot establishment and high environmental benefits/services to be provided from indigenous tree species suggest the need for a fundamental shift in the forest management practices that integrate both exotic and indigenous tree species for enhanced economic, environmental and social benefits.

To improve native tree based forest coverage, selecting tree species for reforestation and/or afforestation is often considered as the best option to promote the ones that are already growing in the area, since they are adapted to the environment and are thus able to regenerate naturally without suppressing the biodiversity and water resources. However practical efforts proved such thought found not able to deliver as expected. Hence, scholars like Daniel et al. (2009) reported that payments for environmental services such as the carbon sequestration and biodiversity conservation provided by native timber plantations could increase the profitability of reforestation with native species and increase the attractiveness of native timber plantations to investors. The ultimate objective of global mechanisms like KP was to achieve stabilization of atmospheric concentrations of GHGs at levels that would prevent dangerous anthropogenic (human-induced) interference with the climate system (UNFCCC, 2003).

The KP sets out mandatory limits on industrialized countries (listed in Annex I of the Protocol) to reduce their GHG emissions by an average of 5.2% below their 1990 levels by 2008-12. This is equivalent to a total reduction of 456 million tCO_2.

The CDM under the KP was the first of its kind of carbon market instrument which advanced following a ‘learning by doing’ pattern. As part of the global carbon market CDM has developed rapidly since 1997.

From very beginning the CDM has been praised as an innovative market based climate policy instrument by optimistic groups while constantly being questioned by pessimistic thoughts. Nevertheless, developing countries including Ethiopia struggled to harness carbon revenue and SD benefits from the CDM. Global climate negotiations were also aimed at scaling up climate policy instruments to steer a rapidly-growing developing world on a low-carbon path.

According to Fennhan (2009) CDM has been spurred by the development of 4,586 projects in 76 developing countries. The author indicated that these projects are expected to reduce global GHG emissions by up to 2.91 Gt CO_2e by 2012. In fact, Emily et al.'s (2009) analysis of the projects registered up to February 2009 were unevenly distributed across regions in Asia and Latin America, with a 67% and 28% share of project numbers, respectively. Africa and the Middle East have been poorly represented. Sub-Saharan Africa (SSA) hosts only 28 registered projects as of February 2009, accounting for 2.97% of registered CER volume up to 2012. Brazil, Mexico, India, China, South Africa and Israel have benefited most within their respective geographical regions.

In view of enhancing the environmental, social and economic benefits of the forested landscape through promoting climate change mitigation efforts and creating climate change financing schemes, the Humbo A/R-CDM project was established in 2016 and registered under UNFCCC A/R CDM in 2009. The major tree species that Humbo A/R-CDM initiative promoted are native through employing FMNR. This research was therefore designed to assess the rate of carbon sequestration via above and below ground live tree biomass.

4.2 Materials and methods

4.2.1 The study area

The area is the Humbo district, which is located in Wolayita Administrative zone, SNNPRS, Ethiopia. It is situated from 6° 46'48.47 to 6° 41'04.28 N and longitudinally ranges from 37°

48’35.44 to 37° 55’14.51 E. The temperature of Humbo varies from 25 ^{o}c to 28 ^{o}c. The elevation is 1200 - 1900 m.a.s.l. Average rainfall is between 800 mm and 1000 mm.

4.2.1.1 Humbo district deforestation

Humbo district is one of the districts of Ethiopia that suffers from anthropogenic deforestation, environmental degradation and associated loss of livelihood. The population pressure surged in the late 1980/90s and coupled with the 1984 drought made the area almost barren. As a result, the community’s coping mechanisms also evolved and led the community to uproot the tree stumps for charcoal. This desperate action coupled with over grazing and cyclical droughts that followed the 1984 drought episode halted the natural regeneration of the trees and hence exposed the land to hostile weather elements that left the land barren until the commencement of the native tree regeneration A/R-CDM in 2006.

Humbo A/R-CDM was selected as a case study for this study site since it is the only and biggest A/R-CDM for Ethiopia and Africa, respectively. Moreover, it is the first A/R-CDM project in getting tCER issuance in Africa and second in the world (WVE Report, 2012).

The main native tree species of the study area were: *Terminalia brownie, Steganotaenia araliacea, Opilia amentacea, Eritrena abisinica, Combretum molle, Tecalea nobilis, Grewia bicolour, Combretum collinum, Combretum molle R. Br.ex G.Don, Balanites aegyptica, Dodonaea angustifolia,* Schrebera alata (Hochst.) *Welw.* Maytenus undata (Thunb.) *Blakelock, Croton macrostaches, Hetromorpha trifoliate, Schrebera alata, Pedocarpus fulcata, Syzygium guineese, Acokanthera schimperi, Maytenus undata, Faurea speciosa Welw, Acacia brevispica, Psychotria orphila, Carissa edullis, Euclea divinorum Hiern, Terminalia laxiflora, Rhus vulgaris Meikle, Pittosporum abysssinicum, Otostegia fruticosa,* Maytenus senegalensis (Lam.) Exell and others.

4.2.2 The study method

The UNFCCC established CDM-EB, which is in charge to approve or reject the PDD methodologies, register and administer project auditors called DOEs, and approve the issuance of certified emission reductions guidelines critically reviewed across this research.

Hence, this study reviewed various reports of the project developer INGO, the PDD document itself from UNFCCC web site, what methodology was employed, how the selected approved methodology applied, the estimation of the baseline and over the year projected GHG emission reduction and monitoring plan[5]. Besides, further reviewed records like how the A/R-CDM lengthy steps and its requirements including site eligibility decision made, how site stratification, baselining, leakage calculation, the PDD validation process, the project registration at UNFCCC, verification and credit issuance processes.

4.2.2.1 Eligibility for A/R- CDM

Before engaging in developing project idea note (PIN) for A/R-CDM, the key step is assessing the eligibility of the land under consideration. The CDM EB developed a mandatory tool to be used to demonstrate the eligibility of lands (EB-22, Annex 16).

According to (Pearson et al., 2005) the eligibility of lands for afforestation and reforestation project developer expected to:

i. Demonstrate that on 31 December 1989, the land was below the national forest thresholds (crown cover, tree height and minimum land area) for forest definition under decision 11/CP.7;
ii. Prove the land is not temporarily un-stocked as a result of human intervention such as harvesting or natural causes or is not covered by young natural stands or plantations which have yet to reach a crown density or tree height in accordance with national thresholds and which have the potential to revert to forest without human intervention;
iii. Submit satellite image; or a written testimony.

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[5] UNFCCC CDM Humbo Ethiopia Assisted Natural Regeneration Project Design Document http://cdm.unfccc.int/Projects/DB/JACO1245724331.7/view

Accordingly, participatory rural appraisal (PRA) has been used to verify when the area was deforested (Humbo, PDD; WVE, 2006). The findings of this PRA clearly indicated that there was significant and consistent decimation of the forest in terms of both density and size as of the early 1970s since the forest was invaded by the ‘commons’, which systematically cleared it for fuel and construction materials (Kamara et al., 2008). The PRA found enough evidence to prove the Humbo A/R-CDM land eligible as the area deforested before December 1989/90.

4.2.2.2 Ethiopia ratification of KP and national forest definition

Like many other countries, the government Ethiopia ratified KP in 2005 in its Proclamation No. 439/2005 for its twin objectives, as this is one of requirements to be engaged in the CDM. With regard to forest definition, the Ethiopian DNA defined forest as land with trees that has a minimum area of 0.05 ha, 20% tree crown cover and above 2 m average tree height. This definition complied with UNFCCC definition of a forest, which described it as having a minimum tree crown cover value that falls between 10 and 30%, land area value falling between 0.05 and 1 ha, and a tree height of 5 m, as presented in paragraph 8 of decision 19/CP.9 (Humbo, PDD).

Ethiopia adopted a new forest definition which stated as “Land spanning at least 0.5 ha covered by trees and bamboo, attaining a height of at least 2m and a canopy cover of at least 20% or trees with the potential to reach these thresholds in situ in due course‟ in 2015 (Minutes of Forest Sector Management, MEFCC, Feb. 2015). This forest definition differs from the definition used for international reporting to the global forest resources assessment and from the forest definition used in the national forest inventory which both applied the FAO forest definition with the thresholds of 10% canopy cover, a 0.5 ha area and a 5 m height. According to the Ministry, the reason for Ethiopia changing its national forest definition is to better capture dry and lowland-moist vegetation resources.

4.2.2.3 Defining and delineating project boundary

The spatial boundaries of the land defined and properly documented from the start to aid accurate measuring, accounting, and verification. To this effect the local community representative committee, kebele administration (KA) leader, district government staff delineated the Humbo A/R-CDM project site and project developer office staff with the help of GPS and a map was produced (Figure 4.1). As a result, each of the seven KA are aware of their respective boundaries, and no boundary-based conflict has been reported so far.

4.2.2.4 *Ex-ante stratification of Humbo Ethiopia A/R- CDM project site*

So as to increase the precision of estimating carbon, dividing the area into sub-populations or strata that form relatively homogenous units is required. Stratification is also expected to decrease the costs of monitoring, while maintaining the same level of confidence. Recommended tools for defining strata include ground-truth maps from satellite imagery, aerial photographs, and maps of vegetation, soils or topography (Pearson, 2005). Out of the possibilities, Humbo A/R-CDM employed vegetation cover of the site to define strata.

4.2.2.5 *4.2.2. 5 Selecting carbon pools to measure*

There are six carbon pools applicable to afforestation/reforestation LULUCF project activities – aboveground trees, aboveground non-tree, belowground roots, litter, dead wood, and soil organic matter. At the 9th Conference of the Parties to the UNFCCC in Milan in 2003 parties determined that project participants may choose not to account for one or more carbon pools subject to the provision of transparent and verifiable information that the choice will not increase the expected net anthropogenic GHG removals by sinks. Hence, selection of which carbon pools is left for the carbon buyer and project developer negotiation to consider several factors, including expected rate of change, magnitude and direction of change, availability and accuracy of methods to quantify change, and cost to measure.

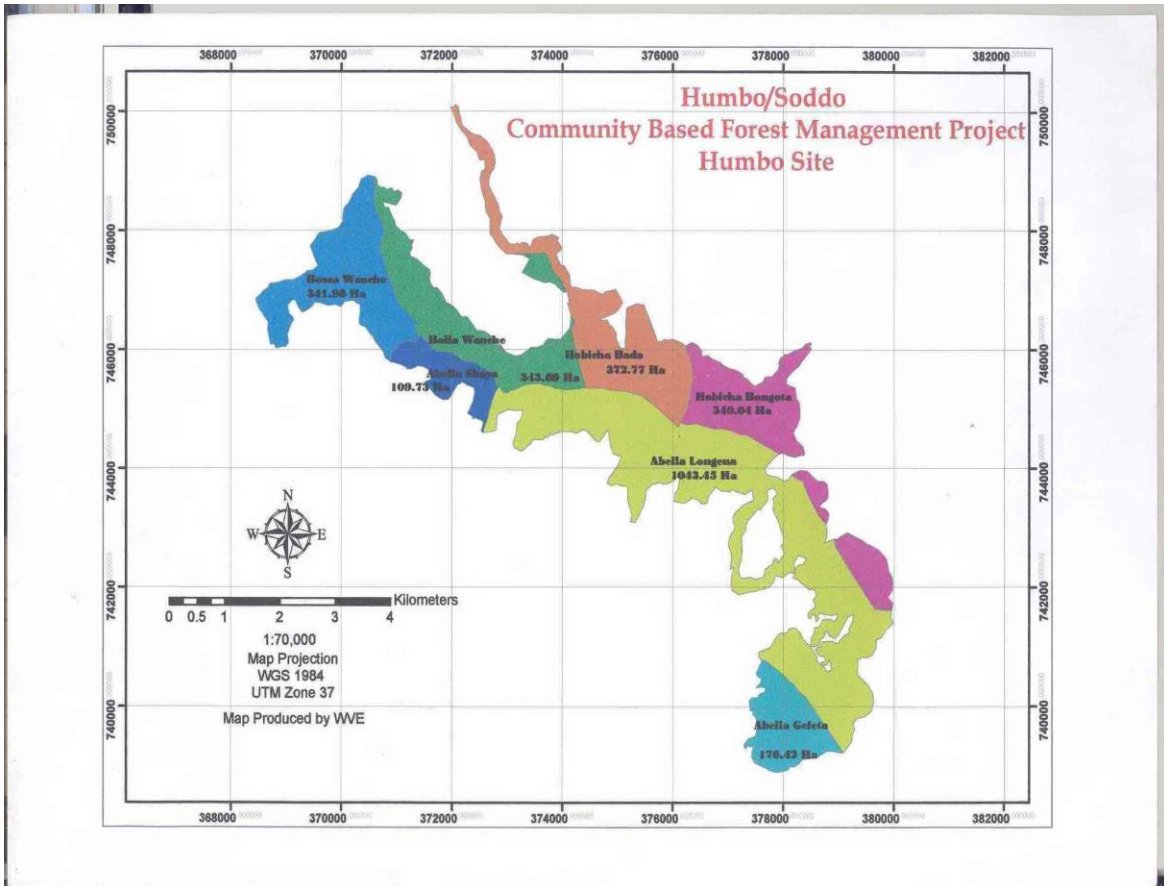
All pools that are expected to decrease because of activities have to be measured and monitored. Pools that are hoped to increase by a small amount relative to the overall rate of change need not be measured and monitored. For instance, dead wood is composed of standing dead trees and downed dead wood; it is unlikely that significant quantities of dead wood will accumulate in the 30-60 years of an afforestation/reforestation project. For agroecosystems like Humbo, studies have shown that soils of semi-arid agro-ecosystems maintained low soil organic matter stocks (Shrestha and Stahl, 2008), and the rate of carbon sequestration is retained slowly in the semi-arid tropics (0.1 - 0.2 t of C ha^{1} yr^{1}) as a factor of climate (FAO, 2001; Lal, 2004). Besides, based on field observation and omission of the Humbo A/R-CDM itself, this study also has not considered the soil carbon pool.

4.2.2.6 Plot determination and sample plots calculation

To estimate carbon changes in trees, permanent or temporary sampling plots could be used for sampling through time. According to Avery and Burkhart (1994), permanent plots for trees were found to be more advantageous. As per the authors, permanent sample plots are regarded as statistically more efficient in estimating changes in forest carbon stocks since temporary plots have high covariance between observations at successive sampling events. Besides, permanent plots permit efficient verification at relatively low cost and enable a verifying organization to pick a random sample so as to monitor carbon stock from the carbon monitoring plan. However, the disadvantage of permanent plots is that their location could be known and they could be treated differently than the rest of the project area. Yet, it is the responsibility of the auditing DOE to ensure that this has not occurred.

Permanent plots are useful for mapping trees to measure the growth of individuals at each time interval so that growth of survivors, mortality, and ingrowth of new trees can be tracked. Hence, changes in carbon stocks for each tree remain estimated and summed per plot.

Figure 4.1 Humbo A/R-CDM project site boundary delineated map



Source: Humbo PDD.

With respect to sample plots, nested circular sample plots of the smallest circle with a radius of 1 m were selected; followed by 4 m, 14 m and the fourth, 20 m, per Pearson et al., (2005). These authors presented steps to be followed to calculate the number of plots:

STEP 1- Identifying the desired precision level

Brown (2002) reported that accurate estimates of the net change in carbon stocks can be achieved at a reasonable cost of within 10% of the true value of the mean at the 95 % confidence. The level of precision determined at the outset of ±10% of the mean is frequently employed though a precision as low as ±20% of the mean could be used.

STEP 2 - Identifying an area to collect preliminary data

Preliminary data are necessary in order to evaluate variance and the required number of plots for the desired level of precision. Between six and ten plots are recommended as sufficient to evaluate variance.

STEP 3 - Estimate carbon stock, standard deviation and variance from preliminary data.

STEP 4 - Calculate the required number of plots (n)

$$n = \frac{(N * s)^2}{\frac{N^2 * E^2}{t^2} + N * V}$$

Where,

E: is the desired half-width of the confidence interval, calculated by multiplying the mean carbon stock by the desired precision (i.e. mean carbon stock * 0.1 (for 10% precision) or 0.2 (for 20% precision),

t: is the sample statistic from the t-distribution for the 95% confidence level - t is usually set at 2 as sample size is unknown at this stage,

N: represents the number of sampling units in the population (= area of the project or stratum in hectares/area of the plot in hectares),

s: represents the standard deviation,

V: represents the variance.

For ‘n^{th}’ strata =

$$n = \frac{(N_1 * s_1)^2 + ...+ (N_n * s_n)^2}{\frac{N^2 * E^2}{t^2} + N_1 * V_1 + ...+ N_n * V_n}$$

For stratum 1, stratum 2 through to the nth stratum

After employing the described extensive steps, the number of sample plots allocated to each stratum found 8 in stratum 1, 14 in stratum 2, 57 in stratum 3, 4 in stratum 4 and 2 in stratum 5. The type of sample plots are nested circular sample plots with 1 m, 4 m, 14 m, and 20 m radius. The location of each sample plot was reached on the ground using GPS through navigation. Tree data such as DBH, height and other data such as stratum number, series number of each plot and species name in each circle were recorded.

4.2.2.7 Tree measurement for biomass and carbon stock estimation

The location of sample plots have been overlaid on the map systematically with random a start and their respective GPS coordinates, stratum and series number of each plot have been recorded. Each sample plot was labelled and the respective coordinates have been uploaded into GPS to be fixed actually on the ground through navigation. Once the location of each sample plot is identified on the ground using GPS through navigation, the tree DBH was measured using caliber and height measured using a graduated pole for each tree species found within the stratum and within the circular sample plots, and the collected data have been used to estimate the ex-post emission reduction.

4.2.2.8 Leakage estimation

Identified sources of leakage in A/R-CDM include activity displacement from the project area to agriculture, grasslands, and forest lands. In case of Humbo A/R-CDM fuel wood and grazing displacement were identified among major leakage sources to determine the amount of fuel wood being collected by the community from the project area before the project study was conducted. Later on the project developer also used the same size sample plots of 100 m^2 randomly from four forest cooperative sites and computed whether leakage due to fuel wood existed or not. Another expected leakage source was due to livestock displacement.

In terms of fuel wood, the pre-project annual volume of fuel wood the community used collect from the project area was computed and recorded as 4.3 m^3 ha^1 (Humbo PDD). To prove whether the indicated volume of fuel wood was being collected from outside project area or not, sample plots of 100 m^2 were taken randomly from four forest cooperative sites to compute the branches and twigs removed as a result of this forest management. The selected communities or cooperatives for this computation were Abela

Longena, Bossa Wanche, Hobicha Bada and Hobicha Bongota where pruning and thinning activities carried out.

To determine the leakage due to livestock, the census results of the district livestock number of pre-project and post four years were obtained from government statistics.

4.2.2.9 Permanence

During the negotiations leading up to the KP and subsequently, there was considerable concern that credits issued for carbon sequestration would be subject to a risk of re-emission due to either human action or natural events such as wildfires; this was called the permanence risk and it is unique to LULUCF projects in the Protocol. Eventually the Parties agreed that credits arising from A/R-CDM should only be temporary but could be re-issued or renewed after an independent verification every five years that sufficient carbon was still sequestered within a project to account for all the credits issued (Pearson et al., 2005).

As CDM deals with the threat of impermanence by categorising carbon offsets as either tCERs or lCERs, projects receive tCERs if they ensure permanence of carbon stocks only until the end of the KP commitment in 2012, while projects that ensure long-term sustainability of carbon stock for 30 years can claim lCERs (Haites, 2004).

In the case of A/R-CDM, a concern about carbon sequestration potential is the threat of impermanence: a forest can be burned or cut at any stage, potentially releasing most of the sequestered carbon back into the atmosphere (Sedjo et al., 2001). Several carbon projects in Africa required addressing the need to ensure permanence of sequestered carbon. For instance, The International Small Group Tree Planting Program (TIST) has set up long-term contracts with participating farmers and the carbon payments they receive are directly proportional to the number of live trees they maintain. If a farmer cuts down trees on his/her farm, the corresponding payment also declines despite the actual impact of tree harvesting on the global carbon balance depending upon the harvesting technique used, the land use after harvesting, and the fate of the wood that is produced. Wood used for furniture or house construction, for example, may sequester carbon for decades or longer.

Reflecting the UNFCCC's approach to non-permanence in the A/R sector, tCO_2e produced in projects are accounted for as temporary credits. Hence, Ethiopia Humbo A/R-CDM credits are called tCER.

4.2.2.10 Ex-ante baseline net GHG removals by sinks

The baseline scenario can either be estimated and validated upfront and then "frozen" for the first phase of the crediting period (30 years, or the first 20 years of up to 60 years), or it is also possible to monitor the baseline during the A/R project (Pearson, 2005). However, even in the latter case, it is necessary to establish a methodology upfront on how to select the control plots, and how to monitor them, and it is necessary to provide an up-front estimation of the baseline including the associated emissions and removals of GHGs. The advantage of an upfront estimated and "frozen" baseline is to ascertain the ERs generated by the project.

Accordingly, the Humbo A/R-CDM baseline mean carbon density estimation was calculated using the formula Biomass = 0.2035 x $_{DBH}{}^{2.3196}$ for dry lands (Pearson, 2005). The stratum 1, 2, 3 and 4 mean carbon density was found to be 8.85, 3.50, 8.73 and 7.09 (tC/ha) respectively. This revealed that the mean carbon stock of the baseline strata was in the range of 3.5 to 8.8 tC/ha because of the constantly degrading anthropogenic pressure. Therefore, the baseline scenario of all the four strata emission (tCO_2e) were considered as zero and hence baseline carbon stock changes are not needed to be monitored. Besides, at year 12th the project developers are granted permission to harvest 50 % of the forest as part of sustainable forest management plan.

Hence the Humbo A/R-CDM PDD developed in 2006, submitted to DOE, passed both desk and field validation processes and registered at UNFCCC EB as A/R-CDM in 2009 with projected total tCO_2e 880,295.9 (Table 4.1) in year 2036.

4.2.2.11 Emission Reduction Purchase Agreement (ERPA)

ERPA is a type of transaction that has its standards set forth by the International Emissions Trading Association (IETA) whereby a purchaser will pay a seller an amount of cash in return for carbon credits. This exchange thus allows the buyer to emit additional units of carbon dioxide into the air.

The IETA developed version 3.0 of the Emissions Reduction Purchase Agreement (ERPA) for the CDM, dated 13 September 2006, which reflected further market development, input from market players and the decisions by the COP/MOP as well as CDM EB. According to IETA the ERPA should be used in conjunction with the CDM Code of Terms (IETA ERPA Version 3.0, 2006).

Table 4.1 Estimated anthropogenic GHG removals by sinks (tCO2e) over the crediting period

Year	Estimated baseline (considering continued decrease)	Estimated actual	Estimated leakage (zero leakage considered)	Estimated net anthropogenic GHG
2007	0	-25594.3	0	-25594.3
2008	0	14399.6	0	14399.6
2009	0	19291.1	0	19291.1
2010	0	27639.3	0	27639.3
2011	0	34133.0	0	34133.0
2012	0	38196.7	0	38196.7
2013	0	41373.5	0	41373.5
2014	0	44077.3	0	44077.3

2015	0	46603.8	0	46603.8
2016	0	50393.4	0	50393.4
2017	0	47538.0	0	47538.0
2018	0	-86275.8	0	-86275.8
2019	0	30826.3	0	30826.3
2020	0	33685.2	0	33685.2
2021	0	38862.1	0	38862.1
2022	0	46164.7	0	46164.7
2023	0	45880.3	0	45880.3
2024	0	47027.1	0	47027.1
2025	0	47027.1	0	47027.1
2026	0	47027.1	0	47027.1
2027	0	47027.1	0	47027.1
2028	0	-82661.0	0	-82661.0
2029	0	27601.9	0	27601.9
2030	0	27601.9	0	27601.9
2031	0	37314.5	0	37314.5
2032	0	47027.1	0	47027.1
2033	0	47027.1	0	47027.1
2034	0	47027.1	0	47027.1
2035	0	47027.1	0	47027.1
2036	0	47027.1	0	47027.1
Total (tCO_2e)		880,295.9		880,295.9

Source: Humbo PDD

Accordingly, WVE and WVA on behalf of the Ethiopia A/R-CDM project owner community, and The Wold Bank BioCarbon Fund as a trustee, signed a tripartite agreement. The World Bank's BioCarbon Fund agreed to purchase 165,000 tonnes worth of these credits and to provide an income stream of more than USD 7,260,000 to the local communities over a minimum of ten years until the end of 2017 (Humbo PDD).

4.2.2.12 A/R-CDM validation

Jaco CDM Limited acted as a DOE accredited by the UNFCCC to validate Humbo A/R-CDM. The validator conducted a desk review of the PDD, conducted a review of the baseline and the monitoring plan, conducted follow-up interviews with project stakeholders, visited during project implementation, and confirmed all the resolutions for outstanding points and issued the final validation report (WVE Report, 2011).

It was evident in the reviewed materials that the DOE validation project developer made every effort to verify the PDD. Major milestones in the development of Humbo A/R-CDM are presented (Table 4.2). Finally, the PDD was submitted to CDM EB by tge DOE with a validation report for registration, and registration at UNFCCC was announced on December 09, 2009.

4.2.2.13 Re-stratification of project site

Five years of intervention, changes in growth of vegetation cover were observed within the strata 2, 3, and 4 during pre-verification assessment period. To address these changes, the pre-verification process advised the project developer to re-stratify.

The re-stratification after the time of pre-verification was supported by the minor amendments endorsed by the CDM EB at the meeting EB 63, documented in Annex 27 paragraph 3. This guideline lowered the minimum DBH of the forest inventory from 4 cm to 2 cm, which was encouraging to project developers. The provision given and the variation of vegetation growth due to respective area difference affected strata 2, 3 and 5 so as to increase the precision of the results of the sampling.

As a result, some parts of stratum 2 moved to stratum 3 and some areas of stratum 3 covered with rocky and scattered vegetation were removed and included into stratum 4. The fifth stratum, which is considered a refill planation area, was estimated to span 500 ha at project inception, and shrank to 50.7 Ha, only due to massive regeneration after closing the site for not more than three years. Each stratum was identified and the sampling design developed following the procedures in the approved methodology AM0003 version 4.

4.2.2.14 UNFCCC EB amendments

In countries like Ethiopia where there are multiple tree species but not data characterizing species-specific behavior, the option has been to use default data, which is usually conservative. As a result, Humbo A/R-CDM used BEF to calculate the tree biomass during the PDD development period. Before the Humbo A/R-CDM reached its verification period, UNFCCC EB amendments were made globally through its EB63 Annex 27 (p) decisions.

Table 4.2 Major milestones in the development of the Ethiopia AR-CDM project

Date/Year	Milestone	Required
February 2005	Project Idea Note (PIN) completed by WVE and WVA and submitted to the BioCarbon Fund of the World Bank	DNA and CDM
June 2005	Completion of a carbon finance document provisional acceptance into the BioCarbon Fund World Bank	World Bank
January 2006	World Bank team assessment of project site and exhaustive consultation with all levels of the concerned government offices from Federal to Kebele by World Bank team through WVE facilitation.	World Bank
April 2006	Acceptance of project into the BioCarbon Fund	CDM

May–September 2006	Baseline analysis and pre-existing biomass assessments undertaken by WVE	CDM
December 2006	Project inception: area closure and introduced selected forestry practice called FMNR	CDM
January 2007–August 2008	PDD developed by WVE and WVA with support of World Bank; and signed ERPA	CDM
August 2008	PDD submitted to JACO for validation CDM	CDM
November 2008	Period of public review of PDD	CDM
March 2009	Validation mission - JACO CDM	CDM
April–June 2009	Clarification and rectification of outstanding PDD issues for validation CDM	CDM
24 June 2009	Submission of validator's report and PDD to UNFCCC for registration	CDM
December 2009	Project registered at UNFCCC CDM	CDM
July 29, 2012	1st periodic verification of the Humbo A/R-CDM, with regard to the relevant requirements. This verification confirmed that the project has achieved emission removals during December 1st, 2006 to December 1st, 2011 reporting period emission reductions of 73,339 tCO2e. Second verification is expected after 2018.	CDM

One of the amendment provisions was allowing employing allometric equations since it was not possible to find out specific BEF equations for the Humbo region and the type of multistory forest at the time of verification. So, an allometric equation *(0.2035*(DBH^2.3196)* was found available and was considered as a better option for the regional climatic growth conditions of the tropical dry forest.

The second provision was allowing accounting ≥ 2 cm minimum tree DBH instead of ≥ 4 cm to estimate ER under EB63 Annex 27 (m). This change resulted in adding more tree numbers and hence led to an increase in estimated biomass. The minimum tree diameter covered under amendment was found to be fair since it represented most of the forest in the five year old stands.

The third flexibility component from UNFCCC EB was allowing maximum relative margin of error of the mean for estimation of aboveground biomass from ± 5% in the PDD to ± 10% during first verification time as stipulated under EB63 Annex 26 (UNFCCC, 2012).

The fourth important guide from UNFCCC CDM EB 63 was that Annex 26 removed estimating and accounting for leakage emissions through fossil fuel consumption, both within and outside the project boundary, for projects developed according to AM0003-V4 methodology, as projects like Humbo were developed mainly manually. Moreover, the lifting up of leakage deduction from soil disturbance for pit preparation, biomass burning, fertilizer use, and fencing were good news for project developers. Such actual context-based amendments were encouraging for a diverse world instead of roping everything into a single policy.

4.2.2.15 Verification

As per the monitoring methodology, a sample of boundary points has been monitored to ensure accuracy of the project boundary. The PDD requires 1% of boundary points be monitored to increase the quality of the data from the parameter. Yet, a sample of 10% of boundary points was monitored. The sample coordinates were selected randomly from the PDD. The main purpose of this exercise was to check the data in PDD (WVE, monitoring report, 2012). To this end, the independent and accredited verifier called TÜV NORD CERT GmbHJI/CDM Certification Program confirmed that the monitoring system is in place and functional in accordance with the applied approved CDM methodology, i.e. AR-AM0003-version 4 m; which provided evidence towards proving the total and net tCER of the first crediting period.

4.3 Model employed to determine AGB & BGB carbon sequestration

Only live tree carbon pools, which are AGB and BGB, were considered for above ground carbon stock estimation. Other carbon pools such as dead wood, litter, and soil carbon were thought to be insignificant. The equation used for AGB biomass calculation was: AGB= 0.2035*(DBH^2.3196), which fits to dry land (900 – 1500 mm rainfall and general tree species group) (Brown, 1997). Below ground tree biomass was computed by applying a regression model from knowledge of AGB (Pearson et al., 2005). The regression model employed was:

BGB = exp(-1.0587 + 0.8836 x in ABG).

Where,

BGB = below ground biomass density in tons ha^1 and

ABG = above ground biomass density (t/ha)

DBH = diameter at breast height

4.4 Result and discussion

4.4.1 Leakage

Major sources of leakage in A/R-CDM include activity displacement from the project area to agriculture, grasslands, and forest lands. In the case of Humbo A/R-CDM, fuel wood and grazing displacement were identified among major leakage sources. The amount of fuel wood being collected by the community from the project area was reported to be 4.3 m^3 ha^1 $year^1$ (Humbo PDD). During the first verification period, the project developer followed the same process and collected data regarding fuel wood collection during the period in which FMNR was practiced from four forest cooperative sites and computed whether leakage due to fuel wood.

The selected communities or cooperatives for this computation were Abela Longena, Bossa Wanche, Hobicha Bada and Hobicha Bongota where pruning and thinning activities have been carried out as part of FMNR practice. The average fuel wood collected from the project area by the community for fuel wood year^1 Ha^1 was 5.1 -6.1 M^3 from project scenario (Table 4.3). This indicated that the amount of forest branches and twigs being removed as a result of forest management practices year after year was increasing, and displacement for firewood was found to be zero. As a result, leakage due to firewood was omitted.

The (DOE report, 2012) further confirmed in its verification report for a period of 2006-12-01 to 2011-12-01) that biomass was removed as part of forest management through FMNR practice and was used as fuel wood by the community living adjacent to the project site, which further proved leakage due to fuel wood does not exist.

Table 4.3 Fuel wood (m^3/ha) collected over four years

Years	Abella Longena	Bossa Wanche	Hibicha Bada	Hobicha Bongota	Total	Average
2008	4.2	4.9	5.45	5.85	20.4	5.1
2009	4.37	4.97	5.94	5.99	21.27	5.3
2010	4.71	5.16	5.81	6.50	22.19	5.5
2011	4.97	5.48	6.97	7.07	24.50	6.1

Source: WVE Report

Another expected leakage source was livestock displacement. To estimate leakage due to livestock displacement, the results regarding community livestock adjacent project site was obtained from government statistics (Humbo Woreda Office of Finance and Economic Development Report, 2006-2009). Accordingly, the number of existing animals grazing on non-project area before the project was 8,684 cattle and 2,288 goats. But after four years, the number of animals reached 11,383 cattle and 429 donkeys and 4,108 goats. The argument was that farmers are increasing the number of livestock in the project area since there was extra existing grazing land under the control of animal owners, and that the various capacity building training events given to the farmers in this sector enabled farmers to improve efficiency. Besides, ample amount of grass was being harvested from the project site using the cut and carry system. During this research period, some of the farmers reported that they even started selling grass harvested from the closed project site as of the second year and generated income out of it. The DOE also closely observed during the first monitoring period and verified that the project activity has not displaced the grazing animal population. As a result the leakage due to conversion of land to grazing was set as zero (DOE report, 2012), despite harvested grass from the project side being fed to the animals obviously converted into methane emission. Like any open access area, if the project site had not been demarcated as a protected area, then the increased livestock would have aggravated carbon stock degradation.

4.4.2 Carbon sequestered

According to (Humbo PDD) baseline mean carbon density estimation employing on the preliminary data collected from 24 plots of four straum was calculated using this formula (Biomass = 0.2035 x $^{dbh2.3196}$) for dry lands from page 43 of the Sourcebook for Land Use, Land Use Change, and Forestry Projects (Pearson et al., 2005.). The biomass stock was converted to carbon stock and CO_2e (CO_2e= Biomass *0.5*3.66)

Table 4.4 Mean AG & BG (tCO_2 ha^1 stock of the baseline

	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Total
Area (ha)	233.88	745.16	1653.9	95.14	2728.08
Mean carbon density (tCO_2 ha^1±sd	8.850±8.50	3.503±2.75	8.727±3.53	7.09±5.44	7.043

As the mean carbon, stock of the baseline strata was very low and in the range of 3.5 to 8.8 tCO_2 ha^1 (Table 4.4). Considering the further anthropogenic degrading pressure the baseline scenario of all the four strata were assumed as zero.

According to the verifier report covering 01/12/2006 – 01/12/2011, the actual GHG removal found amounted to 116,850.19 tCO$_2$e (Table 4.5.). The net anthropogenic GHG removal by sinks was found to be 73,138.49 tCO$_2$e during the first monitoring period, unlike the ex-ante calculation of the registered CDM-PDD which was 69,868.7 tCO$_2$e. This implies that tCERs accrued from the project activity amounted to 73,138.49 tCO$_2$e from a total of 2628 Ha. The increase in net ER was found to be 4.96% higher than the ex-ante (Humbo PDD) value calculated using biomass expansion factor (BEF). The increase could be due to counting trees with DBH $\geq$ 2 cm instead of considering with DBH $\geq$ 4 cm and using the allometric equation adapted for a dry tropical forest.

This indicated that the Humbo, Ethiopia native tree species-based A/R-CDM project sequestered on average a net 5.4 tCO$_{2e}$ year^{1} ha^{1} during the initial five years, which is better than other LULUCF carbon sequestration values reported, which ranged from 0.05–0.7 tC0$_2$e ha^{1} year^{1} (Perez et al., 2007; Aune et al., 2005). Anune et al (2005) further reported that Miombo woodlands and Alnus woodlots sequestered 8 and 5.9 tCO$_2$e ha^{1} year^{1} respectively. Hence, the Humbo A/R-CDM sequestration ha^{1} year^{1} seems fair since it is a multi-storey native tree species-based regeneration where the regenerated tree species are not intentionally selected woodlots.

The project developer, WVE, undertook monitoring sequestered carbon from permanent sample plots during the years 2014, 2015 and 2016 and reported a net tCO$_2$e of 84,848, 103,769 and 111,657 (Table 4.6), which has been bringing the equivalent carbon revenue to the community as per the agreed-upon US$ 4.4 per tCO$_2$e..

Considering the change in tCO$_2$e sequestration, the data revealed an increasing trend of ER, albeit with variation from strata to strata (Figure 4.2) which might be due to altitude, soil fertility, tree species difference and related attributes of the particular strata.

Nevertheless, the project developer and trustee agreed to consider only above ground and below ground carbon pools on the basis that all six pools or at least more than two carbon pools might increase the total tCO_2e sequestered. Quantifying the ER contribution of the remaining pools is left for further research in the future.

Table 4.5 Year 2011 Humbo native tree based A/R-CDM DBH, and total AG and BG tCO_2e per stratum

Stratum	Slope range (%)	Elevation range	**Mean DBH (cm)**				**Grand mean**	Total BG tCO_2/stratum	Total AB tCO_2/stratum	
			1m	4m	14m	20m				
			DBH	DBH	DBH	DBH	DBH			Total AB+BG CO2e tone
1	8.51-24.79	1380-1546	4.28	10.8	29	0	11.1	20248.02	5466.97	25714.99
2	5.15-40.8	1432-1820	3.46	6.89	39	0	12.3	13199.43	3563.85	16763.28
3	8.74-73.49	1421-1914	3.04	6.06	0	0	2.28	58128.34	15694.34	73822.68
4	27.81-60.96	1874-1915	0	5.43	0	0	1.36	432.23	116.7	548.93
	Grand Mean		3.13	6.45	31	0				
Total carbon on study site in 2011								92008	24842	116849.88
Less pre-existing biomass										43,711.70
Net emission reduction from the sink										73,138.49

The China Guangxi A/R-CDM project reported quality reductions of GHGs emission that were measured, monitored and verified. Likewise, the Humbo A/R-CDM also revealed that employing multi-storey native tree species generated GHG reductions that are being measured, monitored and verified.

The finding is in agreement with the report of Talemos and Sebsebe (2014) which indicated that the native multi-storey agroforestry tree species of Wonago district (Gedeo Zone) demonstrated great potential for carbon storage and thus may reduce pressure on the adjacent natural forest, and provide potential payment opportunities to avoid deforestation and forest degradation.

Table 4.6 Net tCO_2e sequestered ha[1] across 2006- 2016 of Humbo A/R- CDM

Strat	Area (ha)	Total tCO_2 sequestered			
		2011	**2014**	**2015**	**2016**
Strata 1	233	25,715	25,656	24,438	22,568
Strata 2	631	16,763	17,940	20,740	21,604
Strata 3	1,699	73,823	84,232	101,500	110,346
Strata 4	114	549	468	483	499
Strata 5	51	*	264	320	351
Total CO2 sequestered	-	116,850	128,560	147,481	155,369
Baseline		43,712	43,712	43,712	43,712
Net CO2 sequestered	2,728	73,138	84,848	103,769	111,657

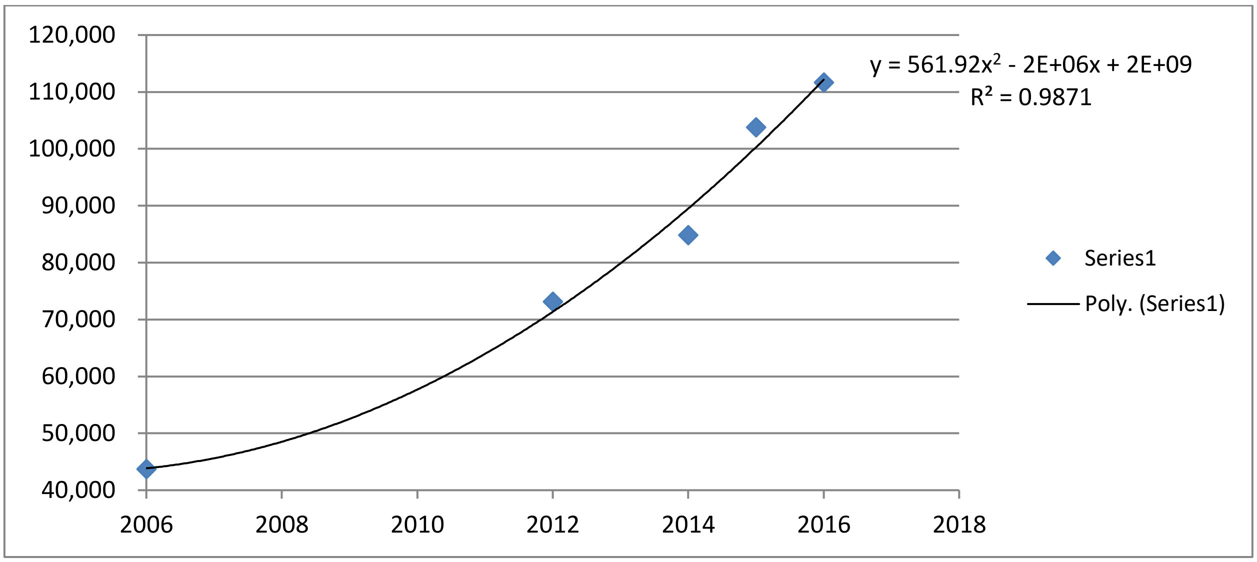
* The planted tree species DBH found $\leq$ 2 cm.

As per the A3 of the IPCC, forests, agricultural lands and other terrestrial ecosystems offer significant carbon mitigation potential (IPCC, 2001). In fact, the level of complexity of early methodologies made A/R-CDM less accessible to project developers. Thus, only highly skilled professionals were able to understand and follow the first versions of the A/R-CDM methodologies (World Bank report, 2011). As a result, the UNFCCC CDM EB amended its early stringent guideline, which was found commendable in enabling Humbo A/R-CDM to sequester 4.69% tCO_2e. Nevertheless, according to Chaturvedi et al. (2011), so as to successfully implement mitigating policies and take advantage of the REDD+ programme, developing countries need genuine estimates of forest carbon stocks.

4.5 Conclusion and recommendations

Under the CDM, project developing countries are entitled to earn a saleable credit for each tonne of GHG they reduce or avoid. The incentive seems to have led to the registration of some 8,000 projects and programmes in more than 105 countries and the issuance of more than 1.6 billion tCERs[6]. Yet, as it is reported by UNFCCC, the demand for CERs has declined, and with it the incentive to set up projects. The Paris Agreement parties' attention has turned to market mechanisms, described in its Article 6, and they are looking at what can be learned or borrowed from the CDM.

Figure 4.2 Cumulative tCO2e sequestration of Humbo A/R-CDM during 2006-2016



Then onward, like many developing countries, Ethiopia has submitted its INDC to UNFCCC according to recent climate change response mechanisms. It contains the goal to limit net GHG emissions, including emissions or removals from LULUCF, to 145 $MtCO_2e$ by 2030 as the target was projected in CGER. This represents a reduction of at least 64% below the Ethiopian business-as-usual (BAU) scenario by 2030, where net emissions are projected to reach 400 MtCO2e. Ethiopia's mitigation primarily focuses on the forestry sector—which is expected to contribute a reduction of 130 $MtCO_2e$ (Ethiopia INDC, 2015)—to become a carbon-neutral green economy in 2025. This study result indicates that this will occur if Ethiopia can remove 145$MtOC_2e$ in 20 years considering 5.2 tCO_2e

[6] https://unfccc.int/news/lessons-clean-development-mechanism-implementation-paris-agreement

year^{1} ha^{1} was achieved in an area about 1,374,230 Ha, since Ethiopia has 36,434,400 ha of land eligible for A/R (Yitebitu et al., 2010).

This study revealed that the Ethiopia native tree species based regeneration through low cost-based forestry practice sequestered on average, a net 5.4 tCO_2e year^{1} in Humbo in the years 2006-2011. In terms of net sequestered tCO2e across years 2011, 2014, 2015 and 2016, the findings were 73,138, 84,848, 103,769 and 111,657 respectively. This implies that the country can achieve its GHG commitments by promoting native tree species regeneration, all the while enjoying the multiple co-benefits of native tree species through systematic management. This research confirmed that the Humbo area native tree species-based A/R-CDM has contributed towards one of the twin objectives of CDM, GHG mitigation.

Project participants have provision to select not to account for one or more carbon pools depending on several factors, including expected rate of change, magnitude and direction of change, availability and accuracy of methods to quantify change, and cost to measure. There is also room to account for all pools that are expected to decrease as a result of activities. These should be measured and monitored. Pools that are expected to increase by a small amount relative to the overall rate of change need not be measured and monitored.

Yet, forest floor and dead wood tend to only be a significant component in mature forests. It is unlikely that significant quantities of dead wood will accumulate in the 30-60 years of an afforestation/reforestation project. Soil organic carbon is also likely to change at a slow rate and is also likely to be an expensive pool to measure. As a result, in this study, only AGB and BGB were considered. However, accounting for those pools in a second verification would provide evidence to understand the remaining carbon pools' sequestration potential.

CHAPTER 5: ATTRACTIVENESS OF FMNR FORESTRY PRACTICE FOR A/R CDM IN ETHIOPIA

5.1 Introduction

Most deliberate efforts to overcome degradation involve tree planting. However, even traditional forms of timber plantation can be risky operations, and, where species selection or early stand management are inappropriate, plantations can fail. Planting to generate ecological services as well as goods is even more difficult, because trade-offs must be made between the productivity of desired goods (i.e., timber) and the provision of ecological services (i.e., biodiversity). The techniques to achieve these simultaneous goals are still being developed (David et al., 2005).

According to Abasse et al. (2009), effective forest resource management requires interrelated technical practices and social arrangements that are appropriate to a specific region's biophysical characteristics and that address protection and sustainable management of resources. This is illustrated across five million ha of land in the Republic of Niger through FMNR. The authors reported that FMNR adoption at farmland and community forest area in Niger raised the annual gross income of the region in Niger by between $USD 17 and 21 million. The rehabilitation of 5 million ha (12.5 million acres) land was further confirmed by using remote sensing in combination with ground truth maps (Reij et al., 2009).

Since 2004, several examples of large-scale creation of new forestry practices have emerged in the West African Sahel (Reij and Garrity, 2016). These scholars reported that farmers in many parts of Africa (e.g., Niger, Burkina Faso, Mali, Senegal, Ethiopia, and Malawi) protect and manage the natural regeneration of woody species on-farm to create new parklands, but in some cases, they also promote natural regeneration off-farm to create new second growth.

One possible question is "What triggered farmers to protect and manage on-farm natural regeneration?" According to Reij and Garrity (2016), farmers were motivated by the combination of environmental, economic, and political crises in the 1980s. High population densities (100+ per km²) in this semi-arid region had led to ‘wall-to-wall’ agriculture, and an almost complete destruction of natural forests. Crop yields in the 1980s were low (400–500 kg per ha) and were declining. Also, because of the high population densities it was impossible for many families to expand the extent of their cultivated land. Low crop yields led to structural food deficits. Many men left the villages during the dry season to find employment in Nigeria. The scarcity of natural vegetation meant that women had to walk increasingly long distances to collect firewood. On average, they spent 2.5 hrs per day to collect and transport firewood. The key question raised and discussed by the authors has been the need to increase the number of trees on farms as well as off-farm. This is important in a context of accelerated climate change and ambitious pledges to restore degraded forestland. The Africa Union (AU) launched the African Forest Landscape Restoration Initiative (AFR100) in December 2015 to restore 100m ha of degraded land across the continent by 2030 (Reij and Garrity, 2016) . As part of the AU pledge, Ethiopia as a country was set to restore 15 million ha by 2030. However, the common prevailing challenge is financing the reforestation.

FMNR involves identifying and protecting the most “vigorous” stems that are growing from living tree stumps, removing the remaining stems, and tying together the selected stems so that they grow straight into a new trunk (Weston et al., 2015). As an agroforestry practice, FMNR can lead to the “re-greening” of landscapes by increasing the number of both on-farm trees and, in some countries, off-farm trees through natural forest management and for the protection and management of natural regeneration on degraded land (Reij, 2012). Agroforestry and re-greening can be considered larger umbrella terms, with FMNR being a specific technique; albeit one that has a great deal of flexibility and adaptability.

5.1.1 Origins and evolution of FMNR

FMNR is not a new technique; it is considered to be a modern version of the centuries-old practice of “coppicing and pollarding” (Rinaudo, 2011). Various forms of FMNR have been practiced for centuries around the world. It gained greater international attention after Nigerien communities in the Maradi region began using the practice in 1983. There is anecdotal evidence that FMNR was also spontaneously “rediscovered” in Niger and neighbouring countries around the time that it began to spread in the Maradi region through SIM (Francis and Weston, 2015).

In 2008, the World Resources Institute reported that over a span of 27 years – since FMNR was introduced in Niger – it has been practiced on more than half of Niger’s farmland (5 million hectares) with minimal NGO or government intervention (Rinaudo, 2011). Francis and Weston (2005) reported that over a 20-year period the average reforestation rate for Niger’s farmland was 250,000 hectares year[1]. FMNR as a systematic regeneration method was introduced to Ethiopia in 2005 through WV (WVE, 2006) to be used for Humbo A/R-CDM. After it worked well, FMNR spread across the country through regions such as the SNNRP, Tigray, Oromiya, Amhara and others. Following its success in Ethiopia, it is spreading across Africa, India, and close to 17 countries (WVE report, 2015).

5.1.2 What encourages farmers’ engagement in FMNR?

Larwanou et al. (2006) conducted a study for the United States Agency for International Development (USAID) to determine what led communities in the Zinder region of Niger to invest in FMNR. They categorized the motivations broadly as: 1) the ecological crisis of the 1970s and 1980s, 2) demographic pressure and changes in production, 3) state involvement and changes in forest policies, and 4) interventions from development partners. Regarding the ecological crisis, the researchers said that community members they interviewed often mentioned strong winds. These winds were no longer blocked by trees and they displaced sand and dust. The sand would mow over young millet and sorghum plants, in some cases requiring them to plant their crops three times before the crop would survive.

Rinaudo (2011) suggested that the breakthrough that encouraged the spread of FMNR to more than half of Niger's farmland was social rather than technical, which involved changing the collective mindset from one in which trees on farmlands were considered 'weeds' that needed removing, to one where trees in farm land were valued.

The importance of farmers having an incentive to practice FMNR is another theme arising from the literature. Rinaudo (2011) said that this does not have to be in the form of cash or a subsidy, but rather an assurance that farmers have something to gain from their efforts. Reij et al (2009) posited that farmers have a greater likelihood of adopting “resource conservation innovations” if significant benefits are achieved in the first or second year. Their study of FMNR in the Maradi region attributed the practice’s widespread adoption to the benefits that are achieved at a low cost to farmers. Labour is the only requirement; there are no other expenditures required for the practice, which makes it accessible to more farmers.

5.1.3 The merits of FMNR

Frequently discussed in the literature is the low-cost nature of FMNR combined with its farmer-driven orientation. Past efforts to plant thousands of trees in an effort to avoid desertification across Sahel, with a higher value placed on introducing non-native species, led to little improvement at a very high financial cost (Rinaudo, 2011, 2012). FMNR takes advantage of the existing “underground forest”, which has led to significantly greater success in re-greening the Sahel. There is no cost to farmers to practice FMNR beyond the additional labour that it requires (Haglund et al., 2011). The knowledge on how to undertake FMNR can be passed on from farmer to farmer, and it relies on farmers using their own knowledge and experience to make decisions about which trees are most useful to them and how they can best tailor the practice to meet their own needs. The flexibility and grassroots nature of FMNR are key factors that make FMNR a more sustainable practice because farmers are using locally available and known techniques and resources (Reij et al., 2009).

5.1.4 Challenges faced in the implementation of FMNR

Several authors discussed the importance of changing the mentality around FMNR and integrating agroforestry into the dominant agricultural development paradigm (Reij and Winterbottom, 2015). Some farmers fear that having trees on their farmland will both lower crop yields and attract pests that would damage their crops (Rinaudo, 2011). In addition to fears, it is reported that the prevalence of a tree-planting mentality—i.e., the belief that planting new trees is a better intervention than cultivating and protecting existing vegetation—is an obstacle to FMNR. Lack of awareness of the benefits of FMNR is also reported as another obstacle to effective implementation, as it is absent in promotion of forest cover increase (Rinaudo, 2011).

Cunningham and Abasse (2005) cited some environmental challenges faced in implementing FMNR. These include the need for live stumps or tree parts of the tree species to be used for FMNR in the fields, the occurrence of droughts (which can reduce FMNR impact if farmers are forced to cut down the trees to gain income in the face of famine), and climate conditions, such as in areas with lower rainfalls where trees may grow more slowly and immediate benefits to farmers may take longer to manifest.

Reij and Winterbottom (2015) posited that the low cost of implementing FMNR can actually be a barrier to obtaining funding for it, in some cases because donors may be more attracted to high-cost projects. Regarding government financing, a perception of FMNR's inability to produce revenue may deter government departments from funding it (Rinaudo, 2011).

Unfavourable land ownership and tree user rights legislation has been cited as an obstacle to effective implementation (Rinaudo, 2011). A lingering result of unfavourable laws has been farmers fearing that they will not benefit from taking care of trees, which reduces their incentive to engage in FMNR.

Some additional challenges cited in the literature are: existing monitoring systems that are unsuited for measuring multiple storey tree growth outside of forests (Reij and Winterbottom, 2015); and cultural values - such as around innovation, individuality, and respect for property – which can affect the uptake of the practice (Cunningham and Abasse, 2005).

In the case of Ethiopia Humbo A/R-CDM, the main intention of introducing FMNR was to restore degraded areas with native forest through the promotion of native vegetation and biodiversity in the area as CDM has no pre-finance. Another objective was to reduce run off and expanding socio-economic benefit streams for communities while using the forest as a sink in GHG removals.

The basis of introducing FMNR practice is identifying the eligible areas based on the presence of live stumps, seeds or any reproducible parts, enclosing the area for at least one year to facilitate regeneration, selecting and pruning five to seven stems and removing unwanted stems when re-sprouting occurs. Practicing FMNR was reported to offer more benefits in terms of fire wood, fodder, habitat, and protection from the wind and shades the soil (Abasse et al., 2009). In fact, in a multi-storey tree population, it is felt that different tree species seem to require different pruning techniques. In the case of Humbo, a small sharp axel is the only tool used for pruning side branches of young shoots. Forest owner community members visit every site every 2-4 months to re-prune as necessary (WVE 2010-15, reports).

The FMNR forestry technique was reported for its advantage in bringing back indigenous tree species from live stumps and soil seed banks in cheaper and more ecologically friendly ways than plantations (WVE, 2011). For instance, during the design phase of the Humbo project the senior forester consultant recommended a 500 ha planation out of the 2,728 ha under the project. Nevertheless, after two years of closing the area, the project developer ended up running refill planting of only 50 ha since the rest of the degraded hills regenerated indigenous tree species. Yet, there was no country-context specific FMNR focused evidence generated despite various promotions.

Therefore, the objective of this research was to examine whether FMNR practice used as a new forestry practice for Humbo A/R CDM project was attractive to bring changes in community livelihood.

5.2 Materials and methods

5.2.1 The study area

Humbo district (Figure 5.1) is located in SNNPRS, in Wolayita Administrative Zone, Ethiopia. Humbo is about 360 km south of Addis Ababa. The area is situated from 6° 46’48.47 to 6° 41’04.28 N and longitudinally ranges from 37° 48’35.44 to 37° 55’14.51 E.

5.2.1.1 Humbo area forest degradation situation

In the mid-1970s after the fall of the Emperor Haile Silasse of Ethiopia the government there reversed the land policy and a proclamation was made encouraging redistribution of land to the landless proclaimed tenants. This time the Humbo area land was distributed to all the landless in the vicinity and the mountainous forest areas were kept as open access land. According to Kamara et al. (2008), within a short period of time large areas that were formerly covered by the forest were without a forest cover. The community further blamed the increased population pressure and the occurrence of the 1984 drought in tandem with high poverty levels, which compounded forest degradation. The stumps of the remnants of trees became lucrative in the processing of charcoal and wood fuel.

Humbo district is one of the districts of Ethiopia suffering anthropogenic deforestation, environmental degradation, and associated loss of livelihood. The population pressure surge in the late 1980/90s coupled with the 1984 drought destroyed the remaining vegetation cover, exposing the land to the current visible effects of soil erosion and left the land almost barren. As trends evolved, the community’s coping mechanisms also evolved, leading them to uproot of tree stumps for charcoal - a coal like fuel from wood that became brisk business in the area. This desperate action coupled with over grazing and cyclical droughts that followed the 1984 drought episode halted the natural regeneration of the trees and exposed the land to hostile weather elements that left the land bare and barren until the commencement of the current intervention in 2005.

The Humbo A/R CDM site was selected as a case study for this study since it is the area where the only A/R CDM for Ethiopia and biggest for Africa is situated and it employed FMNR as forestry practice for the first time in 2006.

5.2.1.2 Major native tree species of the study area

Main native tree species of the study area are *Terminalia brownie, Steganotaenia araliacea, Opilia amentacea, Eritrena abisinica, Combretum molle, Tecalea nobilis, Grewia bicolour, Combretum collinum, Combretum molle R. Br.ex G.Don, Balanites aegyptica, Dodonaea angustifolia, Schrebera alata (Hochst.) Welw. Maytenus undata (Thunb.) Blakelock, Croton macrostaches, Hetromorpha trifoliate, Schrebera alata, Pedocarpus fulcata, Syzygium guineese, Acokanthera schimperi, Maytenus undata,* Faurea speciosa Welw, *Acacia brevispica, Psychotria orphila, Carissa edullis, Euclea divinorum Hiern, Terminalia laxiflora, Rhus vulgaris Meikle, Pittosporum abysssinicum, Otostegia fruticosa,* Maytenus senegalensis (Lam.) Exell and others.

5.2.2 The study method

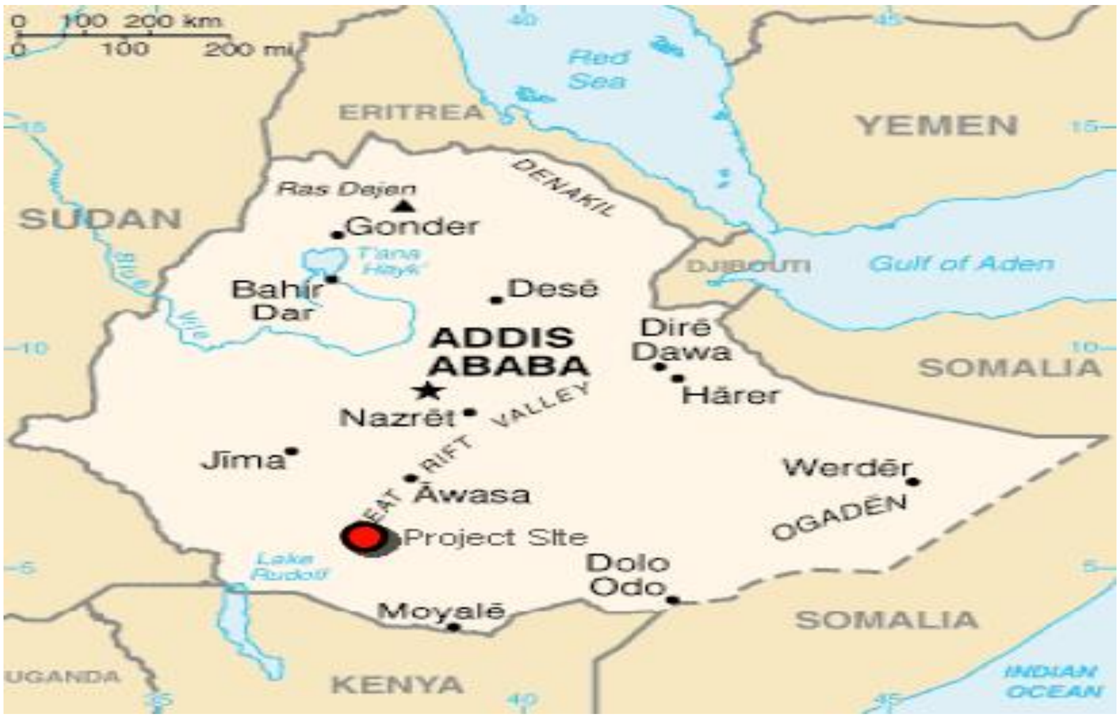
To assess the FMNR forestry practice attractiveness, the HH survey semi-structured questionnaire, FGD, KII and secondary data sources were used. The questionnaire contained questions on household demographics, gender, wealth status; FMNR based A/R-CDM related knowledge, experience and perceptions, and bio-physical changes. The survey instrument replicated a number of questions where the Humbo A/R-CDM project entity was used during base lining.

5.2.3 Sampling

A multi-stage random cluster sampling approach was used to maximize the efficiency of data collection. The calculated sample size (n=390) was divided into 30 clusters ((390 into

30) and gave 13 HH per cluster, for a total sample size of 390. Population clusters were identified using a comprehensive list of ‘gotes’ or sub-kebeles, (Kebele being the lowest administrative structure) in the project area. The survey was also implemented on a two non-project sites proximate to the study area.

Figure 5.1 Humbo A/R-CDM project location



Source: Hobo PDD

In the non-project area, the survey was administered to the same size households. Both the project and non-project area surveyed HHs and found 780. Target kebeles and clusters in the non-project area were selected purposively to: (1) ensure they did not include any population centres larger than those found within the project area; and (2) capture the different levels of remoteness vis-à-vis a paved road and large population centre.

Additionally, 18 KIIs and 14 FDGs were conducted to gather qualitative data about the experiences and perceptions of FMNR forestry. WVE, government staff, and other persons involved in, or affected by, the FMNR based forestry practice implementation were considered. KIIs were held with WVE staff, government officials from the Woreda to federal levels, cooperative leaders, and social mitigation beneficiaries. FDGs were conducted with cooperative members, cooperative as well as non-members living in the project area, youth living in the project area, and elders from the project communities. Other specific data like cost of planation forest and the seedling survival were collected from secondary sources.

5.2.4 Analysis

Quantitative data collected from the household survey was imported into SPSS, version 24, and summarized into charts and graphs. The interview data was transcribed and coded into themes identified in the literature review. Patterns that are consistent with scholarly works and policy implementation results were identified and analysed at one hand and issues of differences substantiated for empirical understanding. In the process of analysis, the systematic survey results and the qualitative summaries supported the triangulation of the authenticity of the responses and evidence.

5.3 Result and discussions

5.3.1 Who participated in and benefited from FMNR?

Most of the information in the literature regarding which segments of the population practice and benefit from FMNR is anecdotal. Haglund et al. (2011) reported that HHs that adopted FMNR tended to live farther from markets and disproportionately in areas with non-sandy soils. FMNR-adopters appeared to have higher incomes, greater assets, and increased cereal production.

Women are said to benefit substantially from the adoption of FMNR, with one advantage being the reduced amount of time they spend collecting firewood once the wood supply has increased. Stickler cites Reij (2006) in saying that the time women spend collecting firewood where FMNR in not adopted averages 2.5 hours, compared to 30 minutes where FMNR is practiced. Another benefit cited for women in Niger’s Zinder region is that they can make up to US$210 year[1] selling leaves from baobab trees that they own; Reij et al. (2009) also say that farmers report that women engaged in FMNR hold better positions economically and are better able to provide a nutritious and diverse diet for their families.

In terms of wealth, Reij and Winterbottom (2015) disclosed that in some cases it may be that poorer farmers in Niger have higher tree densities on their farms than do rich farmers (Yamba & Sambo, 2012, as cited in Reij and Winterbottom, 2015). They suggest this may be due to the strong dependence of poor farmers on their lands to maintain their livelihood. The same scholars indicated that those wealthier farmers generated greater incomes from FMNR than poorer farmers, but that this could be explained by the greater amounts of land maintained by wealthier farmers. When broken down on a per hectare level, "poor and extremely poor farm families" earned higher incomes from FMNR than did wealthier families. Quantitative data on who is practicing and benefiting from FMNR is relatively limited.

During this research period, community level and Woreda forestry expert FGDs explained that the FMNR forestry practice executed in their area relies on the presence of live and reproducible tree parts. They clearly highlighted that closing the area for one to two years, retaining three to four promising stems, and thinning and/or pruning of the unwanted stems from the rootstock was practiced during off seasons. The FGD further indicated that they kept the straightest and strongest stems, and did so almost every months to keep getting firewood. They stated that they were excited by the very rapid re-growth mainly when the forest received light showers to heavy rain.

Continuous training and outreach activities created more awareness about global climate change, natural resource management, the benefits of forests, and sustainable forest management practices. One elder described the change in this community, saying:

> "Before, the weather had become hot… it was very difficult, very hot… Then the FMNR based carbon project educated us about how to protect the forest and land. We began to regenerate the forest, and monitor each other's behaviour. WVE project staff took us to Humbo and Soddo towns for training about how to assist tree regeneration and how to protect the forest…Some of our community members were taken to an area called Dodola, which is about 200km away, to get experience. There is no burning of the forest now."

5.3.2 The landscape and soil fertility

In terms of forest coverage, about 97% of HH survey respondents from Humbo reported that vegetation cover at the FMNR employed area has increased in the past eight years (Figure 5. 2). This revealed that the regeneration of native plant species in the project site has been robust. According to the Humbo FGD report, there has been an increase in vegetation cover, and a decrease in natural hazards such as floods and temperature fluctuations. Among the interviewed respondents, 83% in the FMNR executed area reported reduced soil erosion and 74% highlighted the increases in soil fertility in downstream farmland.

The reported vegetation cover improvement in Humbo is in agreement with a report (Stith et al., 2016) which indicated that FMNR increases tree cover where it is practiced. In Niger, Baggnian et al. (2013) also measured and reported increases in tree density in farmers' fields of Maradi in the village of Dan Saga (from 146 to 151 trees ha^{1}) and El Guiéza (from 60 to 109 trees ha^{1}). In Zinder, tree density in fields increased from 32 to 79 trees ha^{1}. On the other hand where there was no oversight commitment or leadership in managing FMNR, tree density decreased from 650 to 65 trees ha^{1}.

Comparison of HHs practicing FMNR between project and non-project areas during this research period survived. Among the respondents 90.5% of project farmers indicated, they have been practicing FMNR within their homestead, while 9.5% only in the non-project area (Table 5.1). This indicated that FMNR forestry practice adopted in areas where continues promotion and demonstration undertaken.

The non-project area respondents claimed that they heard about FMNR after the Humbo A-R CDM project was famous in their area as they used to hear from their extension agents and other means like social gathering places. The non-project area respondents highlighted that they are already replicating it in their area since it doesn't need sophisticated techniques.

Figure 5.2 Humbo A/R-CDM project site photos of 2005, 2010, 20114 & 2016

Photo of 20005

Photo of 2010

Photo 2014

Photo in 2016

Table 5.1 Percentage of respondents practicing FMNR at Humbo and control sites

	Practicing FMNR (percentage)		
	No	Yes	Total
Non – project area	90.5	9.5	100.0
Project area	9.0	91.0	100.0

Source: Humbo HH survey (2015)

5.3.3 Biodiversity contributions

5.3.3.1 Wild animals

According to interviewed HHs, FGDs and KIIs as well as observation, the FMNR utilized forestry practices affected biodiversity and they reported that multi-story tree and shrub species forgotten from the area regenerated. FGDs and KIIs further reflected that the execution of FMNR impact on local wild animal population has been among the most salient. One of the community members explained, "Because of the forest restoration, birds are coming back, wild animals are getting shelter, and the lands in the surrounding area are in improving condition."

Among interviewed HHs, 97% of respondents reported an increase in the overall population of wild animals in the past eight years. In addition, 73% of respondents reported seeing new types of wild animals in the area in the past eight years. Wild animals (Figure 5.3) reported under this category include leopards (56%), warthogs (36%), wild pigs (26%), and monkeys (24%). The return of wild animals brought the opportunity to attract eco-tourism. On the other hand, some of the community members who are nearer to the forest boundary also recognized it as a threat for the livestock and crops.

On the contrary, only 9% of HH survey respondents from non-FMNR kebeles reported seeing new wild animals appear during the past eight years, which suggests that the reforestation through FMNR has attracted and supported new wild animal populations as compared to non-FMNR area.

5.3.3.2 Medicinal plants regaining

The Humbo FMNR promoted and enhanced plant species diversity, which was highly appreciated by the elder FGD community members for locally sound traditional drug or herbal medicinal use for both human and livestock. To this end, 28 plant species locally identified for their medical value were listed (Table 5.2). While cross validating the responses with FGDs, the community stated that they are extremely thankful to FMNR based reforestation as it has brought back forgotten but crucial medicinal plant species to their original home, which might not have been possible if planation forestry was practiced.

5.3.4 Fuel wood

In Ethiopia, over 90% of the energy source is still biomass. In the rural areas of Humbo, the community fuel wood demand is beyond the national average. This research examined further whether the project site pruning and thinning produced enough fuel wood from for domestic use. As presented in (Figure 5.4), about 78.1% of the project area respondents complemented firewood from their own trees and other biomass as compared to only 38.5% of those in the non-project area. Among interviewed respondents, 14% of households collect firewood from FMNR as compared to only 5% from the non-project area.

Figure 5.3 Ten most frequently reported new wild animals that have appeared in the Humbo A/R-CDM area over the past eight years

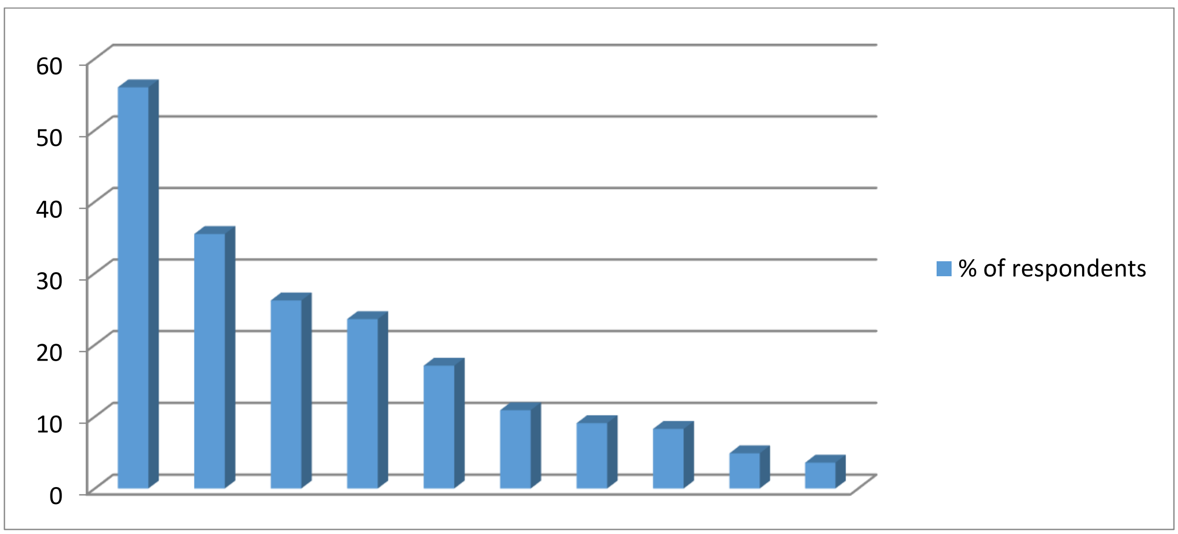


Table 5.2 Identified medicinal plant species in the Humbo A/R-CDM site

SN	Scientific Name	Family	Part used	Disease treating
1	*Acacia abyssinica*	Fabaceace	NA	Rectal prolapse
2	*Acacia Nilotica*	Fabaceace	Inner bark, roots, leaves	Leucorrhoea, lactogenic, Entomeba histoletica, taenia
3	*Albzia gummifera*	Fabaceace	Root, bark	Asgalactogogous, treat piles
6	*Carissa edulis*	Apocynaceae	Root	Snake bite, tooth ache, stomach ache, anthelmintic, anti-parasite
8	*Croton macrostachyus*	Euphorbiaceae	Sap, leaves, roots & barks	Fungal disease
9	*Dodonia viscosa*	Sapindaceae	Decoction from leaves & wings, boiled roots	Wound dressing, sore throat
10	*Dovyalis abyssinica*	Flacourtiaceae	Leaves	Swelling of throat
11	*Ekebergia capensis*	Meliaceae	NA	Wet eczema
12	*Embelia schimperi*	Myrsinaceae	Fruit	Against tape worm, Antihelmitic
13	*Entada abyssinica*	Fabaceace	Roots	Tonic, stomach ache, wound dressing
14	*Erythrina abyssinica*	Fabaceace	Sup	Wound dressing
15	*Ficus sur*	Moraceae	Barks, milky sap, roots	Gonorrhoea

16	*Hagina abyssinica*	Rosaceae	Barks, roots	Antihelmitic, 'Koso'
18	*Maesa lanceolata*	Myrsinaceae	Fruit	Against tapeworm
22	*Olea europaea (O.africana)*	Oleaceae	Stem, barks, leaves	Nice smell
23	*Phytolacca dodecandra*	Phytolaceaceae	Root, fruit, leaves, seeds	Against Schistosome
24	*Premna schimberi*	Verbenaceae	Leaves	Against Tapeworm
27	*Syzygium guneense*	Myrtaceae	Barks, roots, leaves, buds	Act against herpes simplex virus

Source: WVE, Huambo forest management plan

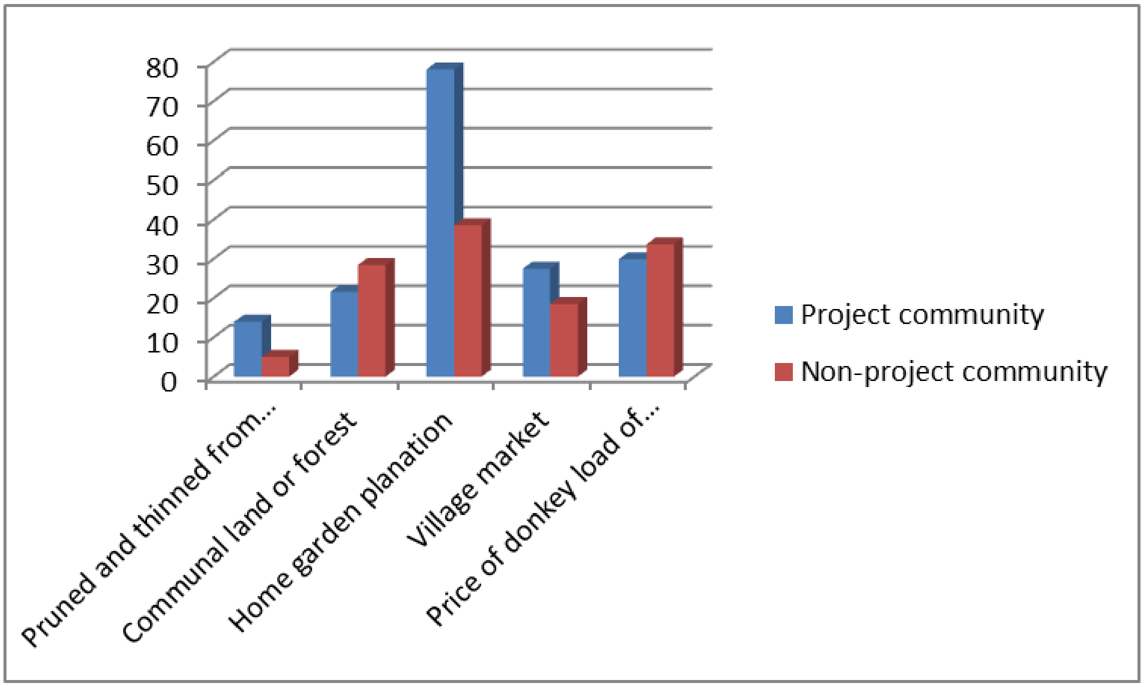
This indicated that the communities exposed to FMNR practice were changing their fuel wood source. This in turn showed a promising trend towards sustainable fuel wood fetching without affecting the tree population per unit area.

The local community further mentioned that their trees were coming back and were fetching money from the carbon market. They didn't hide that they would have been tempted to get forest products from the forest, had the forest not been managed by forest cooperatives with tough by-laws.

5.3.5 Investment cost of reforestation

While the benefits of tree planting are subject to debate, the costs are assumed to be low compared to many other climate change mitigation options by climate scientists. The IPCC indicated, "the mitigation costs through forestry can be quite modest (US$0.1–US$20 per metric tCO_2e) in some tropical developing countries (IPCC, 2007). The authors highlighted that the cost effectiveness of tropical reforestation is not only due to a faster growth rate, but also due to farmers from tropical developing countries who voluntarily plant and nurture tree species, which can improve the productivity of their lands. They further specified that as little as US$90 will plant 900 trees, which is reported as enough to annually remove as

Figure 5.4 Households by firewood source percentage



Source: Humbo HH survey (2015)

much carbon dioxide as is annually generated by the fossil-fuel usage of an average USA resident. Yet, the cost indicated as little is not actually little for countries like Ethiopia planting about 5 billion seedling year[1]. The seedling survival rate was reported to be 58% by MoEFCC (2016) despite the actual field observation. The figure is closer to 50% according to the report of FAO (2014). Another international institute called the World Resource Institute (WRI) also reported tree-seeding survival as not more than 50% (WRI, 2011) due to many reasons, both manageable and beyond control.

In terms of investment, actual expenditure on the scaling up of FMNR reported by Reij and Garrity (2016) found below US$20 ha[1] of adoption in case of Niger. The authors further explained that this is because of FMNR adoption spread across 5 million ha in Niger mainly via farmers spontaneously applying the practice because they observed the benefits and found it convenient to take it up without requiring external support in their dry context.

The average price for one seedling production up to planation at Humbo during the years 2006-2008 for species like *Gravilia robusta*, *Olia Africana, Eucalyptus* spp and others was reported to be 1.1 ETB at Humbo (WVE Reports, 2006, 2007 & 2008). This means, if the Humbo A/R-CDM project site had employed plantation forestry across all 2,678 Ha, a total of 25,470,754.00 ETB (US$ 2,751,312) would have been needed, assuming the Humbo area's tree survival rate is at its optimal rate of 50%. However, employing FMNR with genuine community participation saved the indicated fund amount. Hence, the case study area spent a total of USD 1,157,413 across 2005-2013 to run the project (WVE Report, 2014). This implies that the Humbo A/R-CDM might not have happened if FMNR forestry practice was not introduced since CDM has no pre-financing mechanisms. Such a saving is an enormous amount for developing countries like Ethiopia.

Therefore, it would be a wise decision if forestry-promoting sectors and stakeholders consider rolling out FMNR instead of producing and planting seedling year-out and year-in, as tree seedling survival has been an issue in many parts of developing countries.

Using FMNR forestry practice at Humbo saved an investment cost is in agreement with recently calculated project costs of about 90,000 ha of FMNR in the Maradi region during a period of three years, amounting to US$14 ha^{1} (Place & Binam 2013). The main reason for the low average costs ha^{1} is the speed and the scale of adoption of this practice by local farmers. FMNR does not require the effort to acquire germplasm or to propagate seeds or cuttings and nurture them into seedlings. It instead utilizes community labour for thinning and pruning so as to reduce sapling competition and also provide firewood for local use.

5.3.6 Avoided carbon leakage

One of the challenging concepts in forestry projects seeking carbon finance is accounting for carbon leakage due to fuel wood as leakage; which is the increase in measurable GHG emissions occurring outside the project boundary (Aukland et al., 2003).

The Humbo A/R-CDM project developer INGO computed the average fuel wood collected after running silvicultural practices such as thinning and pruning year^{1} ha^{1} after maintaining the tree spacing for each cooperative site and converting into ha (Table 5.3). This was compared with pre-project annual volume of fuel wood that used to be collected from the project area, which was 4.3 m^{3} ha^{1} (WVE Report, 2011). Interestingly, the fuel wood used to collect in the project scenario through FMNR practice was found to be greater than in the pre-project period. As a result, zero carbon leakage due fuel wood collection outside project boundary was deducted from the Humbo A/R-CDM.

During this research the Humbo community was interviewed about which parts of the forest they collect fire wood from. The vast majority of interviewed community members (Figure 5.4) indicated that they follow sustainable collection practices such as pruning, thinning, broken branches, and trimmings; or collecting only dry wood as per the training, they received. This indicated that FMNR is attractive to increase forest cover while providing sustainable fuel wood for domestic use and getting rid of leakage deductions while computing for ER.

5.3.7 Household income and local economic change from adopting FMNR

The income from the sale of firewood alone in Niger after adopting FMNR has an estimated average annual value of US$ 127–154 HH^{1}. The sale of non-timber products, such as fruit alone, also computed on average US$ 237 year^{1} or an additional value of US$ 0.66 per day^{1} HH^{1} (Place & Binam, 2013, quoted by Francis & Weston, 2015 and Reij and Garrity, 2016).

Binam et al. (2015) reported that FMNR increases income as well as food security. Their economic analysis of a sample of 1080 HH in Burkina Faso, Mali, Niger and Senegal found that an average HH in the Sahel practicing FMNR continuously would gain a gross income increase of US$ 72 year^{1}. They found specifically that the value of products harvested from trees increased by about 34-38% for households that were actively implementing FMNR compared with those that were not.

Table 5.3 Fuel wood collected from Humbo A/R-CDM over four years

Year	Abella Longena	Bossa Wanche	Hibicha Bada	Hobicha Bongota	Average (m^3ha^1)
2008	4.2	4.9	5.45	5.85	5.1
2009	4.37	4.97	5.94	5.99	5.3
2010	4.71	5.16	5.81	6.50	5.5
2011	4.97	5.48	6.97	7.07	6.1

Source: Humbo PDD

According to Abasse et al. (2009) FMNR adoption at farm land and community forest areas in Niger raised the annual gross income of the region in Niger by between US$ 17 and 21 million from the sale of tree products and non-tree products because the investment cost to have tree products via FMNR is almost nil.

Available evidence indicates that Ethiopia been planting about 5 billion tree seedlings year^{1} over the past ten years. Since that is no small investment for Ethiopia, and a 50% seedling survival succeeding is debatable, undertaking critical analysis and reflection whether to continue seedling plantation alone, or balancing planation with FMNR, or more of FMNR where the area and purpose of reforestation suits.

5.3.8 Livelihood contributions of FMNR

The study report of Weston & Hong (2013) aimed to quantify non-monetary benefits of the FMNR, like health and psychosocial benefits, which they cited as a gap in existing literature based on their review. From the data they gathered, they utilized the Social Return on Investment (SROI) methodology and reported that the livelihood impact per HH from the FMNR project was between US$ 655 and 887 year^{1}, including the social, health, environmental, and economic values. These authors found that the most valuable outcomes from the perspective of farmers were increased assets in the form of tree stocks and improved livestock; increased wild fruits for household consumption and sale, associated dietary health benefits, and improved psycho-social wellbeing as a result of a more aesthetically pleasing and comfortable community. They further reported positive outcome of improved soil fertility and crop yields.

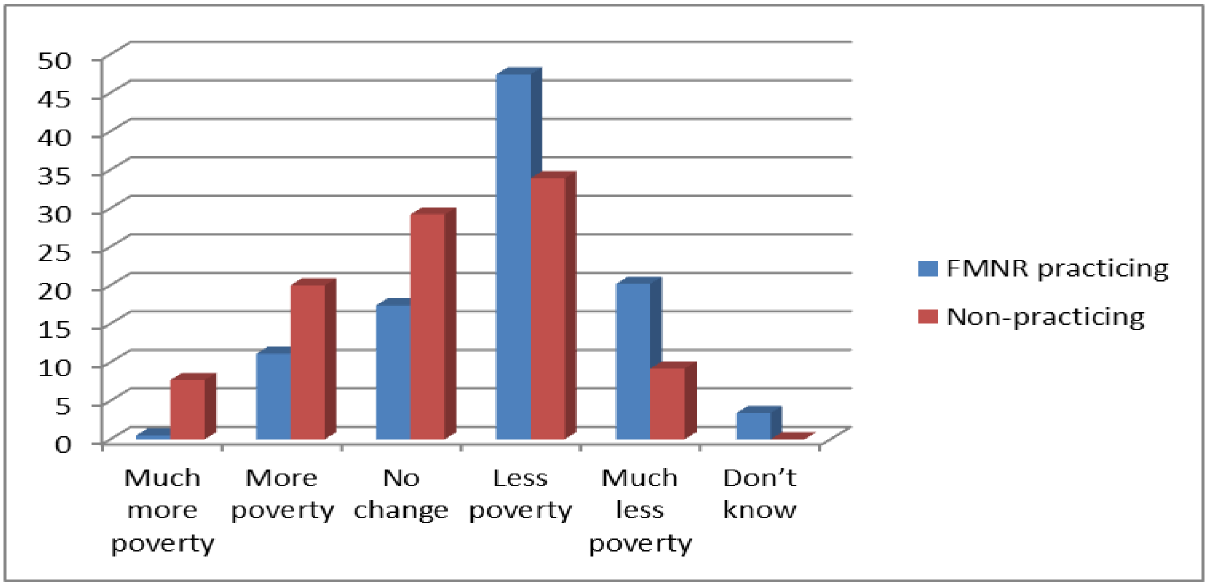
The three main pathways of private benefits are through direct human consumption and/or sale of tree products, indirect benefits on crop production and increased benefits through livestock production. In terms of direct consumption benefits from trees, the major products are foods (fruits, nuts, oils, and leaves) and wood (construction and fuel wood). A recent study of scaling up FMNR in Africa to restore degraded landscapes in the Sahel (Reij and Garrity, 2016) found that all HHs harvested tree products for their consumption, and in many locations, the quantity and value per household ranged from US$ 110 in Senegal to about US$ 250 in Niger. Regarding HH dietary diversity, Binam et al. (2015) measured an increase of 12-14% in Burkina Faso, Mali, Niger and Senegal among those practicing FMNR.

Likewise, the Humbo HH survey result revealed that there have been positive changes in the environment among direct beneficiaries, as well as improved food security, decreased poverty (Figure 5.5) when comparing FMNR practicing and non-practicing areas. The research found that FMNR practicing farmers perceived that the introduction of FMNR practice in their area contributed towards poverty reduction in terms of improving the area’s agricultural productivity.

5.3.9 Carbon sequestration through FMNR

In the case of Humbo A/R-CDM, two carbon pools, namely AGB and BGB carbon pools, were counted. The average carbon sequestrated through FMNR during 2006-2016 was 14.07 tCO_2 ha^1; while through planation, it was 0.8 tCO_2e ha^1 (Table 5.4). This indicated that after 10 years of carbon sequestration, the rate through FMNR was higher than planation. This might be due to the established root system of regenerated trees which enabled faster sequestration while the new planation was establishing itself. Yet, across the years, carbon sequestration from seeding planned sites seems to outpace native tree species0based FMNR sites, which might be due to species' growth characteristics as well as silviluctural practices. The difference in sequestered tCO_2e is due to each strata biomass difference at baseline.

Figure 5.5 Proportion of respondents' perception in change of poverty during the past eight years in FMNR site and non-FMNR practiced site



Source: Humbo HH survey (2015)

5.3.10 Sustainable forest management

According to Humbo (PDD) there is an agreement by the project developer and the trustee to undertake selective harvesting at years 12, 24 and 36 so as to effect sustainable forest management. The management plan prepared to maintain 50% of the standing biomass for the benefits of biodiversity, environmental protection and other ongoing services at each of the harvesting years. The timber was scheduled to be transported by donkey to the nearby city called Soddo so as to avoid emission leakage from the transporting.

Yet, on other side, it was obvious that knowledge about growth and site preferences require evaluating through the forestry inventory measurements to establish forest management. The choice of when to harvest which tree species is a complex decision for native tree species based forests involving a wide range of considerations.

According to KII and WVA (2013) report, the project developer in consultation with community and local forest experts prepared a Humbo Forest Management plan and indicated that harvesting of timber follows a single tree selection system and no large areas are to be harvested in one single process. As the name implies, the system is scheduled for removal of specific trees, leaving the majority of the trees on a site, without damaging the resilience of the ecosystem.

According to the KIIs, the forest management plan (FMP) is one of the requirements to qualify as a sink and ensure forest continuity. The FFMP developed by the project developer (Humbo PDD) was to justify against permanency and reduce damage of unlocking the carbon.

Hence, the FFMP was designed to maintain the low fire rating status through incorporating appropriate articles in the Forest Protection & Development cooperative society by-laws, including banning of fires and charcoal making in and near the vicinity of the forest, reduction in fuels (grass, branches, crop residues), and assignment of responsibilities for monitoring conditions, raising warnings and action to suppress fires. Besides, formation and training of fire patrol groups, purchase of appropriate equipment, building of watch towers and plastic lined dams were to be undertaken according to fire risk assessments.

Secondly, the forest fire pre-suppression activities and systems were put in place. Because of timely placed FFMPs, no fire hazard was reported across all eight years (WVE Report, 2014). KIIs and FGDs explained that no significant fire damage happened since the regular FMNR operations enabled the community to keep patrolling the forest day by day. Yet, during FGD the elders stressed the need for "fire safety rules” and equipment to be safer. The representative from Cooperative KII believes that public education on the dangers of fire and fire suppression measures for local communities is still a priority.

Table 5.4 Humbo A/R-CDM sequestered carbon in 2006-2016 via FMNR and planation

Strata	**Forestry practice**	**Area (ha)**	**tCO_2e**				**Grand total**	**Average tCO2 ha[1]year[1]**
			2011	**2014**	**2015**	**2016**		
1	FMNR based A/R	233	25,715	25,656	28,220	22,568	102,159	43.85
2	FMNR based A/R	631	16,763	17,940	20,740	21,604	77,047	33.07
3	FMNR based A/R	1,699	73,823	84,232	101,500	110,346	369,901	158.76
4	FMNR based A/R	114	549	468	483	499	1999	0.86
5	Planation	51	0	5.2	6.3	351	362.5	0.8
Total CO_2e sequestered			116,850	128,301	150,949	155,368	551,468	
Pre-existing carbon stock CO_2e			43711.7	43711.7	43711.7	43711.7	43711.7	
Net sequestered CO_2e			73,138	84,848	107,551	111,657	377,194	14.07

5.4 Conclusions

The secret of FMNR commences from identifying the area with availability of live tree stumps, roots, seeds and other reproducible parts. The next step is area closure for a minimum of two years, and training the local community or landowner on how to select stems, thin and prune young shoots at least twice year[1], irrespective of seasons, to grow into mature trees. This is because of that one of the limitations of an enclosure-alone approach is that the new woody vegetation protected, but not be in use through thinning and pruning, which challenges sustainability. Actors in forestry sectors have now recognized that active management of the regenerating forests is critical in order to evolve a structure and species composition that will provide sustained benefits to the communities.

The analysis from FMNR attractiveness studies are overwhelmingly positive, with a variety of benefits that are accessible to farmers regardless of income-level. The FMNR promotion at Humbo was found successful. The practice proved its attractiveness in deeply engaging community members across each step while heading to reforest, improving the landscape, bringing back forgotten native flora and fauna, avoiding the silent but huge reforestation investment cost being recurring year in and out, removing carbon leakage. This implied FMNR contributed to community livelihood, while sequestering 14.07 tCO_2e $year^1$ ha^1 carbon as compared to 0.8 tCO_2e $year^1$ ha^1 that of plantation.

CHAPTER 6: CONTRIBUTION OF AFFORESTATION/REFORESTATION CLEAN DEVELOPMENT MECHANISM TO COMMUNITY LEVEL SUSTAINABLE DEVELOPMENT

6.1 Introduction

The Kyoto Protocol to the UNFCCC, which put in place a framework for intergovernmental efforts to deal with the issue of climate change, was introduced in 1997 with the purpose of strengthening the Climate Change Convention by enhancing global carbon emission reduction through support to national reforestation and afforestation programmes. The Protocol was adopted at the third session of the Conference of the Parties (COP3) in 1997. The Protocol entered into force in accordance with Article 23. The Protocol introduced legally-binding targets for the reduction of GHGs emissions from the Parties listed in Annex-I to the Convention. The total cut in GHG emissions for Annex-I countries consisted of a reduction by 5.2% from 1990 levels in the first commitment period, 2008-2012. Only Parties to the Convention that are also Parties to the Protocol, i.e. countries that have ratified it are bound by the Protocol's commitments (UNFCCC, 1997). During the first commitment period, 192 countries ratified the Protocol except Afghanistan, Sudan and the U.S.A. In fact, later on some countries like Canada withdrew. The role of developing nations (non-Annex 1 countries) is to promote afforestation and reforestation activities for GHG emission reduction through carbon sequestration and expanding the use of renewable energy resources, and in this regard the role of the Annex-1 nations is to provide technological and financial support to the non-Annex nations. The CDM projects implemented in Ethiopia are part of these global and national initiatives towards addressing the climate change issues.

In contrast to the emission reductions, contributions to SD are not subject to a generally applicable evaluation procedure. As the KP required a CDM project activity to contribute to SD, many sets of criteria and evaluation approaches have been developed (Markandya and Halsnaes, 2002; 2003; Sutter et al., 2007); however, none have been widely applied. Arens et al. (2014) reported that a successful achievement of keeping global warming below 2 °C must be accompanied by development that ensures sustainable economies, healthy environments and sustainable societies, particularly in developing countries. SD for a world that can be enjoyed by all is therefore a crucial component of a successful fight against climate change as CDM was created with a double mandate: on the one hand, to achieve cost-effective mitigation of GHGs; on the other, to assist developing countries in achieving SD, based on their national development priorities.

Nevertheless, the CDM has been criticized for its underdeveloped contribution to SD (Olsen 2007; Sterk and Rudolph, 2009). Responding to the critique, the CDM EB launched a call for input in June-July 2011 to invite comments on how to include co-benefits and negative impacts in the documentation of CDM project activities, and the role of the different actors and stakeholders in this process. The CoPs serving at the Meeting of the Parties to the KP at its seventh session in Durban requested the Board. The request was to "continue its work and develop appropriate voluntary measures to highlight the co-benefits brought about by the CDM project activities and programmes of activities (PoAs) while maintaining the prerogative of the Parties to define their SD criteria" (8/CMP.7, paragraph 5). The CMP decision launched the process within the EB in 2012, leading to the approval of the CDM SD tool at the 70th session of the EB. Still, the SD tool in its existing form has a number of weaknesses that limit its usefulness for meaningful assessment of the impacts on SD a CDM project may have (Christof et al., 2014).

Like many other countries, Ethiopia ratified KP in 2005, and did so by Proclamation No. 439/2005, for its twin objectives: namely, GHG emission reduction and sustainable development. Despite the fact that Ethiopia has been active in the climate change negotiation forum by being speaker to Africa, across the first crediting period, 2008-2012, Ethiopia presented merely one project developed by the INGO WVE in partnership with WVA, who provided financial and technical support to the project.

The Humbo Ethiopia A/R-CDM project aimed to regenerate 2,728 ha of degraded native forests, so as to bring social, economic and ecological benefits, facilitating adaptation to a changing climate and generating tCERs under the CDM (Brown et al., 2011).

Some of the many requirements of CDM project were getting a letter of no objection (LNO) and a letter of approval (LOA) from the host country's DNA. To get LNO and LOA and to be a point office for regular UNFCCC communication, opening a NDA office was compulsory. After ratification of the KP, Ethiopia set up the DNA, and the DNA Office developed SD criteria comprised of core criteria, namely, economic, social and ecological as a tool to approve CDM projects. As per Ethiopia DNA office CDM projects should answer: does the project contribute to economic, social and environmental development? Each of the three criteria were sub-divided into seven to eleven different impact-related indicators. So as to implement the regulation, the DNA office set up the CDM Advisory Panel (AP). The AP discharged its mandate by conducting CDM project PDD desk assessment to ensure whether the CDM projects meet the host country SD criteria. Based on the AP recommendation, the DNA office approves or rejects the CDM projects for registration. However, there is no communicated mechanism in place to monitor whether CDM projects are delivering on their projected SD benefits during the implementation period.

Therefore, this study focused on determining the CDM contributions to SD by linking various CDM parameters with six selected SD contributing indicators, i.e. two from each core criteria relevant to the community based A/R-CDM project. These criteria are environmental (local climate and community access to natural resource), social (job creation and community social structures) and economic (existing economic activities of the area and local skill development).

6.2 Materials and methods

6.2.1 Study area

Humbo district is located in SNNPRS in Wolayita Administrative zone, Ethiopia. Humbo is about 360 km South of Addis Ababa. The area is situated from 6° 46'48.47 to 6° 41'04.28 N and longitudinally ranges from 37° 48'35.44 to 37° 55'14.51 E.

6.2.1.1 Climate

The Inter Tropical Convergence Zone (ITCZ) is reported as an influencing factor on the climate of Humbo district (Humbo PDD). Average rain fall is between 800mm and 1000mm.

6.2.1.2 Vegetation and of the biodiversity of Humbo

Since the mid-1970s, the forest cover of the Humbo area had undergone depletion due to drivers of deforestation and absence of ownership (Figure 6.1). The community further blamed the increased population pressure and the occurrence of the 1984 drought in tandem with high poverty levels, which compounded forest degradation. The stumps of the remnants of trees became lucrative in the processing of charcoal and wood fuel. As a result, the Humbo district, home to more than 160,000 people, became one of the districts of Ethiopia suffering anthropogenic deforestation, environmental degradation and associated loss of livelihood (Humbo PDD).

Humbo A/R-CDM site was selected as a case study for this study since it is the only and biggest A/R CDM for Ethiopia and Africa respectively. Moreover, it is the first A/R CDM project in getting tCER issuance in Africa and second in the world.

Figure 6.1 The Humbo A/R-CDM location satellite and ground truth based maps

6.2.2 The study method

There are various approaches to collect socio-economic and environmental data such as case study methodology, survey research, questionnaires, interviews, participant and non-participant observations, and focus group discussions.

This study divides the methodology into three sections. The socio-economic survey uses semi-structured interviews to capture data about community perceptions of A/R-CDM contributions to: the environment (local climate and community access to natural resource); social SD (job creation and community social structures) and economical SD (existing economic activities of the area and local skill development). This is complemented with key informant interviews using a checklist so as to get preliminary analysis and look for benefits, constraints, challenges and perspectives. In-depth interviews conducted with experts and knowledgeable individuals that enhanced evidence on data and policy issues. Focus group discussion was held with selected elders, women, children, experts and policy makers in the sector from both project and non-project areas. The interview questions were organized in accordance with the research questions, the points that were drawn from the review literature, and the themes of analysis of the enquiry.

In terms of sample size, the study employed purposive clustering. Out of 390 HHs the ‘n^{th}’ households were divided into 30 clusters, and villages selected by systematic sampling from a complete list of all villages in the study area. Individual HHs were selected using systematic selection from a complete list of households in each village. Control 390 HHs were selected from the area adjacent to the study area. Besides, secondary data was collected from the PDD and DOE audit report located at UNFCCC website, WVE Office and other credible sources.

6.2.3 Analysis

Quantitative data collected from the HH survey was imported into SPSS, version 24, and summarized into tables, charts, graphs and other formats. The interview data transcribed and coded into themes. Patterns that are consistent with scholarly works and policy implementation results were identified and analysed, and issues of difference were substantiated for empirical understanding. In the process of analysis, the systematic survey analysis and the qualitative summaries support the triangulation of the authenticity of the responses and evidence.

The analytical approach used the triangulation design (Creswell & Plano C., 2007). The purpose of this design was to obtain different and complementary data around the same topic. The benefit of this design was to bring together the differing strengths and non-overlapping weaknesses of quantitative and qualitative methods.

6.3 Result and discussion

6.3.1 Environmental contribution

There is global consensus that SD encompasses the three inter-linked dimensions of environmental, social and economic sustainability at different levels, Vis. local, national and global levels (Aukland et al., 2003). With respect to CDM projects' contribution to the environment, projects such as the Jindal Steel and Power Ltd. (JSPL) sponge iron in India was reported to provide indirect environmental benefits by reducing emissions on-site. Because of this, one of the biggest Indian sponge iron companies involved in a CDM project has been sued in the state High Court by concerned individuals and NGOs who claim that the company put pressure on to local villagers to sell their land and to appropriate local water resources for the expansion of the company facilities and its business. These kinds of CDM projects lay bare the issue of accountability in CDM projects, although this is not a direct criticism of CDM projects per se. The question is whether DNAs have adequately addressed environment accountability. Other sponge iron companies across India have also been subject to severe criticisms, and in some cases, local revolts have taken place to protest against employees' bad working conditions (Lohmann, 2006).

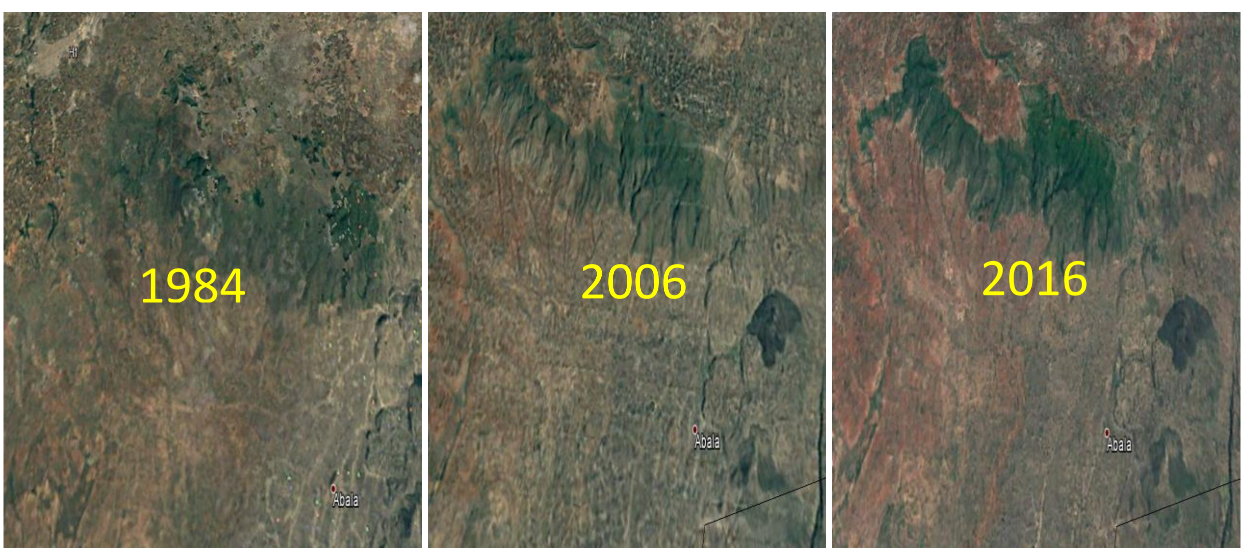
Powell et al. (2002) reported that carbon sequestration constitutes valuable environmental services provided by forests, services like watershed protection, biodiversity conservation and ecotourism. Efforts to put a monetary value on such services have also led to an increase in awareness on the need to protect forest resources, particularly as they can be traded in emerging markets. Due to the nature of A/R-CDM, environment benefits like local climate, community level natural resource ownership, and managing natural resources and the like were anticipated.

6.3.1.1 Land cover change

Satellite imagery alone clearly shows improvement in the Humbo project's site's vegetation cover (Figure 6.2) across 1984, 2006 and 2016 when compared to satellite imagery of the non-intervention area.

Even in mild form, land degradation reduces production in all the land resources and exacerbates rural poverty (Tewoldeberhan, 2006) and this was evident in Humbo. In turn, poverty due to inadequate alternative livelihood and income, lack of access to alternative fuel sources in combination with low levels of awareness on natural resource management contributed to severe deforestation and land degradation. The landcover change improvement since the Humbo A/R-CDM brought improvements in the livelihoods of the downstream community.

Figure 6.2 Humbo A/R-CDM site vegetation cover change



Source: Image Landsat from Google Earth, https://earthexplorer.usgs.gov/

6.3.1.2 Biodiversity improvements

The effects of the Humbo A/R-CDM on biodiversity extended beyond the tree and shrub species that were regenerated. Interview and survey data suggested the effects on local wild animal population have been among the most salient. This highlighted that native tree species regeneration-based climate change mitigation is able to contribute towards ensuring SDG goal number 15, which is increasing life on land. This is in agreement with Rohit et al.’s (2008) report which stressed that biodiversity conservation benefits are more likely to be associated with avoided deforestation than with carbon sequestration from new plantations as natural forests conserved through different forestry practices will provide habitat to more endemic fauna and flora species than plantations that tend to focus on fast growing exotics. Rohit et al. (2008) reported that avoided deforestation and carbon payments can also generate revenues for biodiversity conservation where carbon and biodiversity are jointly produced.

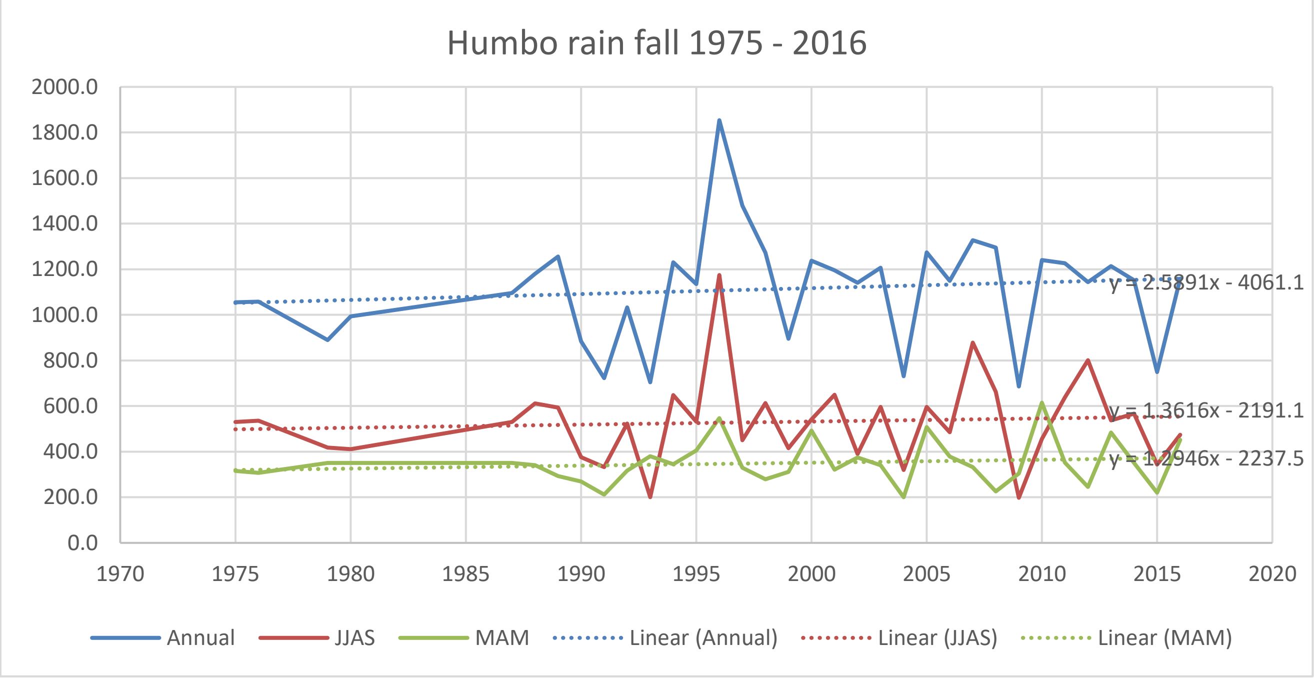
6.3.1.3 Local climate

With regard to local climate, three-quarters of survey respondents of the Humbo community from the A/R-CDM area reported improvements in weather, climate, and microclimate as one of the primary benefits. This implies that changes in vegetation cover have likely affected shade/ground temperature, soil moisture, and, perhaps, evapotranspiration patterns in the area. Throughout KIIs and FDGs, many respondents drew a link between forest regeneration and improved rain fall in the area. This was in agreement with Humbo rainfall data collected from the national metrological agency (Figure 6.3), which clearly indicated the increasing trend of both annual, June, July, August and September (JJAS) and March April and May (MAM) rainfall amount in the area. The association between forest cover and the micro-climatic conditions noted are plausible, which might be not only due to the A/R-CDM area forest coverage but also the nearby areas forest coverage as reforestation spread around. Yet, the perception expressed by respondents and the metrological station data strengthened the importance of forest coverage link with rain fall amount even in less than ten years. This further demonstrates that A/R based emission reduction contributes to SDG goal number 13 – climate action.

The association between forest cover and the micro-climatic conditions was noted as plausible and indicated that the forest cover in such a specific area and may be the nearby farmers' farm tree coverage due to the A/R-CDM initiative contributed towards attracting increasing rainfall in the area.

This finding is in agreement with Murgan and Israel (2017), who indicated that the environmental impact of the A/R-CDM is perceived as the most noteworthy result. The scholars reported that the restoration of degraded forest area had environmental benefits in terms of improving rainfall amount and distribution, improvement in soil moisture retention capacity, reduction in temperature, reduction of soil erosion, and restoration of wild animals.

Figure 6.3 Humbo rainfall during 1975-2016



6.3.1.4 Community access to natural resources

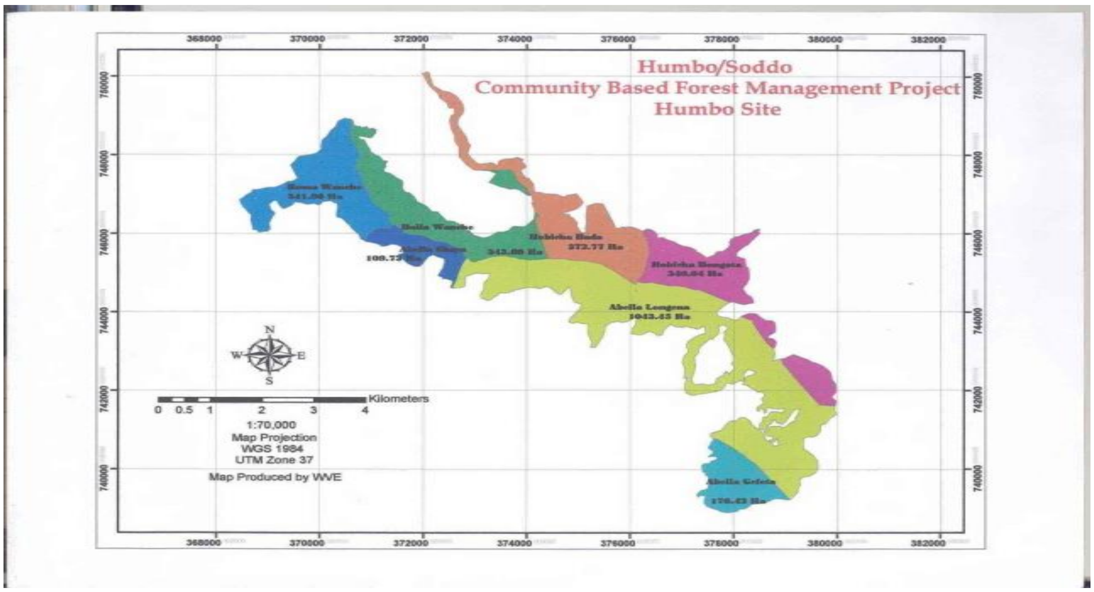
In terms of community access to the natural resources, the Humbo A/R CDM project site land was initially 'no man' land; or locally called 'communal land'. Tenure security has been crucial for implementing carbon sequestration projects since the carbon credit buyer demands a designated signatory. Without clear and defendable rights to land, forest or the sequestration service itself, suppliers cannot make a credible commitment to supply carbon offsets (Gutman, 2003). For A/R-CDMs where local communities act as service providers, it means that unless they have secured rights to the land on which forestry activities are taken up, the investor may have little or no confidence in financing the project.

As per the Humbo A/R-CDM PDD, the project developer had advocated for a resolution to the land tenure issue since 2005/6. A consensus was reached among the government and local community members to split the land among the nearby KAs, where the demarcation would be carried out jointly by the elderly community and the local government. A land user rights certificate was issued to each of the seven forest protection and development cooperatives by Humbo Woreda Rural Development Office of Wolayita Zone as temporary communal land ownership certificates. This was pursuant to The Federal Democratic Republic of Ethiopia Rural Land Administration and Land Use Proclamation No. 456/2005, and the SNNPR Rural Land Administration and Utilization Proclamation No. 53/2003 (Humbo PDD). The latter further indicated a possessory right defined as the right any farmer shall have to use rural land for agriculture or natural resource development activities. In the proclamation, the natural resources are defined as living and non-living things which are a gift of nature found on the land.

Nevertheless, the land proclamations didn't specifically identify carbon ownership rights. Ethiopian law dictates that those who possess community holdings (user rights certificates issued from proclamations SNNPR 53/2003 and Federal 456/2005) have the right to all the products produced from the land, and that the products produced from the land would therefore necessarily include sequestered carbon. As a result the Humbo community has got user rights to access the land, forest and related natural resources on that specific land.

As a result, the 'no man's' land was divided between seven cooperative members (Table 6.1) and mapped through GPS to avoid border conflict (Figure 6.4). Per guidance from community-selected elders, in order to avoid boundary-related conflict, each area was delineated by the joint work of local community representatives, Woreda Government office representatives and a GPS literate expert. Finally, the size of land belonging to each cooperative was calculated. As a result the Humbo A/R-CDM ERPA contract was signed off in 2007 by: WVE as project entity on the behalf of the community, WVA (pre-financer) also as project entity, and the World Bank Biocarbon Fund.

Figure 6.4 Boundaries of Humbo A/R-CDM project forest cooperatives



Source: Humbo Project PDD)

After master ERPA signing off at grass root level sub-ERPA agreement, which outlined the rights and obligations of the Project Entity and the Sub-Project Entity was signed off in February 2009 acknowledging that the obligations incurred by each of WVA and WVE as project entities. Under the agreement, obligations incurred jointly and severally about the generation of emission reductions purchased by the Trustee put as sub-agreement. The later was signed off by WVE, WVA and seven Forest Cooperatives, namely, Abela Gefeta Hoko ,Abela Longena Gamo Saluwa, Abela Shoya sere,Bolla Wanche Gamo,Bossa Wanche Kache , Hobicha Bada Weyito and Bongota Oda Mountain Forest Development and Protection Cooperatives (2009, WVE Report). Such binding mechanisms all the way from the Trustee to Farmers Cooperatives tied the system and found one of useful lesson for long gestation having initiatives.

With regard to community perceptions during this survey, 84.7% (Figure 6.5) of respondents reported feeling more hopeful about their children's future since the land user right now belonged to them legally. This community satisfaction is in agreement with host country DNA set natural resource ownership SD criteria.

Above all, the seven cooperatives members have their own personal plot of land in their respective village. The A/R-CDM site entitlement as incentive and motivated the community.

Table 6.1 Humbo forest development and protection cooperatives land size in ha

S/No	Cooperative name	Land size (ha)
1	Abela Longena Gamo Salu mountain forest development and protection cooperative society	1043.45
2	Hobicha Bada Woito mountain forest development and protection cooperative society	372.77
3	Bola Wache Gamo mountain forest development and protection cooperative society	343.60
4	Bossa Wanche Kacha mountain forest development and protection cooperative society	341.96
5	Hobicha Bongota Oda mountain forest development and protection cooperative society	340.04
6	Abela Gefeta Hoko mountain forest development and protection cooperative society	176.42
7	Abela Shoya Sere mountain forest development and protection cooperative society	109.73
	Total	2727.97

The HH interview respondents were interviewed for their adjacent farm land soil fertility improvement during the last six years. A higher number of project participants believe that soil fertility has improved. This difference was found to be statistically significant (Table

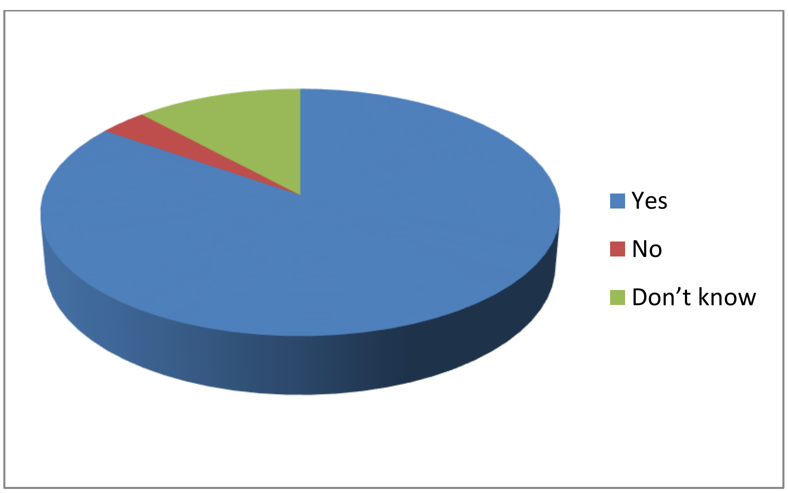
6.2). This indicated that investment on reforestation translated to downstream soil fertility improvement and then to improving productivity. The adjacent farm land soil fertility improvement was further confirmed by 70% of project area interviewed HHs reported for the increase of their farm productivity versus 21% of non-project area respondents.

Table 6.2 HH interview response regarding soil fertility improvement

		F	Sig.	t	Df	Sig. (2-tailed)	Mean difference	Std. error difference	95 % CI	
									Lower	Upper
Do you think your soil quality has improved?	Equal variances assumed	135.205	.00	9.28	776	0.00	0.308	0.033	0.243	0.374
	Equal variances not assumed			9.28	757.27	0.00	0.308	0.033	0.243	0.374

There was a significant difference in mean perception of 'improvement in soil fertility' between programme participants and non-participants ($t_{757.27} = 9.28$, $p<.001$). The average perception of soil fertility was 31% higher than the average of non-participants

Figure 6.5 Distribution of respondents by their hope for a better future



Source: Humbo HH survey (2015)

Some determinants of FMNR adoption are reported as soil type, market access, and education (Haglund et al. 2011). Given the spread of FMNR forestry practice within Humbo and around Humbo, it seems obvious the practice was quickly adopted as it improved soil fertility after bringing back native tree species within a relatively short period.

Farmers reported experiencing many benefits, with some feared about negative consequences as barriers to adoption. Benefits like getting firewood from closer distance, the flour mill facilities and temporary employment opportunities to women have been reported by interviewed respondents, This finding is in agreement with Reij (2006, as cited by Stickler, 2012).

6.3.2 Social contribution

Case study researches on community forestry projects conducted at Nepal Depart of Forestry (DOF), Tanzania (Mascarenhas, 1991) reported them as among the successful and exemplary once of the 20th century. Their success reported as partly credited to the harmonious balance countries have kept between conservation in forests and development of community through livelihood security, and attempts made to look at local level alternatives that might reduce the negative consequences generated by deforestation. Nevertheless, community forestry implementation has not been always successful as they have their own drawbacks. To arrest further degradation and to rehabilitate the degraded forestlands, social forestry, in mid-1970s, provided the most challenging area for social analysis in rural livelihood scenarios and development. The major drawbacks of the implementation of the social forestry programme were lack of transparency and accountability, exaggeration of physical target achievements and unsustainable investments. It did not help in institutional reforms. Unlike the conventional community owned forestry projects, Humbo A/R-CDM forestry passed through tough bureaucracy of CDM. Nevertheless, it became a live lesson for numerous vague inquires

6.3.2.1 Employment generation

In terms of new employment creation the Humbo Ethiopia A/R-CDM project accessed extensive paid and unpaid labour to the community, government, and NGO staff. As per the WVE report (2014) the Humbo A/R-CDM project spent about US$ 1,157,413 on the project from 2006 through end of September 2013. Out of this budget within WVE this project execution created 8 to 12 professional and at least 14 temporary jobs for eight years.

Besides, according to the KIIs from WVE, community members were often paid by WVE for their labour in pruning, thinning, guarding and seasonal duties in the early phases. The wages were necessary to enrol community members in the project's initial years, particularly since skepticism toward the project was high. Government expert KII and community FDG participants further reported that the income from project paid labour opportunities had marked benefits on the community wellbeing. One KA leader indicated that among members in his community:

> "When there were opportunities to prune, thin and guard in the project area, it provided money. Young students were able to use the wages to help their schooling. Those struggling to pay for school material were often chosen to do this work."

Other respondents mentioned that many of the paid labour opportunities allocated to community members identified as negatively affected group, which facilitated an additional offset for the negative effects of restricting access to the forest area. Voluntary labour from cooperative members also used throughout the project, particularly as cooperatives gained more responsibilities for forest management.

Working as forest guards in tree seedling raising for homestead plantation and regenerated tree pruning remained the highest employing opportunities benefitting both the project participants and non-participants, though the former benefited more than the latter (Table 6.3). This finding revealed that the Humbo A/R-CDM not only motivated the project participants but also motivated the non-participants due to the farmer-to-farmer communication, public extension and diverse communication. This in turn indicated that the community was watchful to adapt easy and feasible practices.

The number of those who reported having an employment opportunity due to the Humbo A/R-CDM project (Table 6.3) is much higher than the non-participants (58% vs 21%) and this difference is statistically different (Table 6.4). The indicated employment opportunity was often temporary and short, but provided useful cash infusions to HHs in the project area. The respondents recognize that most of the paid labour opportunities funded by NGO, WV.

Table 6.3 Number of HHs who reported on an employment opportunity

Description		New economic opportunities happened due to Humbo A/R-CDM project		Total
		No	Yes	
Non-participants	Frequency	309	80	389
	%age	79.4	20.6	100
Participants	Frequency	162	227	389
	%age	41.6	58.4	100

The paid works indicated include forest guarding and workers for the grain stores and flourmills. Yet, the non-participants indicated that the PSNP and regular government extension service programmes in their area supported the adoption of the reforestation in their area.

Responses from cooperative KII leaders suggest that precise volunteering requirements and schedules vary across cooperatives. Some cooperatives maintain regular volunteering days (e.g., weekly or bi-weekly), while others tended to organize volunteering on an ad hoc basis. Volunteer labour is likely to remain necessary to the forest cooperative's management of the project into the future as it brings indigenous technical wisdom, and shares the cost of reforestation and community ownership.

The initiative also utilized paid skilled labour (i.e., management, expertise from government offices). Yet, cooperative leaders and government workers all performed responsibilities for the project without direct compensation (excluding per diem). For example, the Humbo Woreda cooperative manager of public staff served as a part-time manager of the forest cooperative union but received only his government salary.

Table 6.4 Employment opportunity created due to Humbo A/R-CDM project

		Levene's Test for equality of variances		t-test for equality of means						
									95 percept CI	
		F	Sig.	T	df	Sig. (2-tailed)	Mean difference	Std. Error difference	Lower	Upper
More than three months employment opportunities	Equal variances assumed	155.34	0.00	11.68	776	.00	0.378	0.032	0.314	0.441
	Equal variances not assumed			11.68	747.29	.00	0.378	0.032	0.314	0.441

There was a significant difference in mean of ‘more than three months employment opportunities between programme participants and non-participants ($t_{747.29} = 11.68$, $p < .001$). On average programme participants report 0.38% more employment opportunities than the average of non-participants (Table 6.4).

Therefore, it is evident that Humbo A/R-CDM brought additional professional job opportunities to NGOs, consultants, government offices within the country during the initial stage. These findings are in agreement with CDM SD components’ contribution; while not in agreement Lohmann (2006) reported that the CDM finance does not bring additional employment or social benefits.

6.3.2.2 Community social structure

With regard to contribution to community social structure, the Humbo A/R-CDM initiative owner seven forest development and protection cooperatives are recognized as legal entities and have got their leaders (executive, audit, credit & saving and forest protection) structure based on the Ethiopia Cooperative Societies Proclamation No. 402/2004. After getting a legal entity, they put in place their structure that the cooperatives connected to formal finance system such as banks and other public and non-public organs.

According to WVE and government expert KIIs, getting land user rights and attaining legal status as forest protection and development societies generated community enthusiasm. These empowered the community to commit themselves and sustainably manage their communal resources. The established forest development and protection cooperative societies governed by their by-laws endorsed at sub-district authority.

The structure of the cooperatives consists of a general assembly, an executive body and sub-committees such as a forest protection committee, forest development committee, credit and saving committee accountable to the executive committee. The cooperative proclamation No. 402/2004 provides that the cooperative societies shall be exempted from income tax, although members shall pay income tax on their dividends. The tax exemption reported by KIIs as one of motivators for members.

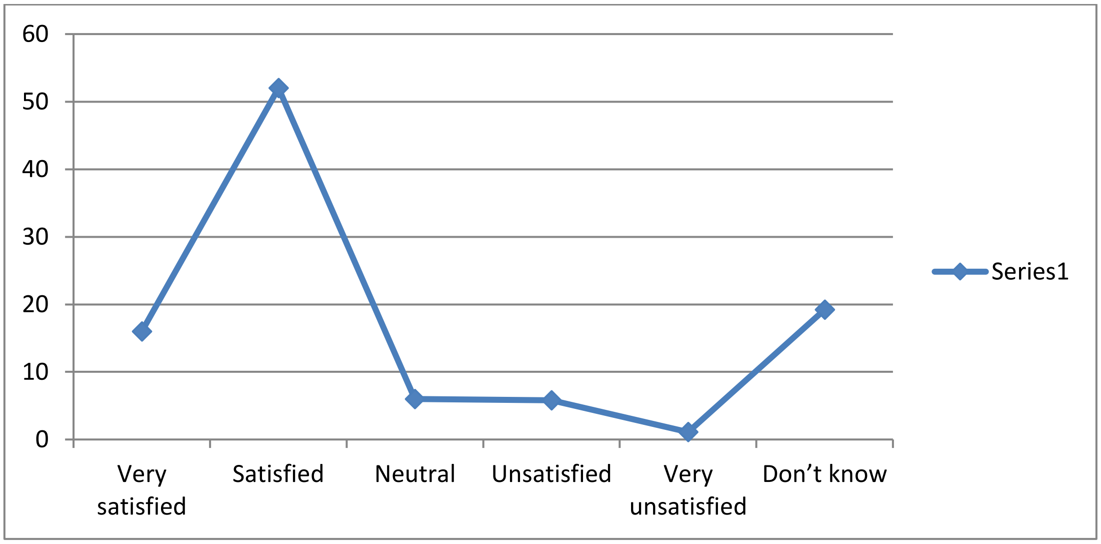
The seven cooperatives gradually evolved as a unified forest protection and development union, which aimed to bring together all cooperative societies and serve as a link to external stakeholders through one door. The union established and opened its office in Humbo district town with its fully-fledged organizational structure. The union has been serving as unified voice for their member cooperatives and ultimately for their member farmers. The union became the body ultimately responsible for delivering carbon credits to the buyers.

Because of the WVE intention to hand over all its responsibilities (including the ERPA) to the properly functioning union, this is already in place. This means each cooperative is responsible for managing the forest in the respective areas. The union will be responsible for linking and providing leadership guidance to each forest cooperative.

Fortunately, the leadership of the union drew from the seven cooperatives whose leadership has received considerable training right from project inception (WVE Report, 2015). With respect to decision-making power, including the use of funds from emission reduction (ER) sales and other revenues, this left to the cooperatives. Findings suggest that most of the cooperative members were satisfied with the cooperatives' leadership management of revenue from ER credit sales (Figure 6.6) as only 6.9% of cooperative members were unsatisfied or very unsatisfied.

One of the global agendas on such forestry-based development has been benefit-sharing equity. The sharing of the revenue premised on the land size per cooperative and the amount of revenue generated from the delineated land area.

Figure 6.6 Respondents' satisfaction on carbon credit income management by cooperative

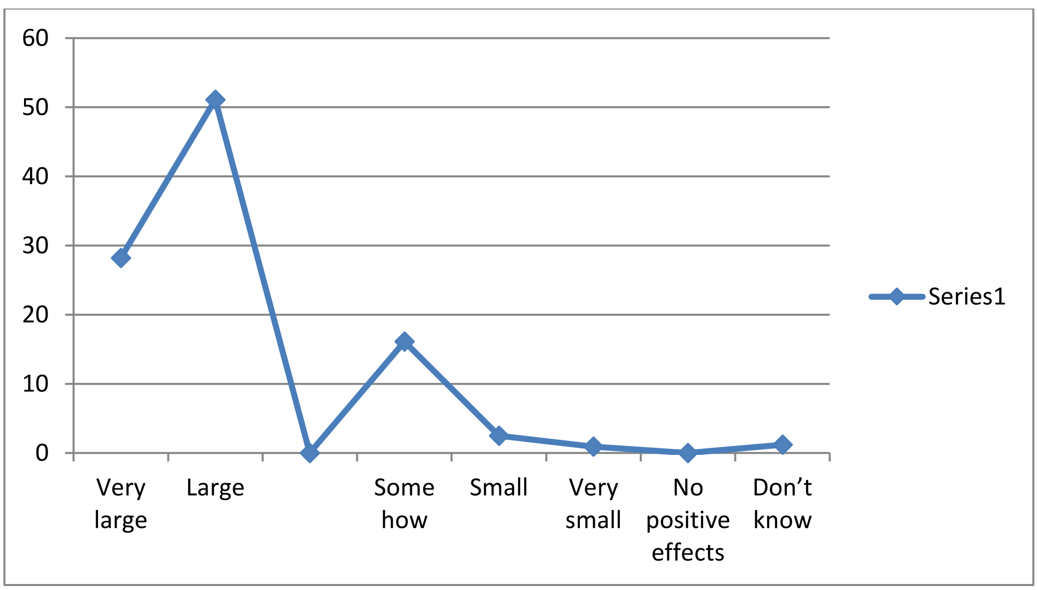


Source: Humbo HH survey (2015)

Regarding community perceptions on equity of project impacts in revenue sharing, respondents perceived the benefits of the project to be widespread. Specifically, 79% of respondents believe that a large or very large share of the population in their cooperatives experienced at least some of the project's benefits (Figure 6.7).

One of many things community level structure was to deliver was making decisions on income from A/R-CDM an investment priority. This requires the community to develop a community development priority based investment plan. Hence, the Humbo Forest Development and Protection Cooperatives facilitated the decision making process in prioritizing the pressing problems and submitted their investment areas to the carbon revenue paying office, World Bank BioCarbon, through World Vision. The investment priorities vary as per the need of each community cooperatives (Table 6.5).

Figure 6.7 Perception on their experienced A/R CDM project benefits



Source: Humbo HH survey (2015)

Such a bottom-up and inclusive process in decision-making process indicated that the community foresaw the carbon revenue and other income and, as expected, the community got the revenue and has been investing according to their plan. According to this research analysis the Humbo A/R-CDM was running smoothly as expected which could be attributed to the community level social structures like forest cooperatives, unions and their links to both public and non-public organs.

6.3.2.3 Institutional backing up

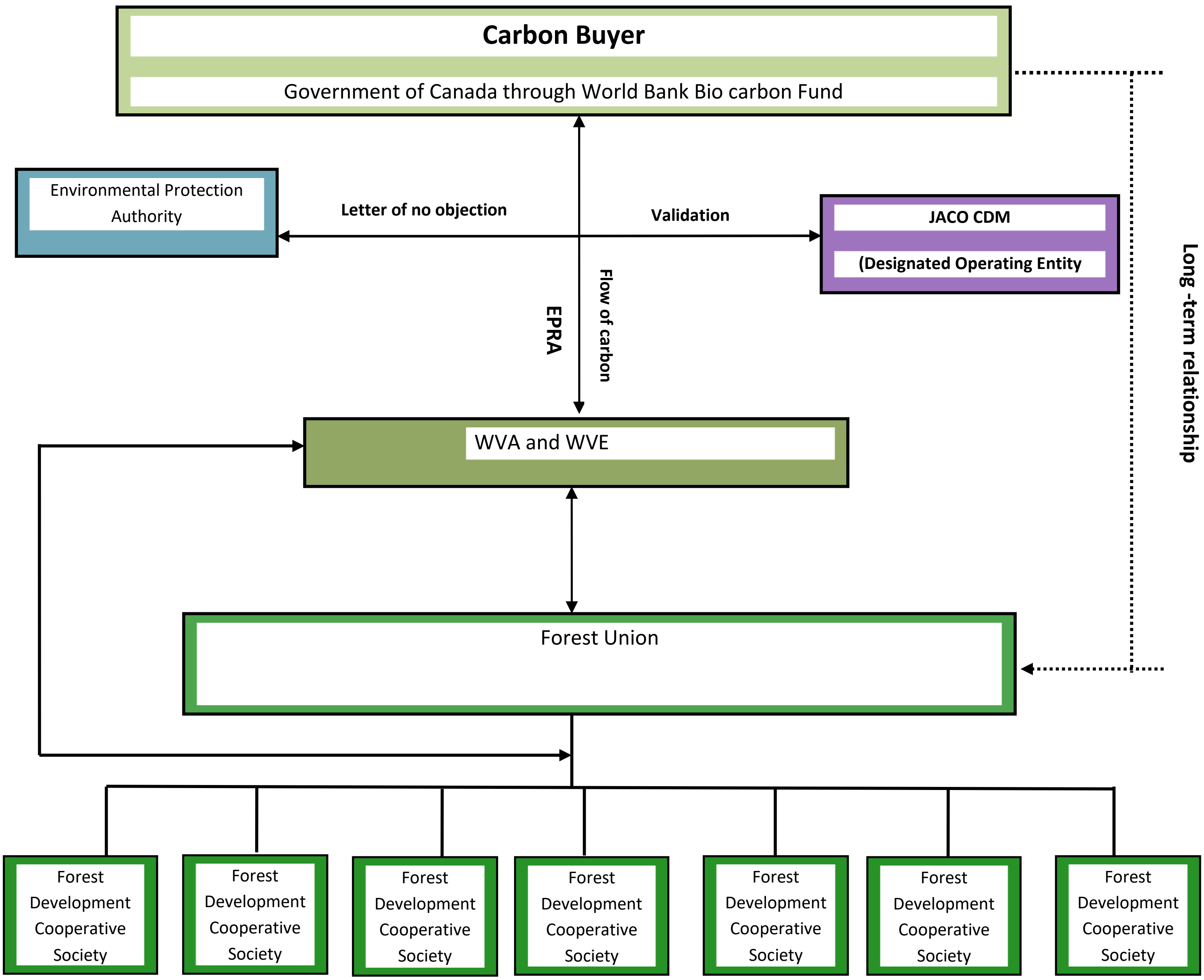
Considering the forestry carbon projects longer duration, the investment is liable to be risky unless backed by long-term governance stability. Institutionally to the intended implementation of carbon sequestration projects requires adequate national and subsequent levels of institutional capacity. In order to attract and sustain market based climate change mitigation tools as a carbon market requires having good governance practices at national, sub-national and local levels. Most importantly, community level functional working institutions are indispensable.

During the year 2011 Nanasta (2007) reported that among a few operational DNAs in Africa most countries were lacking institutional capacity to promote viable carbon projects as a result not only of absence of supporting policy and legal frameworks, but also lack of responsiveness. This might be one of the reasons for Ethiopia having only one A/R-CDM across first commitment period (2008-2012) despite the presence of eligible projects types for CDM in the country.

Of course, many African countries face political volatility and unpredictable governance systems thus making carbon sequestration investments a risky proposition. Several sub-Saharan countries are under the grip of long-term civil strife, making it most difficult for them to attract international carbon sequestration investments if after all the Paris agreement get executed. On the brighter side, in many other African countries the political leadership is taking ownership of conflict resolution, good governance and poverty reduction (World Bank, 2005). According to Humbo ERPA the institutions engaged at different levels revealed complementary partnerships, which in turn helped the community to trust the CDM bureaucratic process.

The community forest cooperatives are ultimately responsible for ensuring that project activities implemented according to plan and that they deliver carbon credits. Their responsibilities are to undertake forest development activities, and/or guarding the area on a rotational basis by members selected from each sub-kebelle/kebelle. This arrangement made the community to consider as their own resources. Intuitional structure designed as per (Figure 6.8), which worked well.

Figure 6.8 Key institutions playing major roles across Humbo A/R-CDM



Source: WVE Institutional Analysis Report, 2011

So, it can be concluded that the much feared but still functioning the only Ethiopia A/R-CDM demonstrated a number of innovative approaches particularly in its institutional architecture. The idea of forming forest cooperative societies that embedded within Ethiopian law was a key innovation that has been ensuring project growth and sustainability. The institutional framework then forms a foundation for other innovations such as ensuring participation of all eligible households in each Kebele as well as equitable sharing of benefits.

Table 6.5 Humbo A/R-CDM owner community investment priority

Priority	Humbo A/R-CDM owner community investment priority						
	Abela Gefeta	Abela Longena	Abela Shoya	Bossa Wanchie	Bola Wanchie	Hobicha Bada	Hobicha Bongota
1st	Grain store	Grain store	Flour mill	Flour mill	Flour mill	Grain store	Grain store
2nd	Credit fund	Credit fund	Grain store	Credit fund	Grain store	Petty trade	Grain mill
3rd	Water supply development	Local health facility	Oxen for plowing	Grain store	Kindergarten	Credit fund	Credit fund
4th	NA	Potable water supply infrastructure	Farm tools	Feeder road	Potable water supply infrastructure	Truck	Credit fund
5th	NA	Village road maintenance	Dairy cow	Track	Village road maintenance	NA	Agriculture tools
6th	NA	NA	NA	NA	NA	NA	Potable water supply infrastructure

In reference to ERPA WVE has been collecting carbon payments through WVA on behalf of the community and disbursing 100% of the funds to respective cooperatives proportionately upon the amount of emissions they have reduced. This responsibility also entails that the Humbo A/R-CDM participants have an active role in monitoring the project to ensure that the terms and conditions incorporated in the ERPA are adhered signed crediting period; and that the trustee receives reports. INGO's responsibilities include ensuring that the project obtains all the necessary approvals by government and other players in the carbon business, providing a link with carbon buyers, linking and mediation services. Bring up the formation of farmers cooperatives and a union (Figure 6.8) that eventually taking on the project leadership responsibilities after 2017 and also serving as an external member of the Board of Directors as a non-voting member also well-articulated by KII. Yet, there is still tendency by community to render technical and advisory assistance from WV, which is a bit fearing. On another side, carbon change monitoring, reporting and filling the NGO shoos indicated the need. Here it is critical the government level service provider capacity and readiness matters.

At federal level the then EPA, which was restructured as the Ministry of Environment, Forestry and Climate Change later, is an autonomous government body responsible to discharge the DNA mandate. The MoANR, BoANR and OoANR are the ones whom were consulted from the beginning of the initiative pre-validation stage.

The World Bank Biocarbon Fund is the carbon buyer using financial resources from the Government of Canada, which approved and authorised voluntary participation of the World Bank in November 2010. Nevertheless, 2017 onward demanded possible market sorting out; resigning contract with World Bank BioCarbon Fund Unit.

Across this research process all KIIs, FGDs and various documents such as Humbo PDD and WVE reports proved that the Ethiopia A/R-CDM initiative was successful since all indicated institutions and community structures discharged and have been discharging their respective roles and responsibilities. Such extensive partnership and teamwork from community to international institutions revealed the indispensability of pooling heads, resources and comparative capabilities to fight climate change and bring sustainable development.

6.3.3 Economical dimension

Obviously, in terms of private business, investors (public or private) like to have economic benefits analysis among other things prior a carbon sequestration project deemed profitable (Perez et al., 2007). From the nature of CDM projects one of the bottlenecks for CDM has been absence of a pre-financing mechanism since the revenue comes upon delivery. So, one unique aspect of the Ethiopia A/R-CDM initiative seems lucky since the project activities have got a pre-financer in the form of WVA and a dedicated project developer and implementer in the WVE.

It also reported that not all sequestration projects provide the same benefits. Obviously many similar initiatives aim and promise to provide economic advantages to local communities. Nevertheless, economic returns in terms of carbon credit from specific LULUCF projects base on the quality of land and the actual land use practice that followed. Dry lands of Miombo woodlands, for example, sequester only 0.05–0.7 $tC0_2e$ ha^1 $year^1$ compared to Alnus woodlots which sequester 5.9 $tC0_2e$ ha^1 $year^1$ (Aune et al., 2005).

6.3.3.1 Existing economic activities of the area dimension due to ER revenue

With regard to tree based carbon sequestration as rural income, Rosander (2007) reported that carbon payments could provide an important boost to the rural incomes. From this perspective, tree-based carbon sequestration considered highly fitting for SSA. The same scholar reviewed 23 projects, but carbon sequestration details were only available for 15 projects. However, from the perspective of baseline conditions, the total carbon sequestration potential of these 15 projects estimated to be 26.85 $MtCO_2e$, with an average of 1.79 $MtCO_2$ per project. These 15 projects estimated to generate US$ 118 million.

Likewise, according to Cmargo (2008), community development-oriented carbon sequestration projects expected to provide significant economic benefits to local communities in the form of cash incomes as well as through access to non-timber forest products (NTFPs) generated through forestry activities. In the Nhambita Community of Mozambique carbon project engaged local households received a cash payment of US$242.60 ha^{1} over seven years for carbon sequestered on their farms. Although the percentage of money paid to each household varies from 30% of the total in the first year to 10% of the total in the seventh year, a simple average works out to US$34.70 per household per annum (taking an average of one hectare of land per household). This represents a significant increase in cash incomes for most households and addresses their need for a regular cash source (Jindal, 2004). Similarly, under the contract with The International Small Group Tree Planting Programs (TIST), local farmers in Tanzania receive US$0.02 per tree year^{1} for a period of 20 years (Scurrah-Ehrhart, 2006) besides benefits to farmers from accessing fruits, minor timber, firewood and any other NTFPs.

From other perspectives the commercial plantations project in Uganda barred local households from harvesting any timber or other NTFPs, which resulted in loss of income for the entire community (Eraker, 2000). Similarly, local communities do not get a share of carbon revenue from the forest rehabilitation project in Mount Elgon and Kibale National Parks in Uganda. In fact, critics have charged that the project harms the poor by excluding them from the park lands (Lang and Byakola, 2006). Local people also can be harmed if intensive plantations of fast-growing trees like eucalyptus interfere with the water available to downstream areas. One of the study recommendations is that it assessing whether or not local people are harmed by commercial carbon sequestration projects.

As to Humbo A/R-CDM economic outcomes, perhaps the most convincing contribution of the project could be the development of institutions to effectively protect the forest, and generate and manage revenues from ER credit sales and other sources. The forest cooperatives and the revenue they generate have emerged as engines of development in the community. The contract signed carbon credit funds they have, and will continue to harness through the sale of ER credits in the first ERPA felt substantial (Table 6.6) being the only initiative in the country. Considering the crediting period as a whole (20006-2036) Humbo A/R-CDM is estimated to sequester 880,295 tCO_2e. This implies that if the price for the carbon credit remains US$ 4.4 per tCO_2e this might alone generate US$ 3,873,298.00 from carbon credit, which is a new funding stream to the community and the country. Out of the total, the ERPA signed among WV and World Bank is for 2006-2017 to buy 165,000 tCO_2e. The cash from carbon credit sales deposited in the bank in the name of each cooperative by WVE after the fund reach WVE via WVA from the trustee.

Moreover, the cooperatives have and will also likely continue to generate revenue through other non-carbon credit. To date, the cooperatives have used their revenue from ER, visitors' fees, selling grass and non-timber products to build and manage grain storage facilities and flourmills, and in some cases to provide their members with in-kind and cash credit as per their investment priority. Since the revenues from ER credit sales for the cooperatives are uneven as they are based on size of land and amount sequestered, not all cooperatives have been able to invest in the same amount of infrastructure as others. However, all of the investments have had clear and wide-reaching positive benefits.

Grain stores allowed members to sell their grains at moderate prices in the month(s) after the harvest and, critically, purchase grains at below-market prices later in the year (i.e., during the lean season). This revealed that the cooperative grain stores improved the security, reliability, and affordability of grain supplies for the community and could be a sign of transforming exiting economic activities. Interviews on site and observations also revealed that the grain store and flourmill facilities attached to grain stores were operating at a profit, thereby generating revenue to sustain their operations.

One of the female cooperative members explained:

> "The grain store is helping community members to sell grain at the harvest time, and purchase it during the lean season. This allowed members to save money compared to paying market prices in the lean season. The price is much fairer here than at the markets in Humbo, Tsebela town. It is also closer, and the profits from these sales go back to the cooperative as dividend."

From youth FDG, one youth explained:

> “Getting the grain store here is very helpful because before we had to go to Sodo [town]. Our mothers did this often… Sometimes got sick doing so and we had to pay the send them to the clinic. The mill saves time and money, and the health of parents is important for youth too.”

Flourmills installed using the carbon revenue also increased accessibility, which was more distant. One KA leader also explained that in the past:

> “Women would have to spend the night in Humbo [town] to have the grain milled there…These places are so very far, and interruption of light [electricity] is very common even in Humbo…so there was often disruption in getting the grain milled there. During the holiday periods, it used to be impossible to get grain milled without many back and forth trips to Humbo town…”

The above expressions highlighted the time, resources, and energy that previously expended to access flourmill facilities. In the past, the burden of accessing the service in the area fell disproportionately on women and children. Those journeys not only represented a time sink, but also increased the risk of potentially expensive health problems.

According to the FGDs and KIIs these burdens are dramatically reduced after having grain mill and storage sites in the communities. Rather than full-day journeys to and from often-overcrowded mills in area markets, many community members accessed these facilities in less than an hour. The implications of this change are not insignificant. One cooperative member stated:

> “Women’s life status has improved… The grain store and flourmill in the community has led to some changes. It gives women the opportunity to protect and care for

their children. They also have time to collect grass for the livestock, and increase the time they spend with their family."

Another female community member explained:

"Previously we [women] went far [6-7 hours] to mill, but now that the mill has been built we can easily access the mill. We can also benefit from the grain store by getting cheaper grain during the lean season…"

Table 6.6 Humbo A/R-CDM ER and its credit revenue across the signed crediting period

Cooperative	Forest area (ha)	Expected revenue from ER (USD)
Abella Gefata	176.4	111,804
Abella Longena	1043.5	248,945
Abella Shoya	109.7	29,983
Bossa Wanche	342	58,951
Bolla Wanche	343.6	85,305
Hobicha Badda	372.8	107,883
Hobicha Bongota	340	84,361
Total		727,232

Source: SDP (2009, revised 2013)

In these accounts, it is clear that besides creating new economic activities, the facilities made available from carbon revenue contributed directly to improved welfare among women and children. Furthermore, both FGDs and KIIs highlighted that revenue from carbon credit stimulated the community economic activities and transformed the locality.

With regard to timber product, 50% of the project area was allowed to get selectively harvested at years 12, 24 and 36 based on the forest management plan maintaining the standing biomass for the benefits of biodiversity, environmental protection and other on-going services (Humbo, PDD). Hence, the Humbo Forest Development and Protection

Union was estimated to get at least US$ 15,150 ha[1] from forest harvest from first harvest. This means a total of about US$ 3.9 million incomes from the 12th year selective harvesting and more from subsequent years.

The pre-financer funding got from WVA implied that each donor dollar generated additional revenue for communities, creating a multiplier effect while addressing ER. This could be a lesson for many NGOs to pick up and support in financing such cumbersome global mechanisms at grassroots and creating learning opportunities for it get scaled up and/or criticized based on field reality.

Net income from ER sale Humbo A/R-CDM facilitated the community to invest in their sustainable development priority and practically stimulated the existing economic activities and proved that the economic benefit is real when the A/R-CDM executed professionally.

6.3.3.2 New economic activities

Given the A/R-CDM age in the area the HHs interviewed were asked whether any new economic activities happened due to the Humbo A/R-CDM. Respondents stated that new economic opportunities in the project participant sites due to the Humbo A/R-CDM more than doubled as compared to the non-participant sites. According to the FGDs and community level KIIs, the realization of a credit scheme within the community, the flourmill service created in the villages, engaging in silvilcultural practice and the carbon credit income considered as new economic activities. This difference is statistically significant (Table 6.7). This implies A/R based climate change mitigation demonstrated its contribution to SDG goal number eight – descent work and economic growth at community level.

6.3.3.3 Reducing transaction costs

One of the various mechanisms to increase economic benefit for the CDM project developer is by reducing transaction costs since CDM projects inherently have a number of transaction costs. These costs include costs of negotiating, contracting, implementing, and monitoring a project (Rohit et al., 2008). There are other transaction costs, which include costs of registering, verifying, and certifying a project, which are usually independent of the project size. Other scholars reported that gaining information about landowners, contacting them, and certifying changes in land use all increase the cost per hectare and per unit of carbon sequestration when working with many small holders (Smith and Scherr, 2003).

Particularly, community development-oriented projects targeting small holders will have the highest transaction costs, making them less attractive to investors. Different scholars reported transaction costs varying from US1.48 per tCO_2e for large projects (generating more than 16,000 tonnes of CO_2e year1) to as high as US14.78 per tCO_2e for small projects (Michaelowa and Jotzo, 2005). Similarly, transaction costs are much higher in absolute terms when dealing with multiple parties (each with separate contracts) rather than a single party. According to WVE KIIs, some of the transaction costs such as initial consultants, validation, verification, registration, certification and social mitigation support costs covered by the World Bank BioCarbon. Besides, both WVE and WVA project entities did not take any money from the carbon credit revenue. These all significantly contributed in increasing the income to the community.

Table 6.7 New economic activities perceived by interviewed respondents

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean difference	Std. error difference	95 % CI Lower	95 % CI Upper
New economic activities happened due to Humbo A/R-CDM	Equal variances assumed	148.89	0.00	7.72	776	0.00	0.26	0.04	0.19	0.32
	Equal variances not assumed			7.72	756.4	0.00	0.26	0.04	0.19	0.32

P<001 so we reject the null hypothesis i.e no new economic activities happened due to the project and conclude that the variance in increase in economic activities is significantly different for the project participants as compared to the non-participants.

There was a significant difference in mean 'New Economic Activities happed/created' between programme participants and non-participants ($t_{756.4} = 7.72$, $p < .001$).

According to WVE KII leveraging local communities' labour, public staff, WV and World Bank Biocarbon Fund competencies contributed to the realization of the cumbersome Humbo native tree species based A/R CDM initiative and enabled the community to enjoy the full size fruit. Yet, in absence of such an innovative partnership, it might be better to have a wider area to reduce transaction costs and increase income so as to generate better income. Lucky enough from the income perspective 100% of the ER revenue reached the community due to all transaction costs being covered by development partners which made the community invest in and improve existing economic activities.

6.3.3.4 Local skill development contribution

With regard to contribution dimensions on local skill development, WVE reported providing at least 4,428 various training opportunities such as agriculture intensification, grazing management, forest fire management, tree regeneration, micro-finance, gender mainstreaming, cooperative societies, and so on for different community members (WVE 2015 report). According to FGDs response trainings enabled individuals to be aware of the initiative objectives and to contribute to the initiative through volunteer work and thus they improved their own livelihoods. In many cases, respondents confirmed that different skill development opportunities gave them various insights and reinforced their indigenous knowledge about the importance of forest protection and other environmental conservation measures. Findings from FDGs and KIIs suggested that training enabled them to diversify their income sources.

The cooperative leaders KIIs and members FGDs reported that they got various trainings such as leadership, finance management, credit and saving, community mobilization, business development, forest management and project cycle. During this research period, the cooperative office documentation has demonstrated their management capacity by successfully passing annual government audits; coordinating infrastructure construction projects; managing volunteers for forest management activities; and handling regular meetings and contributing to the successful development of a forest cooperative union. The competence of cooperative leadership was essential for such initiatives taking root since many of the social and economic benefits of the initiative area realized through cooperative-led interventions. One cooperative leader described the local skill changes in his cooperative saying:

> “We have been constantly empowered and trained. The cooperative management structures, financial management system and the link with government cooperative structures are all in our hands. So, various capacity building trainings and experiences developed us.”

According to cooperative KII the unique skill development within the Humbo community is that some of their cooperative members understood how their project area was stratified, how each plot across strata was fixed, and how tree DBH was measured and recorded. The key informant further mentioned that the trainings given for cooperative leaders in the business plan development, finance management and reporting are some of many skills with which their area is blessed.

The study conducted by Murgan and Israel (2017) reported that the provision of a series of new trainings by the initiative was one of the well-recognized contributions to the human capital of the stakeholder local communities. The authors further indicated that the Humbo A/R-CDM project created a number of training opportunities to local communities on issues related to environmental protection, forest management, land and water conservation, financial management, carbon monitoring, credit and saving management, agroforestry, and wide range of income generating activities. Trainings provided changed the initial unfavourable attitude of some of our community members towards the A/R-CDM. According to the report, the training equipped community members with basic skills on how to restore the forest and manage it.

Tagesse et al. (2017) reported that the Sodo, Ethiopia A/R carbon sequestration project participants in the project area had a highly significant effect on household annual income earnings and significantly greater annual net income than those of the non-participant households, which is in agreement with this research finding. This finding also agrees with Corbera (2005) who indicated that a small carbon forestry project in the state of Chiapas, Mexico contributed to strengthened local capacities and leadership and to reinforcing community based natural resource management across the region.

6.4 The revealed constraints on considering A/R-CDM contribution towards sustainable development

The main feature of sustainability indicators and the composite index indicators is their ability to summarize, focus and condense the enormous complexity of our dynamic environment to a manageable amount of meaningful information.

By visualizing phenomena and highlighting trends, SD indicators simplify, quantify, analyse and communicate otherwise complex and complicated information (Warhurst, 2002). According to Kates et al. (2001), the purpose of sustainability assessment is to provide decision-makers with an evaluation of global to local integrated nature-society systems in short- and long-term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable.

With regard to Humbo A/R-CDM Ethiopia DNA provided LoA to project developer in 2007 confirming that the initiative passed the country SD milestone. According to Government and WVE KIIs, the DNA office visited the site as a learning site. But there was no documented SD indicators for monitoring performed by the project developer and DNA. So, this research presume that if SD is monitored like ER incorporating both three dimensions of SD it might be utilized in decision-making processes, and could calibrate progress toward sustainable development too. The progresses outputs might be used as useful tools to communicate the achievement of the promises.

Having evidence on SD contributions from the first of its kind in Ethiopia and biggest size A/R-CDM from Africa could be an opportunity to respond to fears of A/R-CDM subjectivity.

6.5 Conclusion and recommendations

The findings of this study demonstrated that native tree species based and FMNR employed Humbo A/R-CDM found worse community-based model in demonstrating its contribution to community level SD in terms of selected environmental, social and economic indicators while delivering slightly more than projected ER. The Humbo A/R-CDM initiative addressed a set of environmental challenges in the project site, which had previously limited the potential for economic and social development in the area. Local skill development of both farmers and professionals in public and INGO offices can be considered as part of 'learning from doing' skill development for the country in areas of carbon marketing. The community structure in place can be a lesson to replicate within and outside the country since such a local level forest management and fair benefit sharing mechanism has been instrumental.

This research further assessed the importance of leveraging the comparative capabilities of local communities, public office, INGOs and World Bank Biocarbon Fund as partners in striving for a common goal. This enabled the global mechanism to contribute towards sustainable development. This implies that may be in the absence of such complementing partnerships the SD contribution might not have happened.

Nevertheless, CDM is blamed for its lengthy bureaucratic processes, and robust designing, monitoring, verification and reporting, as well as the demanding requirements of certification for ER. Such a tight process was considered as one of the success factors behind the Humbo A/R-CDM initiative indicated the indispensability of designing, setting up monitoring framework, monitoring, verification of monitoring and reflecting instead of missing globally arising opportunities.

This research showed that Humbo A/R-CDM revealed that the SD contribution is neither measured by the project developer nor by the regulatory body, DNA. Had the A/R-CDM contribution to SD been monitored, documented and reported on, the observed contribution might have varied.

Learning from CDM the Paris Agreement emphasised the intrinsic relationship between climate change and SD and welcomed the 2030 agenda for the global SDGs. According to Karen et al. (2017) there is a lack of assessment approaches to ensure that climate and development goals are achieved in an integrated fashion and trade-offs avoided. Article 6.4 of the Paris Agreement introduced a new Sustainable Mitigation Mechanism (SMM) with the dual aim to contribute to the mitigation of GHG emissions and foster SD. A key conclusion is that the Paris Agreement’s SMM has a stronger political mandate than the CDM to measure that the SD impacts are ‘real, measurable and long-term’. Recommendations for an improved CDM SD tool are a relevant starting point to develop rules, modalities, and procedures for SD assessment in Article 6.4 as well as for other cooperative mitigation approaches. So, setting up context-specific SD monitoring and reporting frameworks could have served to measure Humbo A/R-CDM SD benefits and the intention of CDM protocols.

Scholars like Brenda and Godwell (2014) reported that KP's CDM can be considered as a transition mechanism to Kenya's green economy and the contribution of CDM projects towards SD in Kenya.

This research recommendation is in line with Karen et al. (2017) recommendation that the key SD measuring tools could have been introduced with CDM and certification of SD could have been implemented at the UNFCCC level, while nationally countries could draw up their own SD standards based on international best practice. To ensure the integrity of certification introduction of no-harm safeguards, development of monitoring and reporting guidelines, the use of independent auditors to verify the effects monitored, and strengthening stakeholder participation rules and guidelines might be necessary to enhance CDM co-benefit.

CHAPTER 7: POLICY PERSPECTIVES OF NATIVE TREE SPECIES BASED Humbo A/R-CDM TOWARDS CLIMATE CHANGE MITIGATION AND SD

7.1 Introduction

7.1.1 Global perspective

One of many inclusive policy efforts globally against climate change was setting up KP to the UNFCCC, which sets a framework for intergovernmental efforts to deal with the issue of climate change. It was introduced in 1997 with the purpose of strengthening the Convention. The protocol introduced binding targets to cut GHG emissions of Annex-I countries by 5.2% from 1990 levels in the first commitment period, 2008-2012.

Afterwards, the extended negotiations on the post-2012 agreements and targets have got consensus in CoP21, Paris. In indicated CoP the parties to the UNFCCC reached a historic agreement to combat climate change through accelerating and intensifying the actions and investments needed for a sustainable low carbon future, which demonstrated political commitment.

In accordance with Article 21, paragraph 1, of the CoP21 Agreement shall enter into force on the thirtieth day after the date on which at least 55 parties to the Convention accounting in total for at least an estimated 55% of the total global GHG emissions have deposited their instruments of ratification, acceptance, approval or accession with the depositary. Accordingly, the Agreement entered into force on 4 November 2016. Among all forestry in terms of REDD+, avoided deforestation including forest conservation or sustainable forest management considered as part of the Paris Agreement. Such level global effort was needed since Earth's Bulletin (2016) reported that the earth's atmosphere has reached 407.3 ppm of CO_2 in 2016, as measured at Mauna Loa and stressed as serious global warming is coming much sooner than expected. CO_2 as a GHG has risen more than 40% since the beginning of the industrial age due to the burning of fossil fuels, the cutting down and burning of forests and agricultural interventions.

The IPCC AR5 reported further indicated that beyond reasonable doubt that the earth's climate is warming. This latest report stated that with 95% certainty that human activity, by increasing concentrations of GHGs in the atmosphere, has been the dominant cause of the observed warming since the mid-20th century. The report presents strong evidence that warming over land across Africa has increased over the last 50–100 years (IPCC, 2014) as of 1950 onwards. As a result, in Africa species composition and diversity expected to change due to individual responses of species to climate change conditions (Erasmus et al., 2002). The projected rapid rise in temperature combined with other stresses, such as the destruction of habitats from land use change, are being disruptive (Malcolm et al., 2002).

Moreover, climate change impacts have reported as potential to undermine and even undo progress made in improving the socio-economic well-being of East Africans. The negative impacts associated with climate change compounded by many factors, including widespread poverty, human diseases, and high population density, which estimated to double the demand for food, water, and livestock forage within the next 30 years (Davidson et al., 2003).

7.1.2 Climate change perspective of Ethiopia

Ethiopia's contribution to the global increase in GHG emissions since the industrial revolution has been negligible, so the country has no historical responsibility unlike developed countries. Even after years of rapid economic expansion of the last two decades since the early 1990s, per capita emissions is less than two tCO_2e (CRGE, 2011), which is modest compared with the more than 10 tons per capita on average from emitting countries in the EU and more than 20 tons per capita emitters like the USA and Australia.

With regard to vulnerability Ethiopia's rain-fed agriculture, which is the basis of the economy in providing about 46% of GDP and 80% of employment for the working population, affected because of changing climate (CRGE, 2011). In terms of transport, the

World Bank (2008) indicated that climate change will increase the maintenance costs of the Ethiopia's road network between US$10 million to US$ 21 million, depending on the climate model used. As the country is running to boost its road infrastructure, the negative climate change impact on road maintenance is not good news given the investment road construction consumed.

From energy side itself, climate change-driven droughts have also been detrimental for the Ethiopia electricity system, which is highly dependent on hydropower facilities (Asress et al., 2013). In 2002/3 power supply was lost one day a week over four months because of drought. This caused a sustained reduction in GDP generation. Loss of electricity also affected basic services especially in schools and hospitals. Any loss of electricity affects the country economy and continues to be frustrating since the country is marching to manufacturing, while depending on hydro-based energy.

With regard to health, the IPCC AR 4th report stated that by the 2050s malaria will enter into the highland areas of Ethiopia, where it was not common, and that by 2080 conditions will be highly suitable for malaria transmission. This highlights that the climate science reports have been warning Ethiopia in terms of health too.

7.1.3 Policy response of Ethiopia against climate change

Ethiopia has developed and implemented a range of legal, policy and institutional frameworks on environment, water, forests, climate change, and biodiversity. The Ethiopia established in 1994 to serve a regulatory function. The country has made important decisions and taken various measures to minimize the effects of climate change. It is party to both the UNFCCC (ratified in 1994), the KP (ratified in 2005) in its Proclamation No. 439/2005 for its twin objectives and signed the latest historical Paris Agreement in 2015.

The country submitted the First National Adaptation Program of Action (NAPA) to UNFCCC in 2001 and 2007 respectively. In 2011 Ethiopia launched the Climate Resilient

Green Economy, which is an overarching framework and national strategy. In CRGE seven sectors were identified to deliver the highest GHG abatement potential (CRGE, 2011).

Ethiopia also developed and submitted its INDC in 2015 to UNFCCC. The INDC, being one of the country's political commitments, carried the Ethiopia goal to limit GHG net emissions including emissions or removals from LULUCF to 145 $MtCO_2e$ by 2030. This represents a reduction of at least 64% below the Ethiopian BAU scenario by 2030, where net emissions are projected to reach 400 $MtCO_2e$. Yet, the full size INDC implementation seeks global partnership in terms of finance, technology transfer and capacity building.

According to Ethiopia INDC (2015) the mitigation efforts will focus primarily on the forestry sector, which is expected to contribute with a reduction of 130 $MtCO_2e$. Ethiopia intends to use international carbon credits to meet its target through carbon market. In the same report the government proclaimed that if Ethiopia's CRGE strategy was fully implemented, it would reduce per capita emissions to 1.1 tCO_2e by 2030.

Nevertheless, in presence of CRGE and the five year running program called GTP, climate change aggravated by Eli Nino made Ethiopia face the first of its kind drought in 2014/15, subjecting about 18.2 million people to depend on food aid, causing rampant deaths of livestock, and shifting the government attention away from development boosting to respond to crises protection. Therefore, it is valid to assess policy implications of running one of the global mechanisms - native tree species based Humbo A/R-CDM climate change mitigation.

7.2 Materials and method

7.2.1 The study area

The case study area is Humbo district as indicated in (Figure 7.1). The Humbo area is situated from 6° 46'48.47 to 6° 41'04.28 N and longitudinally ranges from 37° 48'35.44 to 37° 55'14.51 E.

The case study focused where the only A/R-CDM has been undertaken and assessed the relevant to climate change policy aspects of its realization mirroring global perspectives. The study location degradation exacerbated by climate change and led the community to run for coping mechanisms. Among others, uprooting of tree stumps for charcoal led the community to be aid dependent. This desperate action coupled with over grazing and cyclical droughts that followed the 1984 drought episode halted the natural regeneration of the trees, exposing the land to hostile weather elements that left the land bare and barren. Among various efforts, an international NGO called World Vision picked up the issue and processed A/R-CDM since 2005/6 so as examine the mechanism ability to reduce GHG mitigation while addressing local sustainable development dimension.

Hence, the Humbo A/R-CDM project selected as a case study since it is the only and biggest AR-CDM for Ethiopia and Africa respectively. Moreover, it was the first A/R-CDM project in getting tCER issuance in Africa and the second in the world.

7.2.2 Objective of the study

Ethiopia, being one of the least developed countries and one of the hardly beaten countries by revealed climate change consequences, there has been a growing and ambitious need to get knowledge on market based climate change mitigation to tap from climate finance and enhance its climate change response strategies. The opportunities like KP period CDM lessons, however, were not critically analysed in the country climate change related policy context.

Therefore, the main intention of this study was to review the policy related literatures and augment it with case-study based evidence in the light of the global climate change policy dynamism.

7.2.3 Study method

The study method employed was that of reviewing, the Ethiopia afforestation/reforestation based climate change mitigation related policy documents; interviewed KIIs like government of Ethiopia (GoE) and NGO experts. The community perceptions in relation to native tree species based A/R-CDM and its implication for GHG mitigation and its contribution to local sustainable development considered.

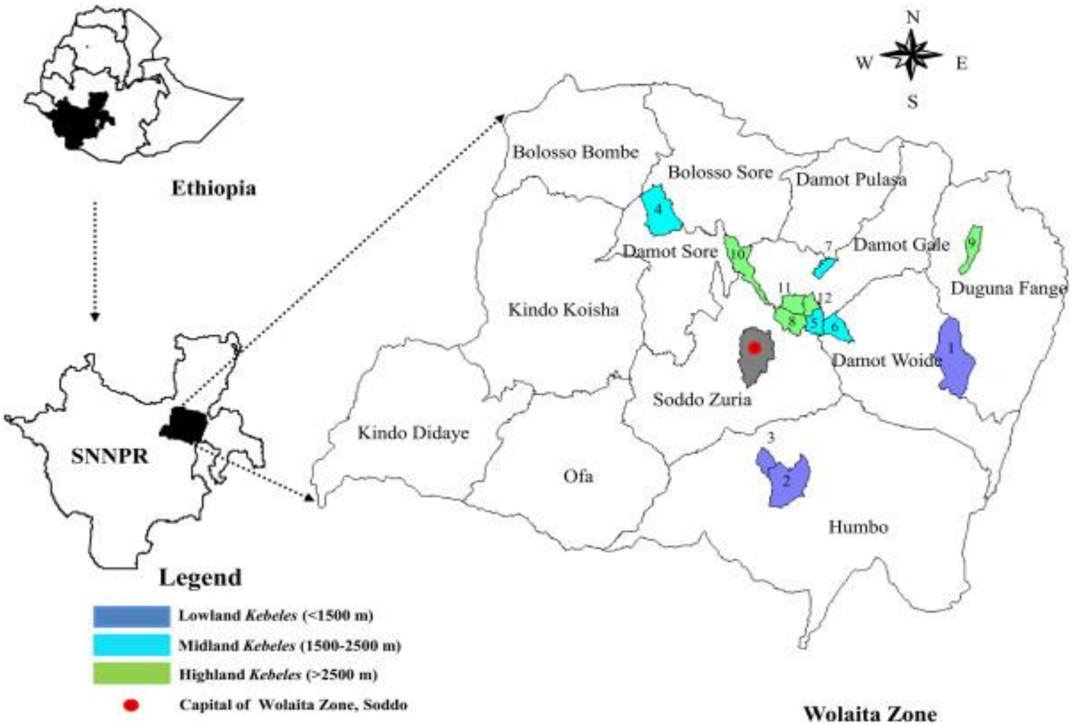
7.3 Results and discussion

7.3.1 Reforestation history of Ethiopia

Ethiopia has a long history of tree planting activities. According to historical records, afforestation started in the early 1400s by the order of King Zera-Yakob (1434-1468).
Modern tree planting using introduced tree species (mainly Australian Eucalyptus) started in 1895 when Emperor Menelik-II (1888- 1892) looked into solutions for alleviating shortage of firewood and construction wood in the capital, Addis Ababa. However, the historic rapid expansion of large scale and community plantations occurred during the 1970's Dergue regime, which resulted in the establishment of large scale plantations. Several fuelwood projects funded by UNSO, UNDP and FINNIDA spread over the country with marked concentrations around big cities (Yitebitu et al., 2010).

After the 1990s, efforts continued with issuance of the 2011 Ethiopia CRGE. Within the CRGE period, and during the GTP-I period specifically, promising achievement has been recorded in terms of natural resource conservation, including native tree species regeneration and seedling plantations throughout the country by mobilizing grassroots communities. At the centre of this accomplishment is extensive education to, and continuous consultation with, the community that resulted in conviction about the benefits of natural resource conservation works in improving land productivity and mitigating climate change. With this and other concerted effects, land covered by forest has reached 15.9 million Ha. As a result Ethiopia forest coverage increased from about 3% in 1994 to 9% around 2010 and reached 15.5% in 2014/5 (MEF, 2014/5). This shows that Ethiopia has been serious in the forestry sector due its significant link to the livelihood of the country.

Figure 7.1 The Humbo A/R-CDM project specific locations



Source: Location of the-Kebeles and administrative Woredas in Wolaita Zone of SNPPR (
(https://www.researchgate.net)

In February 2015, Ethiopia adopted a new forest definition as follows: "land spanning at least 0.5 ha covered by trees and bamboo, attaining a height of at least 2m and a canopy cover of at least 20 per cent or trees with the potential to reach these thresholds in situ in due course " (MoEFCC, 2015). This forest definition differs from the definition used for international reporting to the Global Forest Resources Assessment and from the forest definition used in the National Forest Inventory which both applied the FAO forest definition with the thresholds of 10% canopy cover, a 0.5 ha area and a 5 m height.

According to the MEFCC (2015) report, the reason for Ethiopia to change its national forest definition is to better capture dry and lowland moist vegetation resources. Specifically, the reason for lowering the tree height from 5 to 2 m is to capture *Termilania-Combretum* dense woodlands found in Gambella and Benishangul Gumuz Regional States which primarily consist of trees reaching a height of around 2-3 m and above. The proposed change in forest definition resulted in the inclusion of what previously classified as Ethiopia's dense woodlands, which have a wider distribution through the country (Figure 7.2).

Because of the Ethiopia's modified forest definition, dense woodlands were considered forest. The reason for increasing the canopy cover threshold from 20 to 10 % is to avoid acceptance of highly degraded forestlands into the forest definition and in this way provide incentives for protecting quality forest.

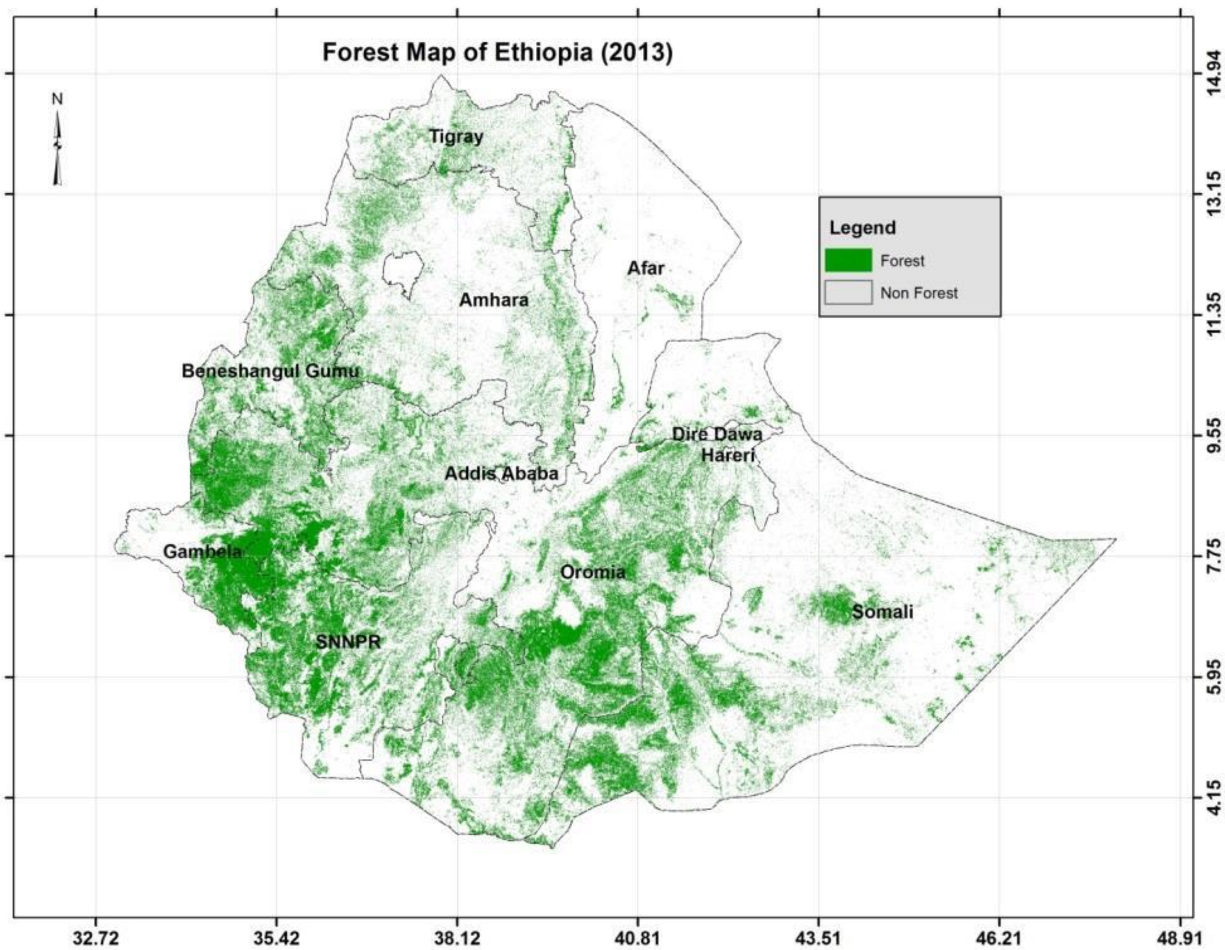
According to Ethiopia GTP-II strategy, enhancing biodiversity is considered a basis for sustainable development (GTP-II plan, 2015-2020). To achieve this agenda focus seems geared around saving and promoting endangered and endemic species including native forest species.

7.3.2 Legislation environment management in Ethiopia

The 1995 Ethiopia Constitution itself included the principle of environmental rights, including the right to live in a clean and healthy environment and the principle of government responsibility to ensure this right (Ethiopia Constitution, 1995). The EPA formulated (Environment Policy of Ethiopia,1997) as part of a wider Conservation Strategy. The Policy defined policy guidelines on atmospheric pollution (although no instruments) and climate change; land use; forest, woodland and tree resources; biodiversity; water resources; and energy resources. Ethiopia ratified the UNFCCC in 1994 and aligned with global political will. The Ethiopia National Meteorological Agency (NMA) climate change and pollution research team established in 1994 with the aim of providing research guidance and directives on climate related issues. Yet, little or no visible research findings have been reported.

Under the late Prime Minister, Meles Zenawi, Ethiopia was at the forefront of Africa's climate policy development. Immediately following the Copenhagen climate conference of 2009, Ethiopia embarked upon the development of a vision and strategies for what it called 'climate resilient green economy'. Two years later, in the Durban climate conference, Ethiopia unveiled its vision to become a middle-income economy by 2025, by building a climate resilient green economy following a sectorial approach (Mengisti, 2014). The baseline year for the Ethiopia CRGE was the year 2010. One of the most important processes Ethiopia undertook at this junction was inventory of emission sources.

Figure 7.2 Illustration of the approximate impact of the revised forest definition



Source: MoEFCC

The 2010 Ethiopia inventory stated that the total annual emissions of the country were about 150 MtCO_2e. After the inventory-projected emissions by 2030 reported to grow to 400 Mt CO_2e based on the BAU scenario. For achieving the middle-income status without increasing the 2010 levels of emissions, several interventions identified and a shortlist of initiatives were drawn up following a prioritization exercise. This could be one of the country level findings in promoting information about climate change and changing the conventional development path in terms of Ethiopia.

As a result, Ethiopia embarked on a CRGE strategy, as a key plank in the wider and even more ambitious Growth and Transformation Plan, GTP (MoFED, 2010). The CRGE strategy considered the first of its kind in Africa when it was launched in 2012.

The CRGE strategy builds on the GTP which is said to be the government's ambitious development plan, aspiring to build Ethiopia's economy to middle-income levels by 2025/30. The first GTP planning period was approved by the parliament in 2010 to run across 2010/11-2014/15. Both CRGE and GTP are considered overarching national policy frameworks governing developmental policies, budgets and government organizations, as well as actions of development partners and foreign investors towards a climate resilient green growth and economy.

The effort of the Government of Ethiopia to transform the country into a middle-income country with zero-net carbon emissions by 2025/30 by implementing the ambitious GTP-I, II and subsequent GTPs through under the umbrella of the CRGE through green technology was reported to be commendable (GTP-I progress report, 2012/13). However, the need for local to international cooperation was considered to be indispensable to scale up better practices and adapt and/or generate new green technologies. Obviously the GTP-II (2015-2020) is under implementation.

The Ethiopia climate change response policy driven strategy described a new model of development that integrates measures of economic performance, such as GDP growth, infrastructure development, poverty reduction, job creation, and social inclusion, with those of environmental performance, such as improving resilience to climate shocks, mitigation of GHG emissions, biodiversity loss and ensuring access to clean water and energy. Strong economic development and economic inclusion objectives recognized simultaneously with environmental and social objectives.

The agriculture and forestry identified 41 key options, including macro-level responses focusing on benefit to GDP, household-level responses of protecting vulnerable groups and biodiversity-focused responses, recognizing its importance for resilience.

So as to run the CRGE the Ethiopia government has established the national CRGE facility to co-ordinate and manages climate finance flows to mobilize, access, sequence and blend domestic and international, public and private sources of finance to support the implementation of and institutional building for the CRGE strategy.

7.3.2.1 Forestry and climate change mitigation synergy in Ethiopia

The CRGE of the country opts to achieve its targets through sustainable land use and efficient agriculture, sequestration in forests, expansion of renewable and clean power energy, and resource efficient advanced technology (industry, transport and building construction sectors). The forestry sector is among the four pillars of CRGE to address climate change mitigation within the existing legal and policy framework (CRGE, 2011). During CoP21 Ethiopia pledged to restore 15 million ha degraded areas by 2030 as part of ARF100, which is another splendid pledge.

To reduce deforestation and forest degradation, Ethiopia was reported to be making good progress in initiation of establishing REDD+ based projects, in participatory forest management projects such as the Bale eco-region (500,000 ha), Yayu and Gedo forests (190,000 ha) and Baro-Akobo in the southwest forest (7,610,300 ha) (Lemenih and Woldmariam, 2010; R-PP, 2011). No doubt, these contributed for reported forest coverage increase after 1990’s.

7.3.3 Ethiopia's engagement in global climate change response mechanisms

The CDM under the KP was the first of its kind of carbon market instrument, which advanced following a 'learning by doing' pattern. As part of the global carbon market CDM developed rapidly. It was designed with two objectives: to contribute to local sustainable development in the host country and to assist Annex-I countries to achieve their emission reduction targets in a cost-efficient manner (UNFCCC 1997).

In 2009 almost every part of the world expected that the climate change negotiation deal would get sealed in COP21 held in Copenhagen, but this did not happen. But did not except continued negotiation. After exhaustive negotiations about the post-2012 agreements and targets, consensus reached in COP21 and adopted as the Paris Agreement in 2015. Parties to the UNFCCC considered the Paris Agreement as an historic agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. This agreement required all parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead.

As of 5th October 2016, 125 parties of 197 have ratified the Paris Agreement and the Agreement entered into force on 4th November 2016 considered global successes. As part of the global community, Ethiopia also ratified the Paris Agreement on January 17th, 2017. Forestry in terms of REDD+ and avoiding deforestation, including forest conservation or sustainable forest management, are part of the Paris Agreement. To this end, Ethiopia ratified its NDCs (Ethiopian NDCs) which focuses on reducing vulnerability to climate change and reducing GHG emissions. National forest sector development initiatives through afforestation & reforestation and assisted natural regeneration on degraded mountain landscape would ultimately have substantial contribution to meet objectives of NDCs. In this respect, Ethiopia's forest development strategy supported with REDD+ program is promoting interventions that enhance tree-based livelihood in rural settings (EFCCC. 2017. National forest sector development program, Ethiopia. Volume I-III, 2018). .

7.3.4 Policy driven responses of Ethiopia towards climate change

Ethiopia took steps to ensure that its economy is green and sustainable. This step published in CRGE vision that evidence revealed that Ethiopia's agriculture, forestry, transport, energy and industry sectors considered as ripe sectors for low carbon development (Ethiopia's vision for a CRGE, 2011). As a result, CRGE followed, sectoral plan to reduce carbon emissions as the 2010 GHG emissions baseline found 150 Mt CO_2e. The projection indicated that by 2030 the emission might be more than double, i.e. 400 Mt.

7.3.4.1 Agriculture

Promoting climate-smart agriculture (CSA) techniques to increase agriculture yields strengthen farmers' resilience to climate change and reduce net emissions through healthy soil and vegetation that serves as a carbon sink given attention.

In Ethiopia agricultural crop production in 2010 was around 19 million tons, which was projected to reach more than 71 million tons in 2030 (CRGE, 2010). Consequently, the indicated production increase estimated to increase emissions from agriculture 60 Mt in 2030 unlike12 Mt CO_2e in 2010. Another identified emission source was livestock.

Hence, the country focused on the adoption of agricultural and land use efficiency measures during GTP-I (Ethiopia academy of sciences, 2017) and intensifying agriculture through the usage of improved inputs instead of encroaching on forests. With regard to livestock, the country selected to go for quality than quantity. According to GTP-I report at the end of the GTP-I period the country's crop productivity increased from 1.65 to 1.78 tons ha^{1}, which revealed progress.

In terms of livestock the country strategy was to promote consumption of lower-emitting sources of protein, e.g., poultry by increasing the share of meat consumption from poultry to up to 30%. However, evidence is no available at all levels where this research interacted. This might be the strategy is not realized or not documented.

Another strategy was to mechanize the draft power through to substitute around 50 % of animal draft power by mechanical equipment for ploughing/tillage despite burning fuels. But within GTP-I mechanical equipment being made available for few graduate youth farmers in some parts of Ethiopia like Amahara Region (GTP-I, report). From the analysis reducing emission from agriculture still gray where it lacks clarity in targeting, monitoring, documenting and making ready for verification.

7.3.4.2 Forestry

In forestry, the impact of human activities is a large source of CO_2 emissions in Ethiopia, like many developing countries, amounting to almost 55 Mt CO_2e (37% of the country's total) in 2010, unlike the global GHG emissions due to deforestation and forest degradation which is about 17%. This indicated where the country to focus so as reduces emission.

According to CRGE (2011) the Ethiopia forestry emissions are driven by deforestation for agricultural land (50% of all forestry-related emissions) and forest degradation due to fuel wood consumption (46%) as well as formal and informal logging (4%).

Considering the 2010 projections, unless action taken to change the traditional development path, an area of 9 million ha might be deforested between 2010 and 2030. Over the same period, annual fuel wood consumption will rise by 65%– leading to forest degradation of more than 22 million tons of woody biomass.

Nevertheless, during GTP-I period in Ethiopia forest coverage increased from 9% in 2010 to 15.5% in 2015 (MoEFCC, 2016). This showed that the country made effort in the forestry sector to realize the green growth path if the added percentage is not due to new forest definition. The forest coverage increase has positive implications in terms of sequestered carbon. Quantification of the sequestered carbon pool change due to increased forest cover demands its own study to track the country's progress towards its CRGE strategy and commitment to global communication.

7.3.5 Acting locally influence on global policy climate.

Understanding biomass dynamics and flows between carbon pools in forest ecosystems enables more effective accounting. Despite substantial progress in the field of forest carbon accounting over the last decade in other parts of world, in developing countries such as Ethiopia carbon accounting remained outstanding challenge because of capacity and traditional forestry practices. In the case of Humbo A/R-CDM ER projected using IPCC default value by employing BEF ex-ante calculation was 69,868.7 tCO_2e by the end of the year 2011. However, replacing BEF into allometric equation of Tropical dry forest and accounting tree with DBH starting from $\geq$ 2 cm instead of $\geq$ 4 cm brought actual ER by the end of 2011 to 73,786 tCO_2 for AGB and BGB. Such 4.96% ER increase could have been left out if the ground reality based evidence does not influenced policy of UNFCCC CDM EB. This indicated that acting locally could influence the global policy climate.

However, interview respondents stressed affirmative policy absence native tree species promoting farmers and private investors, which have been motivating Humbo area and other parts of South Ethiopia towards more of exotic tree species such as eucalyptus. Hence, both FGDs and KIIs frequently stressed the importance of policy incentives to motivate native tree species based reforestation.

The country is set to make per capita emissions below 2 tCO_2 by 2030. Yet, so far the mechanism is not clearly in place to make each citizen accountable to regulate respective emissions. This also needs teaching its citizens structurally, creating a verifiable monitoring, and reporting system to hold accountable each citizen.

Yet, climate change responding policy driven strategy in areas of forest coverage achieved in GTP-I revealed that the political commitment under realization if the momentum continues as the country pledged to reach 30% forest cover in 2030.

CHAPTER 8: CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

The only A/R-CDM in Ethiopia became possible because of environment related constitutional provisions, enabling land use policy, the presence of country forest definition that complied with the international range, timely ratification of KP, the establishment of DNA in order to issue a letter of no objection and to provide a letter of approval, and other enabling policy environment interventions. The CRGE strategy and subsequent GTPs are also policy frameworks with proper environmental attention and readiness, which testifies of the country's political will in this area, despite the country failing to attract carbon finance period during the first commitment period of the KP.

8.2 Recommendations

Considering only the AGB and BGB carbon pool of Humbo native tree species, carbon sequestration changes revealed tCO_2e levels beyond initial projections across ten years. Hence, an intensification of native tree species-based reforestation would bode well for ecosystem services.

The additional certification in the form of CCB certification and receiving gold standard (GS) never brought the expected premium. Such ambiguity has to be rectified whenever going for other market based climate change response carbon sequestration projects since it comes at a financial and operational cost.

According to KP, evaluation of the contribution of the CDM to SD is largely dependent on national circumstances. In fact, the principle of national sovereignty and local level context was found to be a dominant concern in sustainability assessment to such an extent that the evaluation fully rests on the host country without any standardized criteria or monitoring. Therefore, standardized baselines according to project type and digitalizing monitoring might help capture SD more empirically and in a more standardized manner, like that of CO_2.

Having land use policy and ensuring its implementation, clarifying carbon ownership rights, framing forest carbon benefit sharing mechanism and ensuring in country capacity to coordinate climate change responses remain critical so as to walk with changing global climate change related policy arena.

Transitioning to a low carbon economy found the way forward to the Earth. On the other hand, a low carbon path needs various sectors and overall citizens' deliberate engagement. This demands a robust one window dependable system since almost all professional KIIs and the findings suggest that the existing national arrangement towards climate change response has been less effective in coordinating diverse sectors in the country to cope with global dynamism.

Along contributing towards climate change mitigation through carbon sequestration requires a long term and mutual partnerships among communities, service providers and development partners, giving attention to work as partnership remains indispensable. This is well noted from Humbo A/R-CDM.

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Appendix-I Questionnaire

Background

a) Survey Number: ………………………………………..

b) Date: …………………………………………………………

c) Enumerator/s name/s: ……………………………………

d) Completed survey verified by: …………………………..

e) Village/coop name: ………………………………………..

f) Respondent's name: …………………………………….

I. Household survey interview question

1. Respondent's age: ………………………………………………
2. Sex of respondent 1) Male…………..2) ………………..

3. Ages of respondent: ……………………………

5. Education of respondent: …………………………………………..

6. Are you aware of Humbo A/R-CDM project? 1) Yes……2) No………

Cluster 1: Skill & employment

1.1. Have you or a member of the HH attended any skill training given by Humbo A/R-CDM project? 1) Yes…… 2) No…………

1.2 If yes, please indicate major types of trying in relation to A/R-CDM?

1. Forest management……..2. Nursery technique ………. 3.Apiculture………..4. Carbon stock monitoring………… 5. Cooperative importance & its management………..6. None………………

1.3 Do you belong to a Humbo A/R-CDM project forest cooperative? 1. Yes ……… 2. No……………

1.4 If yes, what are the benefits of being member of the forest cooperatives?

(More than one answers possible) 1 Technical skill …… 2. Natural resource ownership 3. Employment opportunity…….. 4. Carbon revenue…………5. Social respect………….6. None……….

Cluster 2: Social structures

2.1. Who has been mainly managing Humbo A/R- CDM project?

1) Government forestry authority…… 2) World Vision project staff …..3) Forest Cooperatives……….4) I don't know…..

Cluster 3: Environmental benefits

3.1. Since 2006 is rainfall distribution in your area 1) Improved………….. 2) Get worse…………….3) get better ………..

3.2. Since 2006 is rain amount 1) increased …..2) Decreased ………3) None ………

3.3. Are you aware of FMNR? 1. Yes ……. 2. No……. 3. No answer…………

3.4. If yes, is FMNR helpful to restore forest? 1. Yes ……. 2. No…… 3. None………..

3.5. If you found FMNR helpful, what made FMNR helpful to restore the forest?

1) Easy at community level……………………………………..

2) Improved biodiversity…………………………………………….

3) Avoided nursery cost……………………………………………….

4) No worry of seedling survival……………………………………

5) Easy to replicate …………………………………………………

6) Doesn't need big investment…………………………………….

7) It is possible to get fire wood through pruning …………..

8) Brought back native tree species ………………..

3.6. Is FMNR practice is attractive to restore degraded area? 1) Yes …..2) No…..3) Not sure………..

II. Key informants

2.1. Elders and women

1. When your area lost forest coverage?
2. By who and when Humbo A/R-CDM started?
3. What changes you are observing after Humbo A/R-CDM projects in your area?
4. Any benefit revealed to women after Humbo A/R-CDM project started in your area?
5. How you have been getting fire wood after the Humbo A/R-CDM project site closed?
6. Who owns the Humbo A/R-CDM project site?
7. Any constraint you observed after A/R-CDM project commenced?

2.2 Forest cooperative leaders

1. How you get elected?
2. How you get capacitated to lead the cooperative?
3. What is your role in realizing Humbo A/R-CDM project?
4. Who owns the Humbo A/R-CDM project site?
5. What community level changes happened after Humbo A/R-CDM project?
6. Who access the project site non-timber benefits?
7. Your readiness to manage the project after WV phase out?
8. Why you are interested to be under one farmers' union instead of seven independent Cooperative?

2.3 District government forestry staff

1. How Humbo A/R-CDM project get supported by your office?
2. What community level social structures happened due to A/R- CDM project?
3. What community level social benefits revealed since 2006 due to A/R-CDM project?

4. What environmental benefits revealed since revealed since 2006 due to A/R-CDM project?
5. Is native tree species based A/R CDM climate change mitigation is worthy to achieve GHG mitigation while contributing community level sustainable development benefits? Why?
6. What could be improved from host country side to monitor report sustainable development indicating indicators?
7. If planation or FMNR attractive? Why?
8. What are the constraints of A/R-CDM?

2.4 National level government expert

1. What you know about Humbo A/R CDM?
2. What do you know about Ethiopia DNA office service?
3. What is your opinion about A/R- CDM and also market based climate change response?
4. How do you see the progresses of Ethiopia Climate Resilient Green Economy strategy guided GTP-I progress?
5. What do you think about Humbo A/R-CDM contribution to the CRGE & GTP?
6. Do you think Ethiopia has policies to respond to climate change and their relevance?

2.5 WV Staff

1. Please tell me about your history in the Humbo A/R-CDM project and your role?
2. Reflecting on the project's progress over time, what are the key achievements?
3. Were there any issues with the project implementation?
4. Observed outcomes of Humbo A/R-CDM met the designed purpose both GHG mitigation and SD?
5. What lessons do you encountered using FMNR Vs planation forestry?

2.6 World Bank Addis office

1. How far do you know about Humbo A/R-CDM project?

2. What are the key achievements of the Humbo A/R CDM Project to date in your view?
3. From the World Bank's perspective, what are the key challenges associated with implementing this type of project?
4. What is your view on implications of monitoring carbon stock and SD indicators?

III. Focus group discussions with direct participants (cooperative leaders and cooperative members), community (women, men & youth) and non- project participants.

1. Are you aware of Humbo A/R-CDM project?
2. What are observed environmental benefits of Humbo A/R CDM project?
3. What are observed social benefits of Humbo A/R CDM project?
4. What are observed economic benefits of Humbo A/R CDM project?
5. Did you felt any climate change impact in your village? if yes, since when? What are the major climatic changes?
6. What is your engagement in the process of forest cooperative leaders' election and other decision making process?

……………………………………..//………………………………………………