# *Study on Production & Trade of Charcoal from Prosopis Juliflora*

## Aysaita & Afambo Woreda of Afar Region, Ethiopia

Name: Alawis Ahmed (MSc)
Submission of Date: August, 2019

# TABLE OF CONTENTS

## Abstract

The main purpose of this study is to understand why an increasingly illegal charcoal production and transportation observable facts in Afar while government banned, what could be main stakeholder's arguments concerning on the production and trade of Prosopis charcoal through a licensing system and what could be main focus areas of changes in behaviour relation to Prosopis management and utilization (what people know, what people can do, and what they think). Correspondingly Afar region BoLAND is interested and motivated by a number of reasons to this study: 1st since regional government was banned charcoal production, an increasingly illegal charcoal production and transportation observable facts; 2nd by the name of Prosopis tree, hardly available indigenous trees used to charcoal production; and 3rd dramatically expansion of Prosopis which resulted very serious risks to livelihoods of afar people and biodiversity. The study focused on the charcoal producer, charcoal trader and government respond to the issues of Prosopis management and utilization such as charcoal production from Prosopis trees. Individual and community member interviews, focus group discussion, key informant interviews and field observation were made to collect some valuable data and information relevant for this study. Besides, literature reviews were made to verify and triangulate what has been collected primary data and analysis Prosopis charcoal production and trade in the study areas. The results revealed: illegal charcoal production is an increasingly and a major cause of deforestation that by the name of Prosopis charcoal production and transportation hardly available indigenous trees are burning; charcoal businesses are frequent source of income paired with other livelihood and a primary option to fill income gaps when the event of disaster/drought provoked their main livelihood; existing government approach to control charcoal businesses are grounds to aggravating incidence to indigenous tree burning as result of increasingly illegal charcoal production; community representatives strongly expressed now time to negotiate with government and look for organized response to Prosopis management and utilization with potential economic benefits and respectively to reclaim potentials land to regenerate indigenous tree, pastures and water points soon; cost-benefit analysis of charcoal production is feasible that cost-benefit ratio is still above 1:3 (for every 1 birr invested producer get above 3 birr in return) for all three categories of Prosopis invasion and two cutting methods; regional Prosopis regulation were not aware and known by significant number of people including lower government administration units; considerable numbers of people were interested charcoal business through a licensing system and piloting in few areas; people very eager government to lift restriction and emplace helpful Prosopis regulation and licensing system; and as study areas natural resources base/available are on land and people are against to land use and cover policy that working haphazardly, it resulted an increasingly illegal charcoal business in the areas and has not considered and adopt land use policy related to natural resource management including charcoal production and Prosopis invasion that charcoal producer has not specific area to make charcoal and created ideal environment for charcoal producer to cut the indigenous tree resource as they want. As result of these facts the study suggested that Prosopis can be managed to be a very valuable sources of commercial products and livelihoods in Afar region and the regional and local government officials need to emplace systematic approach and strategic program to pilot on management, marketing and utilisation of Prosopis products such as charcoal, animal feed,

honey production etc focus on few woredas with objectives evaluating techniques of management (regulation & licensing system), evaluating the relative contribution of Prosopis to the charcoal and animal feed market, the merits/demerits of Prosopis charcoal and animal feed (livelihood, availability, regularity, quality, calorific values), training on best carbonisation techniques, introduction of technologies, strengthening the capacity of production groups in marketing of Prosopis products, as well as assisting the stakeholders in the business to come up with viable market led programs on Prosopis management and utilisation.

## 1. BACKGROUND INFORMATION

Afar National Regional State is one of the nine regions of the Federal Democratic Republic of Ethiopia, which is situated in the northeast part of the country. Afar Region is geographically situated between $8.820^0$ and $14.500^0$ latitude and $39.567^0$ and $42.467^0$ longitude. The Region is entirely situated within the Great East African Rift Valley and boarders four National Regional States: namely, Tigray Region in the north-west; Amhara Region in the south-west; Oromia Region in the south; and Somali Region in southeast. Afar Regional State also borders international boundaries with Eritrea in the northeast and Djibouti in the east. The Region is divided into five administrative zones, which are further extended and subdivided in to 32 woredas and 347 Kebeles, and covers about 92,000 square km. According to the UNICEF Ethiopia Country Office Briefing Note of 2016, the total population of Afar Region is estimated at 1,679,000. Out of the total population of the region, 90% of the people reside in the rural areas and 10% in urban areas of the Region.
The two major and dominant sources of livelihoods in the region are pastoral and agro-pastoral activities. Livestock development in Afar Region is the most dominant and important economic sector that influence all other social, political and cultural activities, which is ultimately used as the basis of reinforcing the socio-economic ties. Approximately 90% of the rural population in Afar is pastoralist while agro-pastoralist consists of a mixture of livestock or animal rearing, and rain fed and irrigated agriculture and crop production along Awash River basins and low-lying riverine areas make up approximately 10% of the population. Afar region is predominantly occupied with pastoralists, and the main livelihood of the rural population depends on subsistence livestock production, which has been estimated based on carrying capacity of the vegetation cover. The estimated livestock population (PADS, pastoral area development study, 2015) in the region are 335,175 cattle, 389,709 sheep, 551,925 goats, 60,560 donkeys, and 182,431 camels, which is approximately equivalent to 621,454 TLU.

### *1.1 Prosopis* Juliflora: the 'Devil Tree'

*Prosopis* is an exotic tree that was introduced to Ethiopia in the 1970s to control soil erosion in dry parts of the country. *Prosopis* grows virulently in dry, acidic soils, and in the last 40 years it has spread rapidly from introduction sites. The extent of *Prosopis* invasion is approximately 3,605 $Km^2$ in the Afar region (AUC=0.94), while the potential habitat for future infestation is 5,024 $Km^2$ (AUC=0.95) (Tewodros T. 2015).

*Prosopis* has had a major impact on the Afar people, who are pastoralists and agro-pastoralists. *Prosopis* often grows to form dense, impenetrable thickets which crowd out other trees and grass, reducing grazing and browsing potential for animals. It has closed off access to important watering holes and migration routes. The large thorns of *Prosopis* can cause injuries to animals and people. Eating large volumes of unprocessed seed pods of *Prosopis* can damage animals' teeth and jaws, and cause constipation and even death if consumed heavily. For these reasons, *Prosopis* has earned the name of 'Devil Tree' among the Afar. A number of characteristics make *Prosopis* very difficult and costly to control. It has very deep roots and coppices vigorously unless roots are excavated at least 30 centimetres below soil. Its seeds are very small and are viable for a long period of time. It is spread very quickly as wild animals and livestock feed on the seed pods, which come twice a year. As pastoralists migrate around the landscape, their animals fertilise the land with *Prosopis* trees.

Despite these threats, nowadays the species create benefits widely used for firewood, charcoal and construction purpose. The interviewed community member admitted that use *Prosopis* products in their households and many people in Afar made money from *Prosopis* charcoal that motivated by this new source of income, even for several Afar people it used as alternative livelihood to better income source, economic job opportunities and coping strategy to the recurrent drought. In the same way:

*"In the late 1990s, the Forestry Research Programme of the UK Department for International Development supported a project by the HDRA in the UK and CAZRI in India to collate information about the most common Prosopis species. The three main conclusions of that effort are that (1) Prosopis can be a very valuable resource for the dry lands; that (2) efforts to eradicate this species are overly expensive and likely to be ineffective; and that (3) Prosopis can be managed to be a very valuable source of commercial products and livelihoods in the dry lands."*

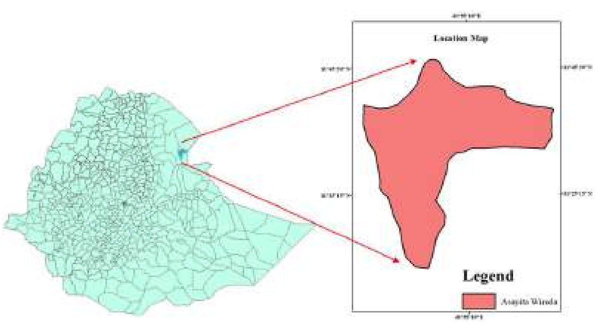
*"In the assessment of the Afar eradication program for instance the area under Prosopis expands more than 20 times faster than the area that is brought under productive use. Also menaces such as Prosopis have not had much attention from research and development community - and this would need to be changed too (Mehari el al., 20 13)."*

## 1.2 Description of study areas

The study is located in Aysaita and Afambo woreda of Afar region.

Aysaita woreda is situated 635 km from Addis Ababa, Western lowlands of Awash basin. The woreda covers a total area about 1678.28 $Km^2$. The study sampled kebeles are geographically located to administration centre (N 11°34.070´ and E 041°26.217´) with elevation 337 m, Kebele-01 (N 11°33.870´ & E 041°26.485´) with elevation 363 m, Kebele-02 (N 11°34.126´ & E 041°26.222´) with elevation 363 m, Galifage Kebele (N 11°39.767´ & E 041°21.567´) with elevation 354 m and Oromayto Kebele (N 11°34.574´ & E 041°23.572´) with elevation 553 m above sea levels. Based on the 2007 census conducted by the CSA, the total population of the Woreda is about 50,803, of which 27,284 and 23,519 are men and women respectively, 31.4% of its population are urban dwellers, 18.42% are pastoralists.

Afambo woreda is situated 655 km from Addis Ababa, Western lowlands of Awash basin and 20 km North of Aysaita. The woreda covers a total area about 1258.97 $Km^2$. The study Kebele is geographically located to Alasabolo Kebele (N 11°31.536´ & E 041°32.475´) with elevation 338 meters above sea levels. Based on the 2007 Census conducted by the CSA, the total population of the Woreda was about 24,153, of which 13, 312 and 10, 841 are men and women respectively, 3.4% of its population were urban inhabitants, 27.03% are pastoralists. The location and coordination points can be found in Appendix I.



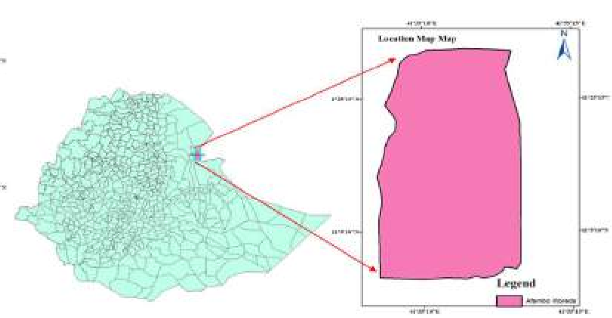



Figure 1: Location Map of Aysaita Woreda Figure 2: Location Map of Afambo Woreda

### 1.3 Objective of the study

Afar region BoLAND is interested in collecting data on production and trade of charcoal from *Prosopis*. This is motivated by a number of reasons: 1st since regional government was banned charcoal production, an increasingly illegal charcoal production and transportation observable facts; 2nd by the name of *Prosopis* tree, hardly available indigenous trees used to charcoal production; and 3rd dramatically expansion of *Prosopis* which resulted very serious risks to livelihoods and biodiversity. Accordingly, this study will compelling data with different levels of arguments concerning on production and trade of charcoal from *Prosopis* trees that possibly will basis for negotiation to control *Prosopis* through utilization such as licensing charcoal production and trade; and so we simply have a better understanding on the ground related to charcoal production and trade facts and fates in the region.

#### 1.3.1 The specific objectives

1. Find responses that affect the three major participants in the production and trade of charcoal: the producers, the traders, and the government.
2. Carry out charcoal cost benefit analysis
3. Potentials and challenges to charcoal production and trade in Afar region
4. Land tenure aspects to *Prosopis* raw materials and possible charcoal licensing system
5. Review regional regulation to control and management of *Prosopis* invasion

## 2. METHODOLGY OF THE STUDY

The study consists of four methodologies such as study framework, data source and collection method, sampling, and data analysis.

### 2.1 Study framework

The study framework proposed to answer two key questions.

- ✓ First, why an increasingly illegal charcoal production and trade observable facts; while government had regulation and banned charcoal production and transportation?
- ✓ Second, what could be main stakeholder's arguments concerning on the production and trade of *Prosopis* charcoal through a licensing system?
- ✓ Third, what could be main focus areas of changes in behaviour relation to *Prosopis* management and utilization? What people know? What they can do? And what they think?

### 2.2 Data sources and collection methods

The study used both primary and secondary data. Prior to field work; data collection formats and checklists were prepared at office. The primary data were collected through individual interview, community member interview/FGD, key informants interview with relevant officials/experts and field observation and trail. On the other hand secondary data were obtained through reviewing relevant study reports and research finding published. Then after the collected multipart data have been reduced or condensed by organizing, classifying, tabulating and presenting the data in a suitable form for analysis.


Figure 3: Sample photo indicating the data collection process (source: field Survey, 2019)

## 2.3 Sample selection

Depending on the severity, accessibility and exploitation groups of *Prosopis* Juliflora, the study kebeles were selected purposively. Three rural & two urban representative kebeles were selected from Aysaita and Afambo woreda. The individual interview aimed for a total of 60 sample individual interviews and five group interviews across the selected five kebeles. This sample size was chosen because it was believed enough to feasibly realise in the time available and were distributed randomly between the selected kebeles ( Table 1).

| Woreda | Kebele | Sample (target) | Actual sample (achieved) |
|---|---|---|---|
| | Galifage | 10 | 10 |
| | Orumoyato | 10 | 10 |
| | Kebele 01 | 15 | 15 |
| **Aysaita** | Kebele 02 | 15 | 15 |
| **Afambo** | Aalasabulo | 10 | 10 |
| **TOTAL** | | **60** | **60** |

**Table 1:** Study sample

### 2.3.1 Interview with individuals

A total of 60 individuals were interviewed with charcoal producer and traders that data collected on the areas of opinions; perception; potentials & challenges; social value; economic benefits; land tenure system, market chains, economic feasibility and implication of regional *Prosopis* regulation. The interview questionnaires can be found in Appendix 5.

### 2.3.2 Interviews with community member/representative

Group interviews were followed checklists of key questions (see Appendix 6). Group interviews were envisaged as a major component of the study and in all five kebeles were done with total participants of 50 community representatives.

### 2.3.3 Interviews with key informants

Interviews with key informants/specialists shed light on the broader context of the *Prosopis* tree management and utilization and were especially useful for exploring issues related to government policy/regulation, programs, *Prosopis* impact, environmental issues, market feasibility and coordination and networking. A total of 12 key informants were interviewed including government officials, NGO workers and research institutions. See Appendix 7 for a list of interviewees.

### 2.4 Data analysis

The collected data was organized and tabulated according to their similarities under the theme issues raised in the study questions and interview. Moreover, the collected information through interview was presented to fit together the data obtained by means of secondary data. Information obtained from field observation, through an interview made with community members and focus group discussions were analyzed qualitatively, whereas some of the information obtained by employing interview questionnaires was analyzed using simple descriptive statistics methods such as percentage, figures, pie chart, and cross tabulations. Finally, conclusions were drawn from the major findings and possible recommendations from the identified question/ problem were suggested.

## 3. LITERATURE REVIEW

### 3.1 Prosopis Juliflora and Ecological Distribution in Afar

Various invasive alien species (IAS) such as *Prosopis* Juliflora, Parthenium, hysterophorus, Lantana camara, Euccorniacrasipes and Straiga species were introduced to Ethiopia either deliberately or accidentally (Hailu et al., 2004; Senayit et al., 2004, Taye et al., 2004 Adefires and Worku, 2008). Today, IAS is among the major threats challenging sustainable development in the country.

Among others, P. Juliflora, a multipurpose tree or shrub native to South America, Central America and the Caribbean was introduced to Ethiopia intentionally as an agro-forestry species in early 1980s (Ameha, 2006). Reports revealed that, few individuals of this species were first planted as agro-forestry trees around farmlands and homestead at Lower Awash Agro-industry state farms, MelkaSedi. However, after few years of silence, the species quickly started to spread and invaded hundreds of kilometres from the original plantation sites causing severe threat to the silvo-pastoral rangeland of the region in particular (Dubale, 2006; Ameha, 2006; Adefires et al., 2008). The infestation of *Prosopis* which originated from a couple of shade trees planted around the homestead, not only invaded rangeland in Afar, but also the different land uses including farmlands, resident areas, ritual sites and etc. The species is also crossing borders to the neighbouring districts within Afar and other Regional States, for instance, Oromia, Amhara, Somali and Tigray causing the same threats.

Nowadays it is repeatedly reported to be one of the invasive and problematic trees in the Afar region as well as in the country. Many scholars reported that the species has been increasing in density as well as area coverage from year to year even from month to month. Currently, this noxious tree heavily infests most agricultural as well as potential rangelands in the Afar region. The thorny nature of the plant, remarkable ability to withstand adverse conditions, non-browse able nature, and above all, the mobile nature of the people have paved the way to invade most potential lands of the region. More importantly, the species is severely displacing the indigenous plant species that sustain the livestock, which is the mainstay of the pastoral communities. Furthermore, *Prosopis* is causing various health and other social problems. Despite the negative impact and different perceptions among the large part of the community (farmer and pastoralist), *Prosopis* Juliflora has become an income source for the livelihood of part of the community including daily labourers and fuel wood and charcoal producers.

*"Prosopis Juliflora (mesquite) is a tropical and subtropical tree and shrub, mainly found in the arid and semi-arid regions of the world (Pasiecznik et al., 2001). The historical contexts of Prosopis and different opinions have led to the present position with two widely held points of view. There is one argument for further planting and improved management of Prosopis Juliflora while the other one supports eradication and control. (Magid et al, 2014)."*

## 3.2 Nature and Process of Charcoal Production

Charcoal is traditionally produced in earth, brick or steel drum kilns in batches from about I to 5 tons. Common kiln types and production methods are detailed in e.g. (FAO, 1983) and recently in (UNDP, 20I0). Fuel wood is gathered and cut to size, and placed in an underground or above ground kiln. The kiln is fired and the fuel wood heats up and begins to pyrolyse. The kiln is mostly sealed, although a few air pockets are initially left open for steam and smoke to escape. As the kiln emissions change colour, the charcoal producer may seal some air pockets. The production process may take up to a few weeks. About half of the energy in the fuel wood is typically lost in the process (but the charcoal produced has higher energy content per unit mass). When the process has ended, the kilns are opened or dug-up and the charcoal is removed. The resulting charcoal resembles smaller, lighter pieces of blackened wood. These will have higher energy content by weight than fuel wood (Kammen and Lew, 2005).

Figure 4: Sample photo indicating kilns charcoal production at Aysaita (source: field Survey, 2019)

In Africa, a limited number of people consider charcoal production as their main economic activity, while a majority engage only occasionally as a means to generate income, particularly in times of financial stress, such as when making large payments for things such as medical costs, funeral expenses, food supplies in the event of poor harvests, marriage ceremonies, and school fees. Cash income from charcoal may act as a form of insurance against crop failures (FAO, 1983).

In general, the charcoal producer brings the charcoal in bags to the roadside from where it is transported by truck, other motorised vehicles or by animal to the urban centres. Wholesalers or transporters often contract charcoal producers, but they also work and sell their products individually. The majority of charcoal is sold to large or small-scale transporters. Some large scale transporters are also wholesalers. These wholesalers then pass the charcoal on to smaller scale retailers and consumers (WB, 2009). The retailing of charcoal offers trade opportunities for many people, in particular women (BTG, 20I 0).^

### 3.3 Significance of Charcoal in National Development

*Environmentalists feel that charcoal production should be stopped because of its destructive nature as presently practiced (Achard el 01, 2002). However, Arnold and Persson (2003) asserted that both rural and urban dwellers in some developing countries have developed a strong appetite for charcoal use. Therefore, attempts to ban the production or the use of charcoal will be mostly unsuccessful mainly due to the inter play of socio-economic interests. Since operators can use free raw materials (wood from natural forests or farm clearing) and turn them into a marketable commodity in high demand, there is the need to have much respect for the sustainability of the resource.*

The Food and Agriculture Organisation (2000) points out that, charcoal is a very important energy source for households. Its saturation ranges from 54 to 71 % in urban areas and it is the main fuel for more than I million families in Sub Saharan Africa. It was also noted as a valuable commercial fuel, with an annual turnover of some US$60 million at current market prices. The FAO assumed that if 80% of this amount corresponds to labour payments at US$ I .50 per day, its production and marketing create some 144,000 permanent. Jobs earning twice the average minimum wage (US$0.7S per day) of most sub-Saharan African countries as of the year 2000 (Stephen, 20 I I).

The implication of this is that as the economies of developing nations grow, one would expect to see a decline in the wood fuel mix of the country (Girard, 2002). This has indeed been observed in Asia where the consumption of wood fuels is declining in favour of alternative fuels, reflecting the rapid economic growth of the region since the 1980s. However, in Africa, one of the most marginalised regions in the world, economic growth has been slow and wood fuel consumption is increasing (SEI, 200 I ; Kituyi, 2004). This growth is associated with the rural to urban migration found in many African countries combined with low incomes and savings, which inhibit the transition to others fuel types. As a result of, Africa's wood fuel dependence is likely to persist for decades to come, which could have significant consequences for forest resources and the rural livelihoods dependent upon them (Richard, 2007).

The FAO has estimated that for the world as a whole total charcoal production in 2009 was 47million tones and increased by 9% since 2004. Africa accounted for an overwhelming share of world's charcoal production (about 63% of global production) in the 2004. Ethiopia is among the leading producer (8%) in the world production of charcoal following Brazil (11%). FAO report also put Ethiopia among the five top world's wood fuel producing country in the period 2004-2009 only next to India (16%), China (II%) and Brazil (7%) in that order. Ethiopia according to the report had 4th rank in its share to global wood fuel production contributing about 5% in the covered period. Fuel wood is preferable energy source for industrial heating in small and medium scale industries (e.g. soap industry). Charcoal is also utilized by small cottage and craft industries (Dawit, 2012).

Table 2. FAO Projections of Fuel wood Consumption to 2030 in the main Developing Regions

| Year | 1970 | 1980 | 1990 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|---|---|
| Firewood (million cubic meters) | | | | | | | |
| South Asia | 234.5 | 286.6 | 336.4 | 359.9 | 372.5 | 361.5 | 338.6 |
| Southeast Asia | 294.6 | 263.1 | 221.7 | 178.0 | 139.1 | 107.5 | 81.3 |
| East Asia | 293.4 | 311.4 | 282.5 | 224.3 | 186.3 | 155.4 | 127.1 |
| Africa | 261.1 | 305.1 | 364.6 | 440.0 | 485.7 | 526.0 | 544.8 |
| South America | 88.6 | 92.0 | 96.4 | 100.2 | 107.1 | 114.9 | 122.0 |
| South Asia | 234.5 | 286.6 | 336.4 | 359.9 | 372.5 | 361.5 | 338.6 |
| Charcoal (million tons) | | | | | | | |
| South Asia | 1.3 | 1.6 | 1.9 | 2.1 | 2.2 | 2.4 | 2.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| South east Asia | 0.8 | 1.2 | 1.4 | 1.6 | 1.9 | 2.1 | 2.3 |
| East Asia | 2.1 | 2.3 | 2.3 | 2.2 | 2.1 | 2.0 | 1.8 |
| Africa | 8.1 | 11.0 | 16.1 | 23.0 | 309.2 | 38.4 | 46.1 |
| South America | 7.2 | 9.0 | 12.1 | 14.4 | 16.7 | 18.6 | 20.0 |

Source: Broadhead *el al.* (2001)

In 2001 the FAO began a significant effort to reassess their projections of fuel wood consumption. The FAO study shows a growing consumption of fuel wood worldwide, particularly in Africa (Broadhead *el al.,* 2001). According to the FAO (2000) the quantities of charcoal needed by 2020 and 2030 in Africa alone is estimated at 38.4 and 46.1 million tons respectively (See Table 2). This shows that charcoal will continue to be a key source of household's domestic and commercial cooking energy form for most rural families in the developing world. The overall quantities involved, and the numbers still relying on fuel wood will continue to be very large.

The International Energy Agency (lEA) (2001) also estimated that in 2030, biomass energy will still account for an estimated three quarters of total residential energy in Africa. Additionally, due to population growth, the number of people using fuel wood and other biomass fuel demand will rise by more than 40 percent during 2000-2030 to about 700 million. In Asia, despite declining consumption, there will still be an estimated 1.7 billion users in 2030, while 70 million would be in Lat in America.

Barnes *el 01.* (2002) estimates that charcoal consumption is often growing faster than firewood consumption. Charcoal is becoming a much larger part of the fuel wood total in Africa and South America and, growing close to the rate of population growth. Significant variations between countries exist, but the general trend of decreasing per capita consumption of both fuel wood and charcoal with increasing income remains.

There is a kind of ladder of energy sources in the urban areas: from firewood at the bottom, through charcoal, kerosene and LPG, to electricity at the top (Kammen and Lew, 2005). People generally climb this ladder as their income increases. Therefore charcoal, which is infrequently used in the rural areas because of availability of free wood, is quite popular in urban areas because of higher income and other factors such as its lightness and non-smoking nature (FAO, 2000).

As income rises, initially more fuel wood is consumed, but beyond a certain level its use decreases due to its substitution by other fuels (Kammen and Lew, 2005). According to Filmer and Pritchett (200 I) price influences the amount of fuel that is consumed, but only minimally affects the choice between fuels. Growing urban populations are relying on the more compact charcoal as the primary source of urban cooking energy (Kammen and Lew, 2005), with many transitioning from firewood to charcoal as the cost of wood increases in urban areas (Barnes *el 01., 2002).*

### 3.4 Charcoal utilization pattern in Ethiopia

It is evident that the Ethiopian economy (as most economies) is highly dependent on natural resources. Exploitation of these natural resources may generate large economic benefits in the short term. However, in the long term unsustainable use of these natural resources increases not only environmental degradation, but decreases economic growth and livelihood opportunities (Cesar and Ekbom, 2013).

Heavy skewedness of Ethiopia's energy consumption towards biomass resources is attributed to deprivation of access, deep rooted poverty, technological backwardness, and numerous other factors. International Energy Agency report evidenced the unhealthy reliance of Ethiopian economy on biomass fuel resources for national energy requirement which has caused multifarious puzzles. According to the report, in the year 2008 alone 92% of Ethiopia's energy demand was met from biomass source. Hydro power and oil products claimed mainly I % and 7% respectively. These shows the extent to which national energy balance of the country is resilient on biomass resources (Dawit, 2012). Only about one household in every four (23%) has electricity, with a very large disparity between urban and rural households (85% versus 5%). Due to the lack of electricity, other energy sources such as wood, charcoal, dung and crop are used for cooking and heating. Urban populations are growing and although an enormous effort has been put into the provision of housing and basic services and improving slum areas, further efforts are required due to increasing demand. There is a need to improve urban land management, the implementation of solid waste disposal and waterborne sewage disposal systems (Cesar and Ekbom, 20 13). This also indicated that economic costs of environmental degradation on poor are clear, as the poor are unable to protect themselves adequately against environmental hazards, such as drought, afford to take sufficient remedial actions, to engage in alternative livelihoods, which can protect them from the environmental risks or to provide themselves with alternative sources of income and employment.

Trend and share of different biomass fuel sorts in total biomass consumption for the last decade was presented below. Firewood was the major biomass type consumed in Ethiopia. The country is the number one producer in its share to world's charcoal and woody fuel wood as compared to other African countries. Evidences indicate that 99% of households, 70% of industries and 94% of service enterprises use biomass as energy source. Trend in total biomass consumption different sectors implies that households consumed almost all biomass fuels in the last decade. Computed average share of household biomass fuel consumption out of total biomass consumption as fuel over the II years stood at about 99.6% (Dawit, 2012). In Ethiopia, a wood energy survey of 1996/ 97 indicates that 230,000 tonnes of charcoal are used every year. Seventy percent of the total production is used in towns, supplying 97% of household energy needs (Mugo and Ong, 2006).

### 3.5 Charcoal production from Prosopis Juliflora

*Prosopis species produce high quality charcoal depending on the type of species. The wood does not spit, spark, or emit much smoke and thus, it is call wooden anthracite. Moreover, the durability, strength, less shrinkage, less cracking and hardness make the wood of Prosopis Juliflora more useful for many purposes (Victor, 2007).*

*Prosopis* provides more firewood than other species due to its high biomass production on marginal land (Kassahun Z, Yohannes L, Olani N (2004). The wood is probably the most important product of woody invasive plant species use either as a fuel wood or structural material (Mwangi E, Swallow B (2005)). The wood is heavy and hard with excellent fire generating quality. The wood can be trade and commercialized for industrial fuel wood production, brick furnaces and bakery oven and grill charcoal for household consumption. According to Ethiopian Institute of Agricultural Research carried out experiment in Afar region, showed that *Prosopis* trees stumped 10cm below the ground had not coppiced over six months after cutting. This was thought to be a good option to control *Prosopis* invasion if it is specially linked with schemes that facilitates utilization of the harvested wood for fuel wood or charcoal production. As well as experiment finding has indicated that depth of cutting to prevent coppicing depends on the size and age of the tree and the density of the vegetation stands. They reported that matured trees where there is thick coverage should be cut 30cm below the ground to remove the bud zone of the root system to prevent reshooting.

Energy from *Prosopis* can be obtained through several ways that include, direct burning, carbonization, gasification, pulverization, and fermentation (Pasiecznik, 2001; Silva et al., 2011).
*Prosopis* trees are good sources of fuel wood around the world; in Ethiopia, the trees are made into charcoal which are then transported and sold in urban areas. Over 90% of energy consumption in Ethiopia comes from biomass fuel (Mekonnen, 2009). Currently, most of the fuel wood biomass in Afar region comes from Acacia and *Prosopis* trees. Charcoal in the Afar region is produced traditionally with very minimal cost. Earth mounds are built at harvesting sites; hence, there is no or little transportation cost of raw woody material. This traditional method doesn't require large investments and the labor associated with charcoal production is cheaply available in the area. Moreover, production size is not a limit.

It has turned large hot dry plains green in the last 30 years - but still it is a major scourge that goes largely unattended: mesquite or under its official botanical name *Prosopis juiijlora.* In the last thirty years this hardy well rooted shrub made its way from Latin America to all parts of the world, covering millions of hectares in for instance India, Pakistan, Yemen, Sudan, Somalia or Ethiopia. In many places it was first introduced in sand dune stabilization projects. However *Prosopis* has the habit to 'overstay its welcome' and expand rapidly and not go away. The area estimated conquered by the invasive species in the last ten years in India, Pakistan, Yemen, Kenya, Sudan and Ethiopia is way above 10 million hectares (Mugo and Ong, 2006).

Particularly in areas where there is livestock grazing *Prosopis* spreads rapidly: the seed pods cling to the animals and are distributed widely. *Prosopis* germinates easily and once it has settled in an area it is difficult to get rid of it. It takes over the natural vegetation, does not allow undergrowth and hence greatly reduces the grazing value. It also tends to creep into waterways -including dry riverbeds- choking them in the process and causing rivers flood to run wild. The *Prosopis* thorns are poisonous and can even cause blindness (Mugo and Ong, 2006).

*Prosopis* is not only a scourge. It also has some benefits to its credit. Particularly when the plants are not too craggy (as happens in the more arid areas) the wood can be used for charcoal or even timber. The pods attract bees and have high sugar content - they can serve as animal feed or be processed even into a sweetener. *Prosopis* juliflora can be used to improve the worst - saline or alkaline soils. Particularly, when some of its charcoal is added as biochar, degraded soils get a boost (Mugo and Ong, 2006).

On balance however it is a scourge that is steadily undermining the livelihoods of large populations in some of the most vulnerable dry agricultural and pastoralist areas. By now there are several attempts to control ·the mesquite tide' with mixed results. In Afar in Ethiopia the production of charcoal from *Prosopis* was very much encouraging. The problem however is that the *Prosopis* charcoal is inferior to the one from acacia for instance. Instead of *Prosopis* charcoal the acacia was widely processed - accelerating the degradation of the common land. A total ban on charcoal trading was hence re-invoked in several parts of this region (Mehari *elal, 2013).*

### 3.6 Charcoal production in Afar of Ethiopia

Farm Africa has worked on eradicating *Prosopis* in a number of ways. First is to uproot the plants and then very rapidly convert the area in an agricultural area or into a well managed grazing area so as not to allow a comeback. Secondly, encouraging regulated production of charcoal through a number of co-operatives. Thirdly is to systematically collect the pods and crush them into animal feed - making sure they do not germinate but are turned into an economic asset.

Observation in Afar region showed that regional state was endorsed a regulation to Control, Manage & Eradicate the Invasion of *Prosopis* in Afar" on July, 2011 with proclamation N0. 64 published while regulation not fully implemented. Consequently since 2014 charcoal production and trading in the region was banned while local communities are producing and trading *Prosopis* and indigenous trees charcoal illegally and it becoming important source of income and frequent part of communal natural resource utilization in the region. Many community members are involved into charcoal production to generate income, thus benefiting from an ever growing local and regional energy market. From the legal perspective, charcoal production in Afar is generally forbidden, whereas, from the users' and academically perspective, it is probably the best form of use this invasive species as control and management of *Prosopis* invasion and improve land use management and alternative income source to afar pastoralist livelihood.

### 3.7 Techniques for managing Prosopis

Many literatures have showed *Prosopis* control types are five while tendency of control types are vary from country to country. And the study has compiled available control types and its advantages and disadvantages related to different country experiences and including Ethiopia:

| Control type | Advantages | Disadvantages |
|---|---|---|
| Biological control | ✓ Relatively inexpensive once implemented<br>✓ Works over large areas, including areas that are inaccessible for mechanical control<br>✓ Minimal associated costs after bio-control agent is released (monitoring is required) | ✓ Bio-control agents have not yet had substantial impacts on reducing stand density or extent of invasions and rates of spread in some areas such as South Africa but have been more successful in places like Australia<br>✓ Initial research is expensive<br>✓ Potential to spread across borders unintentionally<br>✓ Inapplicable in areas where native *Prosopis* is weedy<br>✓ Conflicts of interest around the use of biological control in areas where *Prosopis* invasion is seen as beneficial (e.g. South Africa, Kenya) |

| | | |
|---|---|---|
| Mechanical control | ✓ Efficient at removing *Prosopis* over large areas | ✓ Labour and capital intensive |
| Chemical control | ✓ Efficient at removing *Prosopis* over large areas | ✓ Labour , capital intensive and environment |
| Utilization | ✓ Maximizes on benefits to be had from biological invasions<br>✓ Promotes rural social–economical development<br>✓ Reduces overexploitation of native spp.<br>✓ Profits counteract management costs | ✓ Encouraging utilization may create dependency on the species, thereby exacerbating conflicts of interest<br>✓ Some areas have lower-value *Prosopis* spp. (more thorny, bitter pods, shrubby forms) making utilization more difficult<br>✓ Many *Prosopis* invasions are in remote areas making large-scale utilization difficult |
| Cultural control (e.g. stand management, fire, grazing and livestock transport management) | ✓ Low costs<br>✓ Can also prevent other types of degradation | ✓ Requires people to change perceptions<br>✓ Large-scale education programmers are needed<br>✓ Does not always work for all *Prosopis* spp. e.g. fire-tolerant hybrids<br>✓ Not applicable in all areas, e.g. places with low biomass and fire-tolerant hybrids |

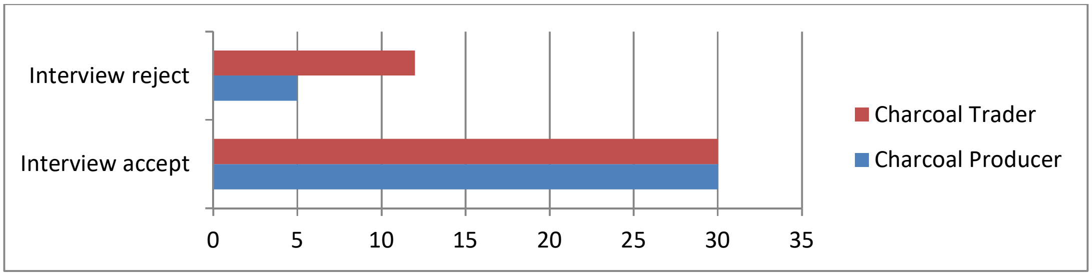
Table 3: A comparison of techniques for managing Prosopis

## 4. RESULTS AND DISCUSSIONS

This is a summary of results and discussion with presentation, analysis and interpretation that were collected through interview, focus group discussion, field observation, secondary data and literature review. The study categorized the respondents into tree groups' such as charcoal producer, charcoal trader and regulator/government; and the summary draws on the analysis of data collected from individual interview with charcoal producer and trader, focus group interviews with community member (clan leader, elders, chairperson, women, youth and so on) and key informants interview with government officials, research institution and NGO's. The study first brings together findings on "why illegal charcoal production an increasingly phenomenon" and it followed by findings on "what are major stakeholders' arguments concerning on *Prosopis* charcoal production and trade" and "what could be focus areas of changes in behaviour relation to *Prosopis* management and utilization'' in the study areas.

## 4.1 Characteristics of the respondents

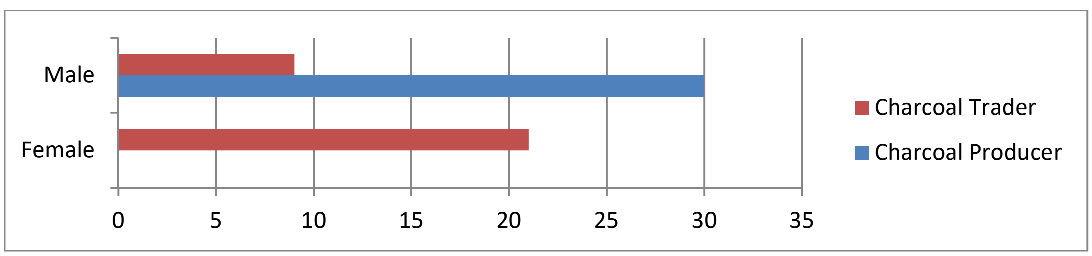
### 4.1.1. Respondent's interview accept and/or reject




Source: authors' analysis of survey data

While the purpose of interview were briefed and introduced to 77 respondents; it revealed that 78% were accepted and 22% were rejected interview. Most of the respondents who were rejected interview; provided common reasons that frequently their charcoals were detained by government and fear to be in prison. As well as the level of rejection/frustration is very high in urban/charcoal trader than rural/charcoal producer; this can relate to government supervision focused on urban than rural. This attributed to charcoal producer and trader who engaged in charcoal businesses are with frustration and fright to government police. As well as we can attributed in the study areas while no conducive environment for charcoal production and trade; significant number of people an increasingly engaged in charcoal business that people either couldn't interrupt or change to alternative income sources.

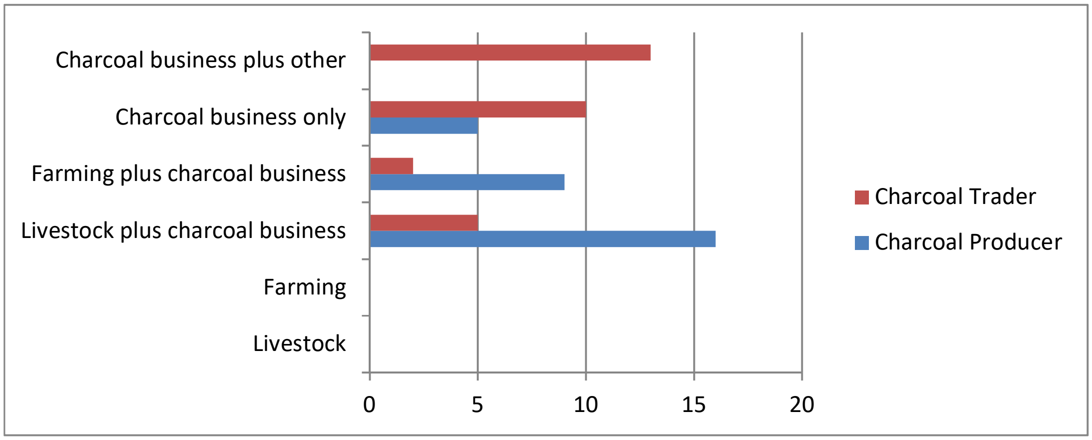
### 4.1.2 Sex of the respondents




Source: authors' analysis of survey data

The finding revealed that charcoal production is dominated by males compared to females; 100% of the producer respondents were male; 70% of the trader respondents were female and 30% were male. This attributed to status of gender involvement in the process of charcoal making is very low while in trading is very high. Majority of charcoal producer and charcoal traders are male and female respectively. This indicates that women have little involvement into production aspect while high involvement into trading aspects. This is not surprising because the production is laborious and full of hard work. This set of people can determine activities in charcoal production effectively that gender mainstream is relevant during intervention of charcoal production and trade.

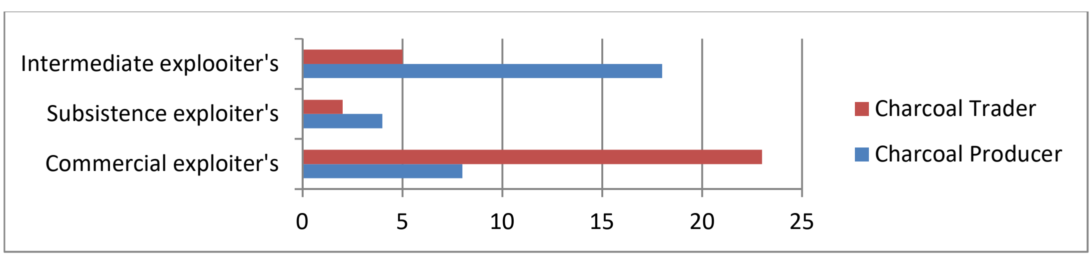
### 4.1.4 Livelihoods category of the respondents




Source: authors' analysis of survey data

The finding of livelihood category of this study illustrated that 53% of producer respondents were categorized to pastoralist plus charcoal business; 30% were categorized to agro-pastoralist plus charcoal business; 17% were categorized to charcoal production & trade alone. Similarly charcoal trader illustrated that 43% of the respondents were categorized to charcoal trade plus other such as petty trade, shop, employee etc; 33% were categorized to charcoal trade alone; 17% were categorized to livestock plus charcoal trade; 7% were categorized to farming plus charcoal trade. These can attributed to charcoal businesses are frequent source of income paired with other source in the study areas. As well as we can attribute to considerable people of livelihoods were based on complementary with charcoal businesses especially during drought period, dry/Hagay season and agriculture lean season. Thus charcoal businesses in the study area is an element of livelihood and option to diversify their livelihood's additional to fill income gaps when the event of external factors induced such as drought, disease outbreak, price inflation and so on. These scenario could be reason to illegal charcoal production and transportation an increasingly phenomenon and areas livelihoods element and drought coping strategies as it is low investment cost, abundant *Prosopis* trees and high market demand in surrounding town, woredas and boarder regions.

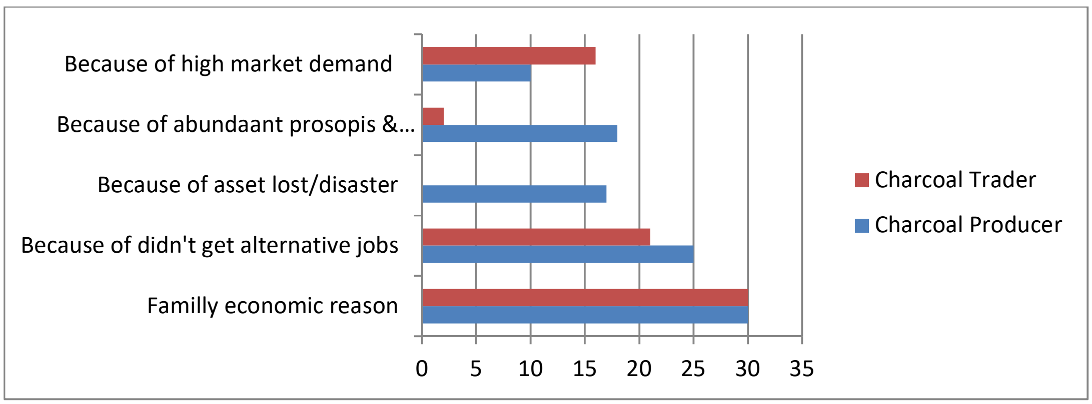
### 4.1.5 Status to charcoal business orientated & exploitation




Source: authors' analysis of survey data

The findings of charcoal producer exploitation status illustrated that 60% of the respondents were intermediate exploiters those who partly involved and engaged in charcoal business and their source of income is partly depended on charcoal production; 27% of the respondents were commercial exploiters those who directly involved and heavily engaged in charcoal business that their sources of income is heavily dependent on charcoal production; and 13% of the respondents were subsistence exploiters those who marginally involved and insignificant or no engagement in *Prosopis* charcoal business and their source of income is not or marginally depend on *Prosopis* charcoal production. Similarly charcoal trader exploitation status illustrated that 77% of the respondents were commercial exploiters; 17% of the respondents were intermediate exploiters and 6% of the respondents were subsistence exploiters. Thus we can attribute a great number of people have engaged in charcoal occupation with degree of business orientation and exploitation very high to commercial and intermediate exploiters. We can also attributed to charcoal business for producers more categorised to intermediate exploiters (60%) and for charcoal traders more categorised to commercial exploiters (77%) while subsistence exploiters were categorised very small for both producers (13%) and traders (6%). As result of this fact; illegal charcoal production and transportation is an increasingly phenomenon in the study areas that considerable of people were commercial and intermediate business oriented/exploiters.

### 4.1.6 Reason involved in charcoal business

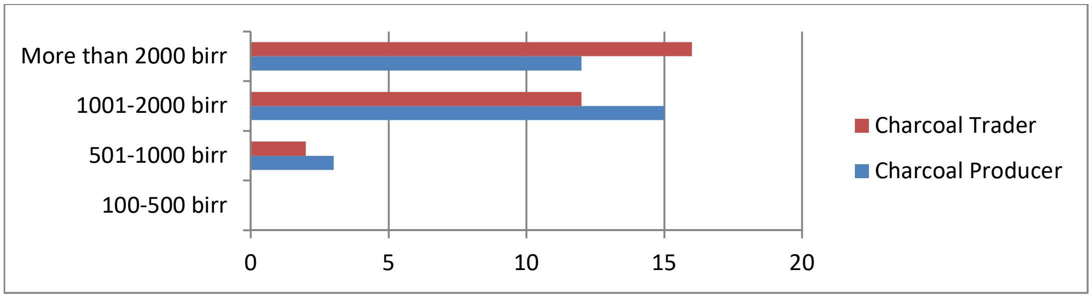



Source: authors' analysis of survey data

The findings of major reasons involved in charcoal business revealed that 100% were for family economic, 77% were for didn't get alternative job's, 28% were for livestock asset lost, 33% were for abundant *Prosopis*, and 43% were high market demand. This scenario can attributed to charcoal business in the study areas are alternative income to support household's economic demand, economic job opportunity and drought coping strategy to pastoralists. As well as we can attributed to local people have started to believe *Prosopis* can be managed through utilization such as charcoal production and trade that 33% of the respondents reason was due to abundant *Prosopis* and control through utilization.

## 4.2 Economic benefit and contribution to expenditure

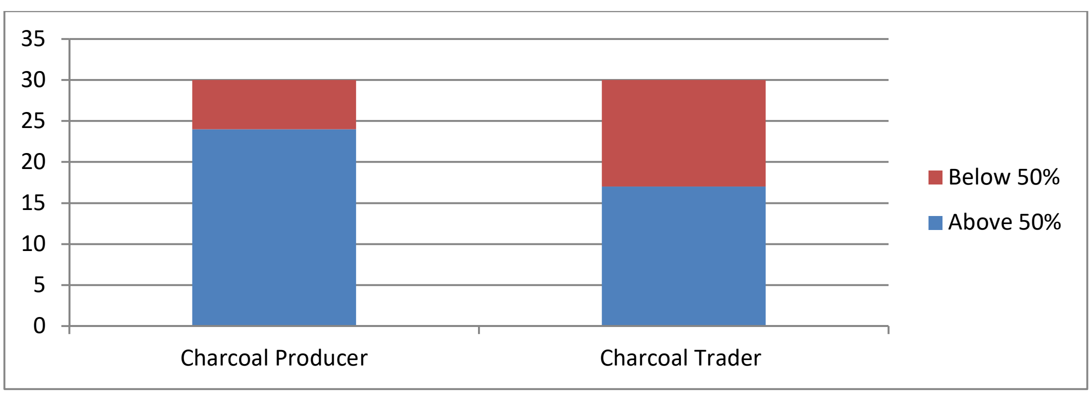
### 4.2.1 Monthly money getting from charcoal selling




Source: authors' analysis of survey data

The findings to monthly getting money from charcoal selling; charcoal producer respondents illustrated that 50% were earning 1001-2000 birr per month; 40% were earning more than 2000 birr per month and 10% were earning 501-1000 birr per month. Similarly charcoal trader interview illustrated that 53% of the respondents were earning more than 2000 birr per month; 40% of the respondents were earning 1001-2000 birr per month and 7% of the respondents were earning to 501-1000 birr per month. This figure revealed that charcoal businesses are substantial economic benefit and income sources to the study areas. Here we have to consider these range of monthly earn received with unfavourable working environment such as government banned charcoal production and transportation; we can assume if there is favourable policy/regulation and government support, people could sell and earn great money that could transform welfare of people.

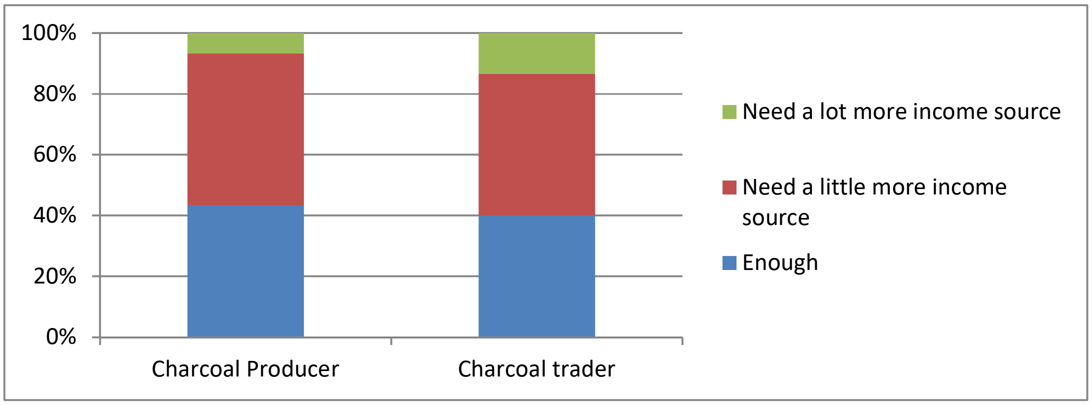
### 4.2.2 Contribution to household expenditures




Source: authors' analysis of survey data

Finding to household expenditure used from monthly charcoal earn; illustrated that 80% of producer respondents were used above 50% and 20% were used below 50%. Similarly 57% of trader respondents were used above 50% and 43% were used below 50%. This can attributed to great money getting from charcoal selling used to household expenditure especially to producers and thus it is very crucial business to address day to day household expenditure in the study areas. In general charcoal business was contributing a lot for household expenditure and well-being of the people who involved in charcoal production and trade. It normally contributed to household foods, goods, medicals, schools expenditure, financial stress and part of remained money was used to fixed asset and saving.

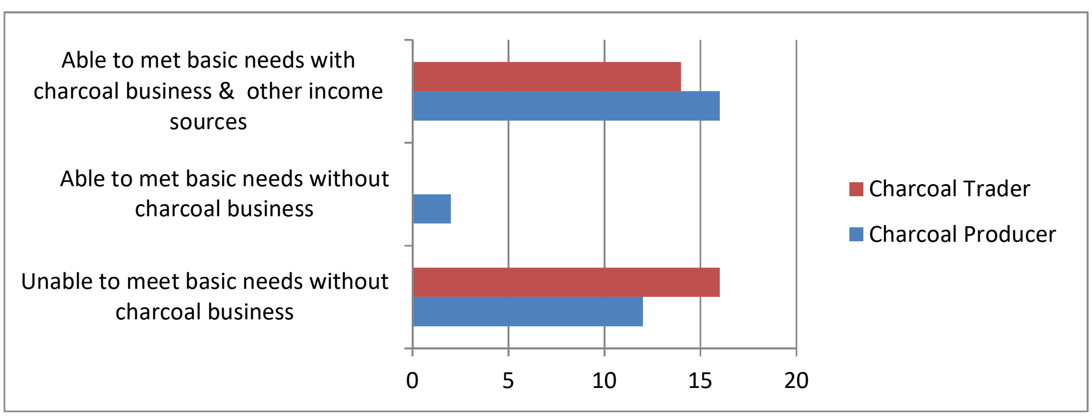
### 4.2.3 Money earn from charcoal business




Source: authors' analysis of survey data

Money earn from charcoal business data illustrated that 48% of the respondents were expressed need a little more income; 42% of the respondents were expressed enough and 10% of the respondents were expressed need a lot more income sources. We can attributed to charcoal business can potential and encouraging economic occupation mainly paired with other income sources. The study also assumed this figures could significantly contrast if in the areas were emplaced conducive business environment and government supporting to legal charcoal production and transportation.

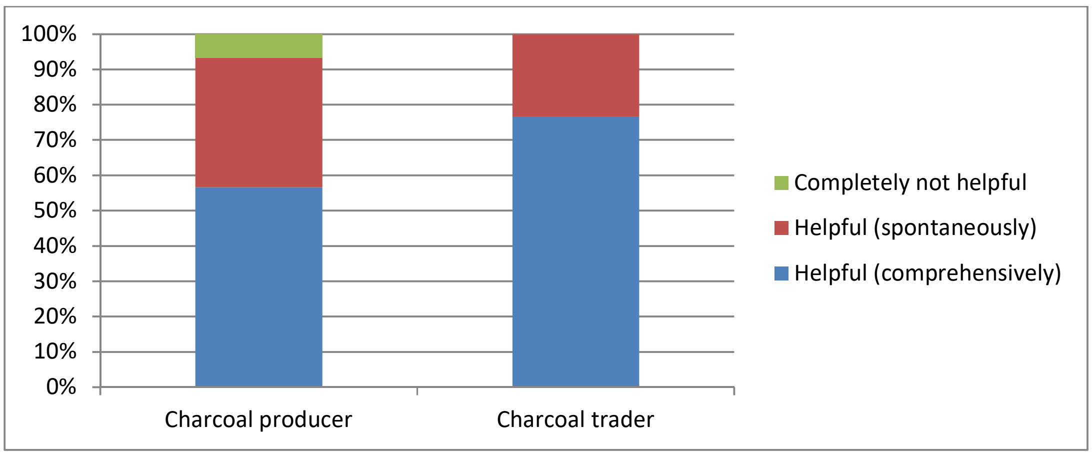
### 4.2.4 Household basic needs versus charcoal business




Source: authors' analysis of survey data

Findings on household basic needs support by charcoal earn illustrated that 53% of producer respondents were able to meet basic needs with charcoal business and other income sources; 40% of the respondents were unable to meet basic needs without charcoal business and 7% of the respondents were able to meet basic needs without charcoal business. Similarly for charcoal trader respondents illustrated that 53% of the respondents were unable to meet basic needs without charcoal business; 47% of the respondents were able to meet basic needs with charcoal business and other income sources and nobody able to meet basic needs without charcoal business. Significant numbers of the respondents were able to meet their basic needs with charcoal business paired with other livelihoods; especially great number of charcoal traders couldn't able to meet their basic needs without charcoal business. Only some people could able to meet their basic needs without charcoal business that possibly to charcoal producers than trader. This can attributed to charcoal business have great inputs into the economic drive and fulfilment of household basic needs in the study areas. And this scenarios attributed to illegal charcoal production and transportation is an increasingly phenomenon while banned by government.

### 4.2.5 Charcoal business scopes to economic support

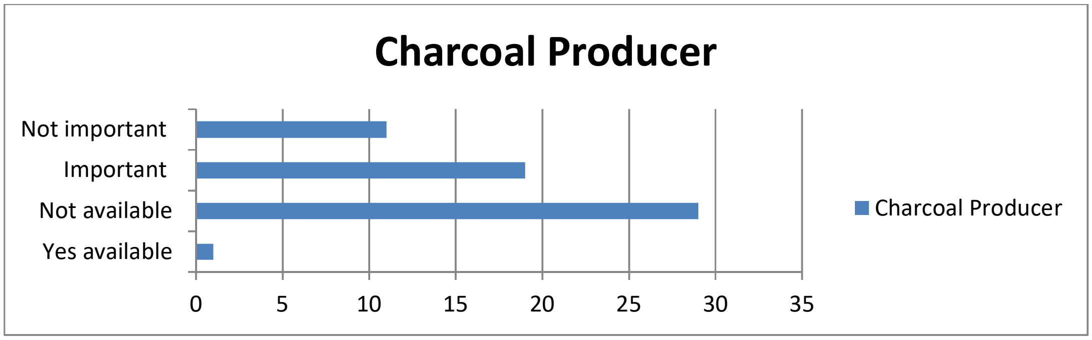



Source: authors' analysis of survey data

The degree of economic benefits from charcoal business illustrated that 67% of the respondents were replied to comprehensively helpful; 30% of the respondents were replied to spontaneously helpful and 3% of the respondents were replied not completely helpful. Hence the majority of the respondents were expressed charcoal business is comprehensively helpful (67%) and some expressed to spontaneously helpful (30%) and few completely not helpful (3%). When we compared degree of economic support provided by producer and trader; it varied in way that producer more give to spontaneously helpful while traders more give too comprehensively helpful. This scenario directly associated with their scale of business oriented to charcoal production and trade. The charcoal business could have well sufficient economic supports to better income sources with degree of comprehensively and spontaneously helpful. It obviously known that in the study areas there are very abundant *Prosopis* raw materials that available throughout a year, increasingly in communal land, low investment cost, high market demand; this scenarios enforced charcoal business to be energetic economic support to better income sources and entering points to economic jobs opportunities.

### 4.3 Charcoal production management and method

#### 4.3.1 Specific areas for Charcoal production and trade

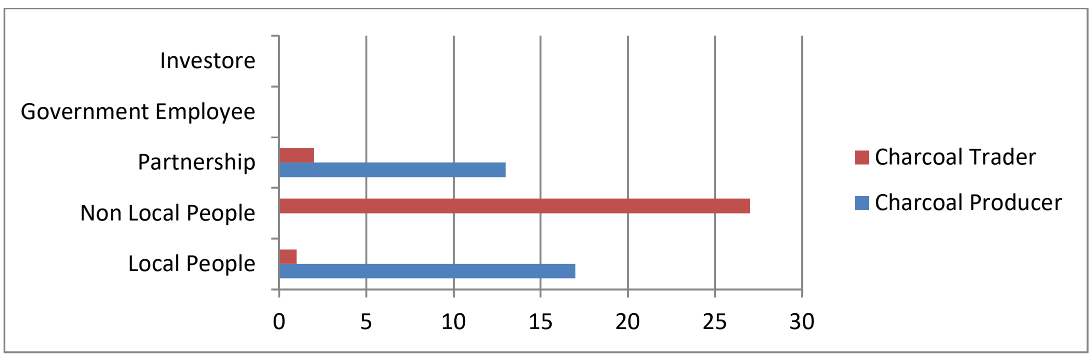



Source: authors' analysis of survey data

Majority of the study areas didn't have specific areas provided to charcoal prodution/burning. From data showed that 97% of the respondents were said No, there are no specific areas provided to production/burning; and 3% of the respondents were said "Yes" there are specific areas provided to burning while we couldn't see practically. When we are looking for respondents perspective towards important; 63% of the respondents were said specific areas to charcoal production is important and 37% of the respondents were said not important/not interested. As well as from focus group discussion; attended people were expressed so far there are no specific areas allocated for charcoal burnings while all strongly are believe to allocate specific areas are very important with respect to environment/air pollutions and residential people health conditions. We can attributed in the study areas, there are no charcoal production specific areas were allocated by concerned people/official that charcoal producers were used areas selected individually based on *Prosopis trees* nearness and other preferable conditions. Regarding to importance more respondents were believed that specific areas allocate to charcoal burning is important through associated with air pollutions and health issues. While some of the respondents were contrarily believed not important associated with uncertainty of specific areas possibly will far away from their residence, *Prosopis* raw materials, selling points and incurred additional cost.

Figure 5: Sample photo indicating haphazardly charcoal burning & air pollutions

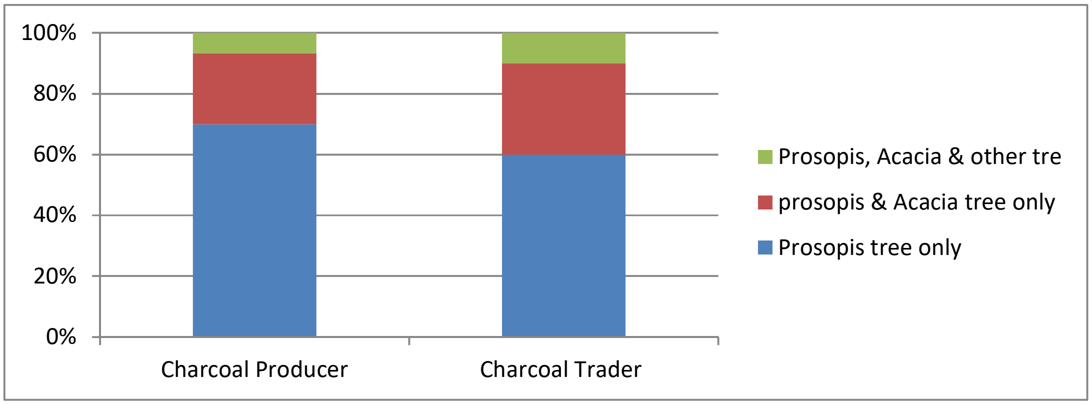
### 4.3.2 Who produce and trade charcoal?




Source: authors' analysis of survey data

Normally in the study areas charcoal were burnt by local people and partnership with non local people while traders were non local people and only some partnership with local people. From focus group discussion we could understand that there are factors determined people who can produce and trade charcoal. Factors such as land tenure/user & user right, social value, experience (skills and knowledge) are determining who could be a charcoal producer and trader. Correspondingly interview respondents were showed that charcoal were mainly burnt/produced by local people and partnership between local ad non local people in the study areas; whereas charcoal were mainly trade by non local people and a small number of local people trading through partnership with non local people. These attributed to study areas that more local people were involved as charcoal producer and more non-local people were involved as charcoal trader; while partnership were more happening during charcoal production than trading. The scenario to afar local people not practicing charcoal production alone; presently seems completely changed and trends to partnership with non-local people are declining through time as technical skills & knowledge were gaining throughout and their major livelihoods were weakening to cope with the recurrent drought and lost to basic assets; corresponding to abundant *Prosopis* and low investment cost could be factors to afar local people involvements an increasingly observed in the study areas.

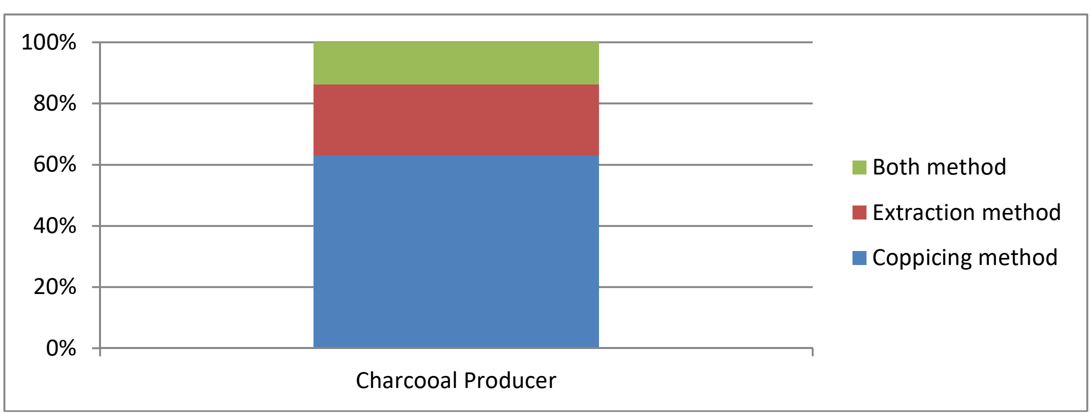
### 4.3.3 What are burnt into charcoal production?




Source: authors' analysis of survey data

Finding data to mainly burning tree in study areas were illustrated that 67% of the respondents were burnt *Prosopis* tree only; 27% were burnt *Prosopis* & acacia trees and 8% were burnt *Prosopis*, acacia and other trees. Beginning to *Prosopis* tree charcoal burning is very encouraging and comparatively good from last 2-3 years; this scenario was also supported during focus group discussion done in all places that community attendance described as far as they known nowadays in their areas nobody burns other trees except *Prosopis that* community members learnt from last years and closely follow up indigenous trees not burnt into charcoal. However, from the interview respondents including charcoal traders were showed that few people possibly will burn *Prosopis* with Acacia indigenous trees. This can attributed to more charcoal were from *Prosopis* tree and some charcoal were also from indigenous tree such as acacia/keselto. Thus government control couldn't stop charcoal production either from *Prosopis* tree and/or indigenous trees. These associated to very poor control and increasingly illegal charcoal production from both *Prosopis* & indigenous trees are cases for hardly available indigenous trees lost by now and past periods.

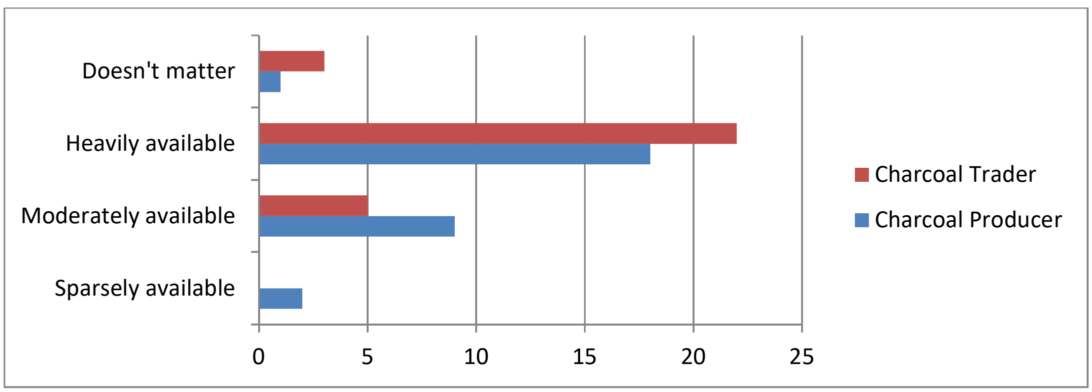
### 4.3.4 Prosopis tree clearing/cutting methods




Source: authors' analysis of survey data

Normally in the study areas *Prosopis* charcoal cutting used methods are two; coppicing method which means cutting the stumps just above ground level and extraction method which the roots are extracted down to 10 to 30 cm underground. Using each method's will have different results to regenerate, time taking/labours and yield/charcoal. Consequent to interview data illustrated that 64% of respondents were used coppicing method; 23% of the respondents were used extraction method and 13% of the respondents were used both methods. This can attributed to study areas great charcoal producers were used coppicing method; some were used extraction method particularly when intending to use cleared land for farming and few were used both methods. As coppicing method users were greater (63%) and it possibly charcoal production will expand *Prosopis* than control; except necessary awareness creation, conducive regulation, licensing system, land cover/mapping are emplaced and to reinforce charcoal producers significantly to practice and use extraction method; and based on land covering/mapping and community consensus to *Prosopis* invaded/degraded lands are marginal and demarcated only for charcoal production to use coppicing method and it could  have implication on flowering and seeding afterwards brakes seed spreading and distribution into potentials land such as rangeland, farm lands, settlements  and water points.

### 4.3.5 Preferable Prosopis lands related to charcoal production




Source: authors' analysis of survey data

Preferable *Prosopis* land interview illustrated that 67% of the respondents were preferred heavily available; 23% of the respondents were preferred moderately available; 7% of the respondents were replied doesn't matter and 3% of the respondents were preferred sparsely available. These attributed to study areas, heavily available *Prosopis* land were more preferable than moderately and sparsely available *Prosopis* associated with collecting high yield of charcoal including good quality and profit. When comparing preference between producers and traders; producers were ranked more moderately and sparsely than traders; and these could also an indication to producer frequent problems to heavily available *Prosopis* cutting and produce charcoal that some producers will preferable moderately and sparsely while traders and consumers are will uncertain in its quality and dimension. As well as type cutting methods determines the preference of *Prosopis* lands associated with cost-benefit ratio of different cutting methods.

### 4.3.6 Charcoal production methods and process

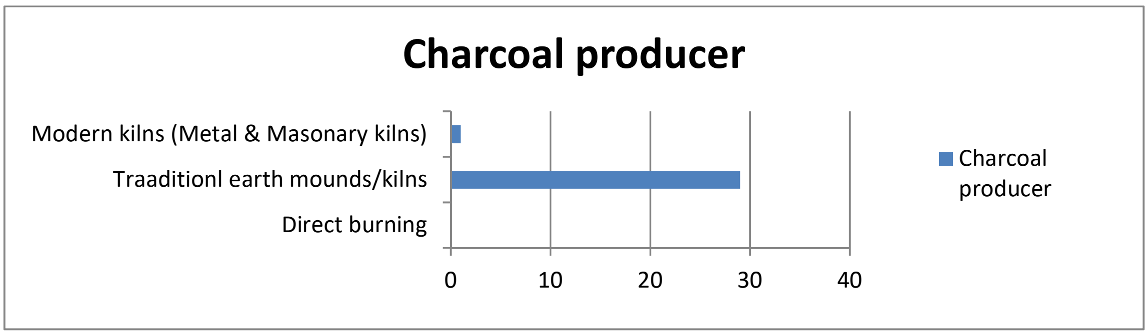
#### Methods of charcoal production

The major factors that influence charcoal conversion efficiency and yield are:

1. Moisture content of the wood at time of carbonisation (optimum 20% or less).
2. Type of carbonising equipment (kiln) used.
3. Management of carbonisation process (mainly stacking of wood and air control). High charcoal conversion efficiency and quality can be achieved through proper control of the carbonisation process.

The three most common methods of charcoal production today are: Earth Kilns, Masonry Kilns and Metal Kilns.

- ✓ Earth Kilns are of various types but the most common are the traditional, improved earth kilns and the Casamance kiln.
- ✓ Metal Kilns are of the Drum kiln, Meko kiln and Portable Metal Kiln.
- ✓ Masonry Kilns are usually of the Beehive and Half Orange type; they are recommended for charcoal conversion in areas where there is available fuel wood over a long time period, such as large-scale land clearing and fuel wood plantations.




Source: authors' analysis of survey data

The majority of charcoal producer respondents (97%) were used the traditional earth mounds method of charcoal production. This attributed to the way of charcoal production in the study areas are traditional method with a consequence of small yield, high air pollution and health problem to producer and residence near to burning area. It possibly will require innovating and accessing a modern carbonization metal kilns technology and improve efficiency of charcoal production and free air pollutions and health problem.

The process of charcoal production in the study areas followed with 3 stages and outlined as below:

***1st Cutting and harvesting stage***

1. Charcoal production process often commences with the selection of location where the trees found in abundance.
2. The identified trees are then cut and harvested over a period of time for free. Some of the selected wood lands are communal lands of the clan.
3. The cut wood are sorted by diameter and stacked next to the burning site

***2nd Payrolisis stage***

4. The wood is then stacked into a dug-out earth pit or heap on a relatively flat plain up to a reasonable height and covered with a layer of grass/ leaves and sand. A heap of sand is then gently used to cover the entire heap. They leave two very small openings for fire to be lit and smoke exit. Several amounts of top soil and shrubs are needed to cover a single heap.
5. The fire is then lit from the opening. After the entire woods/logs catch tire the hole is sealed with small sticks and grasses.

6. The process is then closely monitored both day and night for about 10-15 days, depending on the size and moisture content of the wood during carbonizing. Gradually the logs burn into the required charcoal. During the process, a series of events are created in each earth mound. This is done to allow proper ventilation and continued burning for up to one or two week depending on the size of the woods and the heap. If the earth kiln is not vented properly, it can either smother the fire before carbonization takes place or burn too hot, causing over burning, leaving only a pile of ashes. The process of carbonizing is completed when it stops smoking and cools.

***3rd Packaging stage***

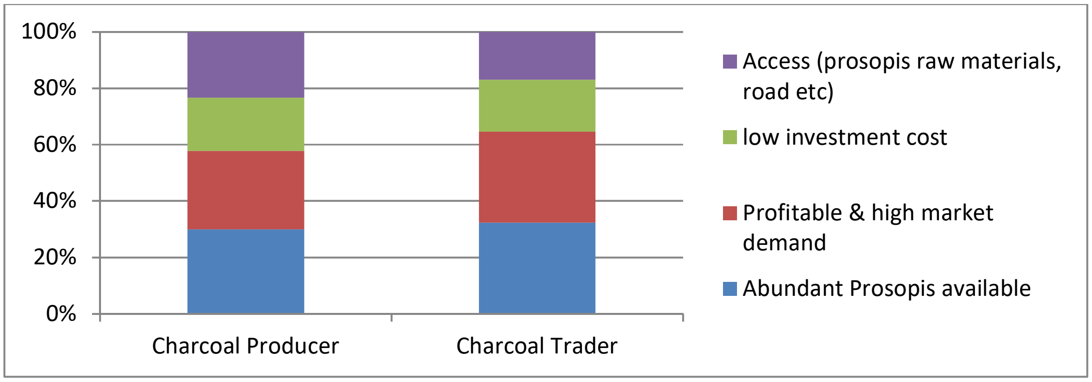
7. After completion of carbonization, the charcoal worker begins separating the dirt and debris and grading the newly formed charcoal. About 2-4 days are spent in this process, depending on the size of the labourer available. The charcoal is then collected into bags and delivered to charcoal owner then it is ready for market.
8. Finally, selling to end user or middle men.

The earth mound method of charcoal production causes damage to the vegetation. As observed from major charcoal producing sites in the study area, this process has *several weaknesses*. These weaknesses contribute immensely to the degradation of the natural environment. Traditional method of charcoal making could trigger bush fires through the events and other openings. During discussion with APARI researcher expressed apart from cutting trees for charcoal production, the researcher also observed that forbs and herbs are at risk during charcoal processing. The process usually damage: the surface of the top soil and shrubs, as a result of digging and burning during the production. Moreover, the result of focus group discussion confirmed that the traditional earth mound method have high air pollutions that health problem to nearby residence people and children; as well as areas will not regenerate for several years even as rain saturate.

Figure 5: Sample photo earth mound charcoal production at Aysaita (source: field Survey, 2019)

## 4.4 Potentials and challenges/risks exist for charcoal production

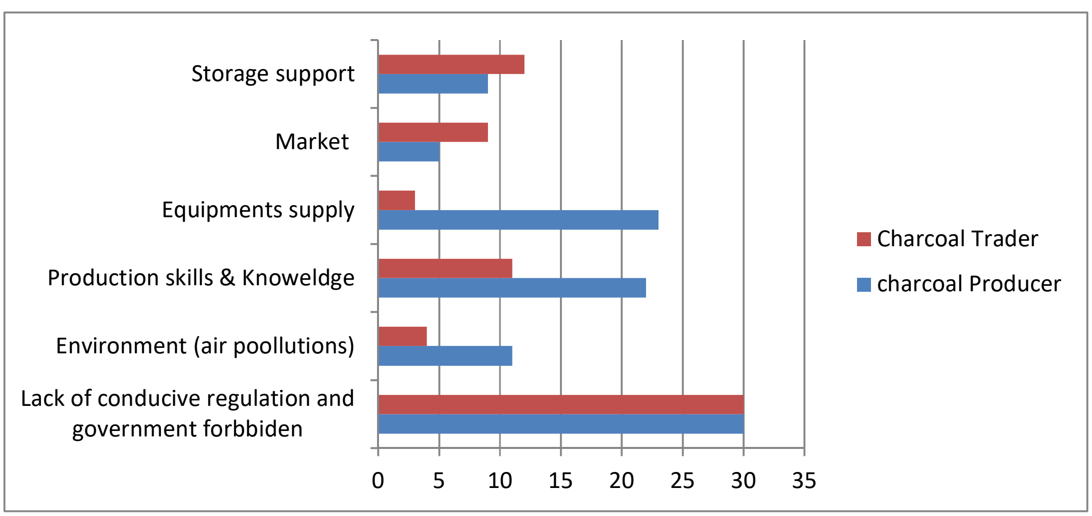
### 4.4.1 Potentials exist for charcoal production and trade




Source: authors' analysis of survey data

Based on interview respondents to potentials exist to charcoal production and trade; it organised into four category such as *Prosopis* abundant, market demand, investment cost and access to raw materials, road etc. The interview data showed that 80% of the respondents were expressed to abundant *Prosopis* available; 77% of the respondents were expressed to high market demand; 53% of the respondent expressed to access and 48% of the respondents were expressed to its low investment cost. More or less all four potential's are proportionally selected with slight degree of the respondents (producer and trader). This attributed to charcoal production and trade could have these four major potentials that possibly will drive to intervene *Prosopis* charcoal business with require formality and coordination to relevant stakeholders. This also reasons why illegal charcoal production and trade an increasingly phenomenon in the study areas while government charcoal production and transportation banned.

### 4.4.2 Challenges and/or risks exist for charcoal production




Source: authors' analysis of survey data

The interview data illustrated that 100% of the respondents were prioritized challenges to lack of conducive regulation and government charcoal forbidden; 43%of the respondents were prioritized challenges to equipments supply; 38% of the respondents were prioritized challenges to technical capacity (skills & knowledge); 35% of the respondents were prioritized to financial service & storage support; 25% of the respondents were prioritized to air pollutions & health problem; and 23% of the respondents were prioritized to market problems. This indicated to the study areas, listed six major challenges were prevalent to charcoal production and trade while degree of challenges could varies to producer and trader. As well as it analyzed from focus group discussion, these are major challenges existing in the study areas; that challenges are multiple and complementary each other. If government will lift restriction and initiate charcoal business through a licensing system, it necessary a wide ranging plan, coordination and intervention should address prevalent challenges in the study areas; not only focus on regulation/controlling issue, equivalently requires to consider others challenges as it have complementary nature.

Moreover, during the interview and focus group discussion, what improvements and major actions to be done and take away challenges were discussed? Mostly the respondents were underlined regional government should facilitate a conducive regulation and to lift restriction; community members were highly expressed “at present nobody can judge about our people fate and outcome except ourselves as past 5-10 years nature itself educated us, what was natural and manmade threats and also how we could mitigate with threats”. Community members were strongly expressed now time to negotiate with government and look for intervention on *Prosopis* management and utilization and committed to regenerate vanished indigenous trees and pastures. Therefore, community members and interview respondents were highlighted government initially to arrange forum for negotiation with community members and enable to develop very inclusive and conducive *Prosopis* regulation related to manage/control by utilization. Similarly government should organize different forum how to pilot a licensing system that could benefit and scale up *Prosopis management* through utilization approach. Finally attendance closed discussion by reminding “people not need to suffer and die as result of ever-increasing *Prosopis* invasion and charcoal production and transportation banning and government’s poor attention to the impact of *Prosopis* invasion into our life and areas; there should be systematic actions either to eradicate *Prosopis* or mannage *Prosopis* through utilization; and we could have economic benefit and control *Prosopis* systematically.

Figure 6: Photo indicating indegenous tree lost by *Prosopis*(source: field Survey, 2019)

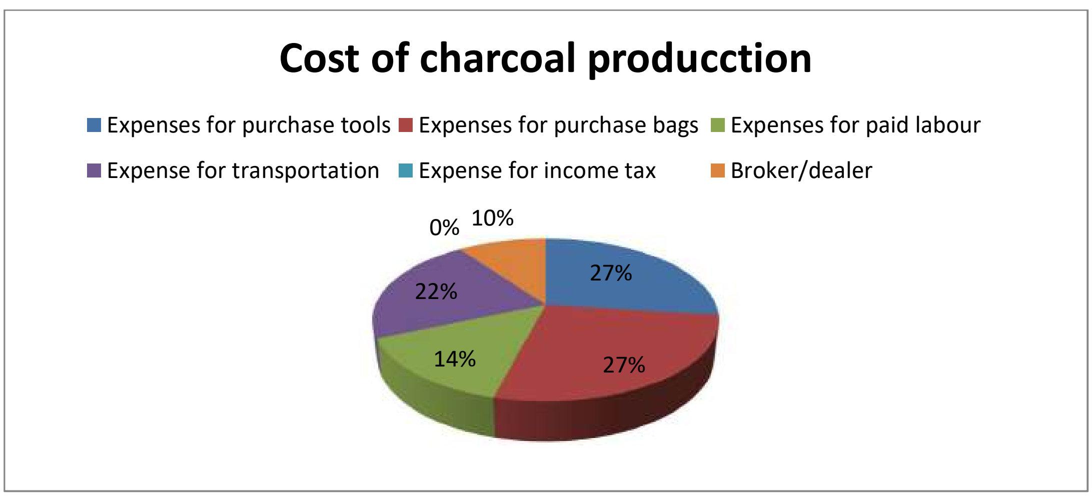
After indepth analysis of focus group discussion and interviwes; the study have come to understanding of major constraints to prospis management and utilization and supports needed by community:

- ✓ As communities living in *Prosopis* affected areas; natural resource management planning trainings and silviculture education are very crucial that study assured communities have not had any training that enable them to understand impact and potential uses of Prosopis. Forestry education to practice of planting and managing of indigenous tree and giving basic knowledge of *Prosopis* management and rational utilization. During the study, it clearly observed there are very little exposures about *Prosopis* control techniques and technologies that can be used to optimize management and utilize the species. *Prosopis* education can focus on three main types of changes in behaviour relation to *Prosopis* control/management and utilisation: what people know (knowledge), what they can do (skill) and what they think (attitude) through good demonstration areas and proper publicity. The *Prosopis* education is to make people conscious of the impacts and importance of *Prosopis* and their rational use to inspire people to *Prosopis management* through utilization.
- ✓ Lack of enough research findings is also a constraint in the success of *Prosopis* management and utilization, mostly there is no research works to appropriate knowledge and understanding of the tree management and its usage. We have no answers to fundamental questions regarding its usefulness in timber, animal feed, honey production, stand-management; and effect of trees on soil fertility and yield.
- ✓ Incentives are needed if popular participation in *Prosopis* management is to be achieved. It would bring very positive results if some incentives are provided to the people to motivate them, especially on land tenure. These could be in the form of lease of land to the landless or leasing *Prosopis* infested land to the private sector. The private sector would be given leaseholds on wastelands, for instance, deal in charcoal production from Prosopis. These leaseholds can be valid for a year and sector would then take care of dealing with Prosopis. In addition to the private sector, the leaseholds can also be given to community-based associations, which are then provided with technologies to produce charcoal or other products. They can be provided with technologies, machinery and trainings for reclaiming of *Prosopis* infested land, certificates and prizes for good performance, financial service/loans and marketing facilities.
- ✓ A government policy (resource use and land tenure) normally shapes the responses to the management of Prosopis. And when looking for afar government policy and practices may also constrain to the range of possible management and profitable uses of the *Prosopis* species. For instance, the *Prosopis* regulation and ban on charcoal transportation may discourage management through profitable use of *Prosopis* products, which may have contributed to controlling the rapid spread of Prosopis. Such as GIS studies that are complemented by socio-economic/livelihood studies, can help in shaping government policies and response on the *Prosopis* by advocating for the establishment of a longer-term management framework. This multifaceted framework will be used for monitoring and assessment of the *Prosopis* species dynamics and putting in place a mechanism for rolling back the species while supporting the livelihood systems recover from the implications posed by the species. The results of the programme can also be used to extrapolate long-term implications of the species for vegetation resource dynamics and hence put in place remedial measures as necessary, since the economic mainstay of the population is livestock production.

- ✓ In all study areas investigated, land tenure is still a problem with most of the land classified as communal land, under the care of local leader/clan leader. Desertification often occurs as a result of social and economic problems, including poverty and lack of access to land, and poorly defined or inequitable land tenure regime. Land degradation and desertification is the precursor to *Prosopis* colonisation of bare lands. The reversal of land degradation is vital for the livelihoods of people of the studied areas and it requires significant investments in land reform efforts. Sustainable *Prosopis* management can be achieved through support for efficient, effective and equitable common resource use arrangements. This will need to focus on removing capacity and policy obstacles to addressing *Prosopis* degradation of arid and semiarid lands. Effective, secure, access to land resources can provide an essential incentive for land users to invest in sustainable land use practices.
- ✓ The study areas livelihood strategies were different consequent to peoples' perceptions of *Prosopis* invasive species unlike. Peoples' perceptions of invasive species are determined by whether the species meets their socio-economic needs (Pasiecznik, 2001); that in study areas the different livelihood strategies pursued by individuals have a bearing on the distribution of costs and benefits of living with *Prosopis* among various segments. The directly resource dependent segments such as some pastoralists and agro-pastoralist will incur higher costs/losses due to loss of pasture/rangelands. Some commercial and intermediate exploiters of *Prosopis* products/charcoal on the other hand will add greater benefits. Therefore, disaggregation of the population into its various livelihood components is the starting point in any programme that is designed to manage the *Prosopis* problem.
- ✓ And inadequate capital and experiences among pastoralists and agro-pastoralist is also most obvious constraints to the success of *Prosopis* management and utilization.

### 4.5 Charcoal production cost and market

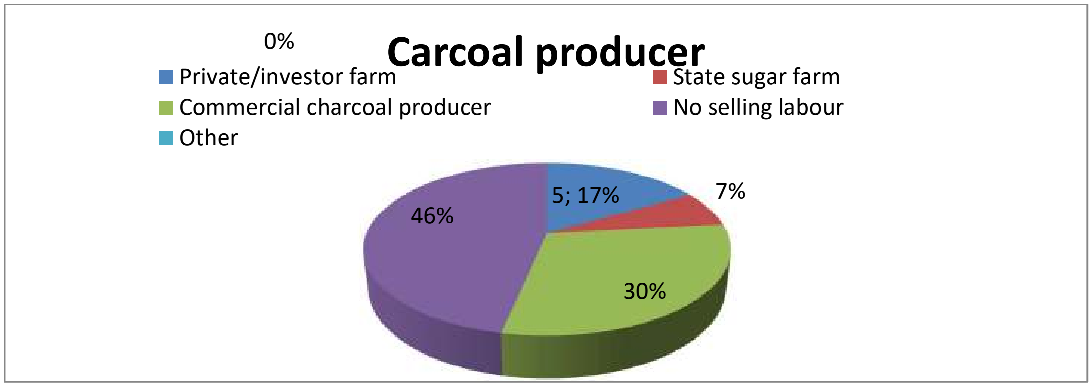
#### 4.5.1 Costs of production/expenses to produce charcoal




Source: authors' analysis of survey data

Normally charcoal cost of production in the study areas more or less similar and we could categorize into six lists. The interview findings illustrated degree of cost as 27% of the respondents were expended for tools and bags; 22% of the respondents were expended for transportation; 14% of the respondents were expended for paid labour and 10% of the respondents were expended for broker/dealer and nobody were expended for income tax. Detailed Cost benefit analysis annexed in APPENDIX 6.

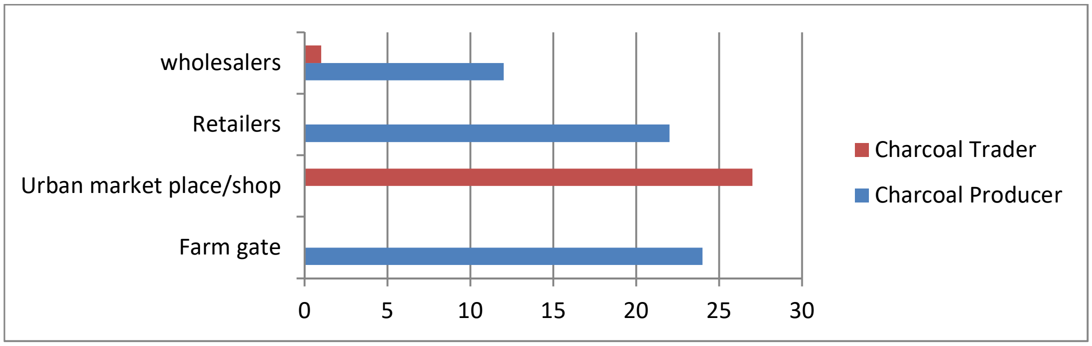
### 4.5.2 Alternative source of income to selling labour




Source: authors' analysis of survey data

From focus group discussion and individual interviews on alternative source of income through selling labour; analyzed that three sources of selling labour in study areas, i.e. private/investor farm, sate sugar farm & commercial charcoal producers. Interview data illustrated that 46% of the respondents were not selling labour; 30% of the respondents were selling labour to commercial charcoal producer; 17% of the respondents were selling labour to private/investor farm; 7% of the respondents were selling labour to state sugar farm. When looking for selling labour to commercial charcoal producer (30%), this can attributed to charcoal business was an alternative source of income through selling labour and created economic job opportunities than others sector (investors farm and state sugar farm) in the study areas. If government committed and reassess the existent scenario to ever increasing *Prosopis* invasion, an increasingly illegal charcoal production, and government charcoal control and banned; and possibly will develop and emplaced inclusive and conducive *Prosopis* regulation and product licensing system including other correlated activities (awareness, trainings, market linkage, technology innovation, financial services etc); charcoal business could be economic job opportunity for unemployed people living in the study areas.

### 4.5.3 Where are you selling charcoal




Source: authors' analysis of survey data

Basically a charcoal selling was done in five categories like farm gate, urban market place/shop, retailers and wholesalers. And the producers' interview illustrated that 80% of the respondents were sold at farm gate; 73% of the respondents were sold to retailers; 40% of the respondents were sold to wholesalers and no one sold at nearby urban market. Similarly traders' interview illustrated that 90% of the respondents were sold at urban charcoal market place and/or own shop; 3% of the respondents were sold to wholesalers and no one sold either to retailers or at farm gate. This result direct correlated with effect of charcoal forbidden to follow normal market chains (producer-retailers-wholesalers) that in the study areas people have great frustration to government control and pressured to keep normal market chains.

### 4.5.4 Cost-benefit analysis of charcoal production and trade

The following cost-benefit analysis showed that charcoal producer could substantially return on investment of charcoal production and could play a crucial role in contribution of control and management of *Prosopis* through utilization such as charcoal production and trade in the study areas. The study was used two different sources to collect data on labour time, yield and farm gate price of charcoal. The sources were charcoal producer, community members and filed plot trail as well as study was used experiment conducted on average labour time/man-days and yield per hectare of *Prosopis* charcoal production. Getting data from these sources were supported to validate data and provide evidence to commercial viability of charcoal production.

The cost-benefit analysis was conducted on two scenarios to assess the return on investment of charcoal production. The scenarios are: levels of *Prosopis* invasion (sparse, moderate and heavy) and clearing/cutting methods. Accordingly, estimates were provided for three levels of *Prosopis* invasion: sparse, moderate and heavy. As well as for clearing/cutting was used two methods: coppicing, which means cutting the stumps just above ground level, which makes them regenerate quickly; and extraction, in which the roots are extracted down to 30 cm underground, this is required to effectively prevent the trees from growing back. As well as the study estimates of man-days/labour time and opportunity costs are based on interviews with charcoal producer and community members and field plot trail done with the supervision of GIZ project field officer on August 2019.

Comparing the costs and benefits of converting a hectare of *Prosopis* into charcoal suggests that it is feasible, even when the roots are fully extracted to prevent rapid re-growth. Although production costs per hectare are increased on average by approximately 70% when properly extracting the roots, the roots can be turned into charcoal and increases the number of bags per hectare on average by approximately 41%. The cost benefit ratio is therefore still above 1:3 (1 birr invested get above 3 birr return) for all three categories of *Prosopis* invasion.

| Level of *Prosopis* invasion | Total labour *Clearing, pyrolisis, packing charcoal into bags* | Marginal costs (birr) | Average charcoal yield (bags) | Marginal revenue | Marginal profits (birr) | Cost-Benefit ratio: *For every one birr invested, producers get this much birr in return* |
|---|---|---|---|---|---|---|
| Coppicing | | | | | | |
| Sparse | 50 | 6000 | *150* | 25500 | 19,500 | 4.25 |
| Moderate | 60 | 7200 | *200* | 34000 | 26,800 | 4.72 |
| Heavy | 120 | 14400 | *500* | 85000 | 70,600 | 5.90 |
| Extraction | | | | | | |
| Sparse | 90 | 10800 | *200* | 34000 | 23,200 | 3.15 |
| Moderate | 120 | 14400 | *300* | 51000 | 36,600 | 3.54 |
| Heavy | 180 | 21600 | *700* | 119000 | 97,400 | 5.51 |

Table 4: Per hectare production costs and revenues. See APPENDIX 6 for full details of estimates and assumptions.

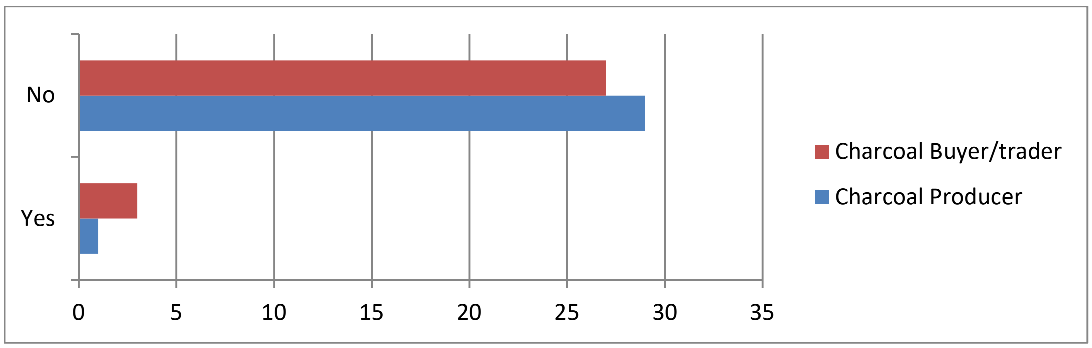
The study finding indicated that extraction method of *Prosopis* clearing still profitable and question was asked community members "Why do charcoal producers not extract the *Prosopis* roots in practice if it is still profitable overall?" and one simple reason is they can earn more if they coppice the trees instead of extraction in particular to sparsely and moderately that very small difference to heavy invaded *Prosopis* land. The calculation assumes that coppicing and extracting *Prosopis* have an equal opportunity cost of 120 birr per day, based on the most common alternative sources of cash income in the area working on private farms/sate sugar farm. This opportunity cost may not reflect that digging up *Prosopis* requires far more energy than simply cutting the branches and felling at the stump.

First, the regional government needs to conduct a more in depth analysis of the charcoal market. Growing demand for charcoal from Ethiopia's escalating urban population that the charcoal trade could make it economically feasible to scale up *Prosopis* clearance to millions of hectares. However, as the production of *Prosopis* charcoal scales up it may suppress charcoal prices which could act as a limit on clearance/control. The economic sustainability of charcoal producer and trade may also be limited if *Prosopis* clearance is effective and large areas become depleted. Analysing these two elements of the charcoal market and resource base is important for the long-term economic sustainability of *Prosopis* reclamation.

Second, the regional government should find ways to address the economic disincentives and production technology for private charcoal producers to dig up *Prosopis and efficient production*. *Prosopis* control and management regulation that approved by the government of Afar national regional state provides guidelines for getting private charcoal producers i.e. charcoal producers involved in clearing *Prosopis* so the land can be reclaimed for cropland and pasture. This includes which designating which institutions (at Kebele and woreda level) have responsibility for monitoring and enforcing the regulation guidelines, and suggested punishments for violations. This is good, but the regulation does not provide answers on how to address the economic disincentives and production technology for private charcoal producers to properly extract *Prosopis* when they cut the tree and trade only *Prosopis* based charcoal. These disincentives and production technology may make it difficult to enforce the regulation in practice.

## 4.6 Perception on *Prosopis* control & management regulation

### 4.6.1 Awareness on Prosopis regulation




Source: authors' analysis of survey data

The findings of the study on the perception of *Prosopis* regulation is very poor that majority of the respondents were not aware. The interview illustrated that 97% of the charcoal producer and 90% of the charcoal trader didn't have awareness about *Prosopis* control and management regulation whereas 3% of producer and 10% of traders were aware regulation. Totally 93% the respondents were not aware and only some 7% were known regulation from different information sources. As well as from focus group discussions; it analyzed that regional *Prosopis* control and management regulation absolutely not known and nobody so far consulted them about *Prosopis* regulation and it first time heard from this discussion. Similarly interviews with Aysaita and Afambo PADO head and NRM specialists; on the subject of *Prosopis* control and management regulation; expressed that both office head and NRM specialists were aware about the regulation informally and few were aware due to were attended workshops when regulation was ongoing to develop and endorse. Based on interview discussions held with both woreda PADO's team; *Prosopis* control and management regulation was not sent officially from region and confirmed regulation not cascaded as per requirement that it is in the bureau of BOLAND. As interview with regional BOLAND head and NRM team; were expressed that early it was tried to aware, cascade and practice in few areas and quickly finally disregarded as result of poor official/political commitment and resource limitation.

Generally *Prosopis* control and management regulation in the study areas were not aware and known by significant number of people including lower government administration units. And resulted regulation not tested and adopt at all level of government structures and community members.

201708/04

የአፋር ብሔራዊ ክልላዊ መንግስት

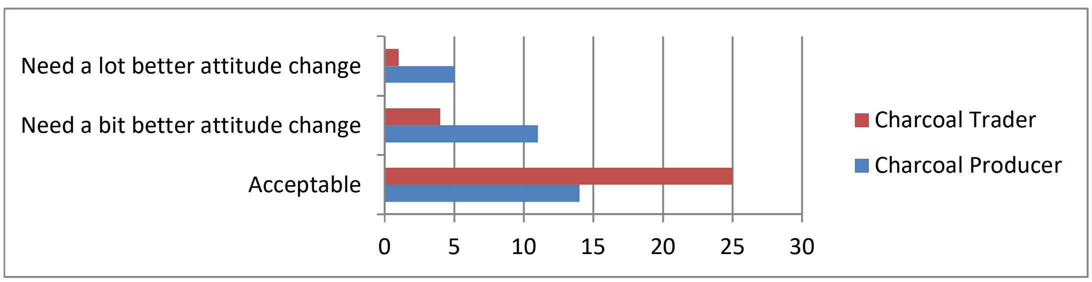
የአፋር ክልል ዲንካራ ጋዜጣ

AFAR REGION DINKARA GAZZETA

| ___ኛ ዓመት ቁጥር 64<br>ሠመራ _ቀን 2004 ዓ.ም | በአፋር ብሔራዊ ክልላዊ መንግስት<br>ምክር ቤት ጠባቂነት የወጣ | ___th year :-No 64<br>samara____2011 |
|---|---|---|
| Qafár Agattiinoh Rakaakayal kaxxam baxcisimak geytimta pirosoppiis caxa loynisoonuh, teetit kalalitak waasoonuh yewqe edde-xinta. Culmeyná | ማውጫ<br>በአፋር ብሔራዊ ክልላዊ መንግሥት በስፋት እየተዛመተ የሚገኘውን የፕሮሶፒስ ዛፍ ለመቆጣጠርና ለመከላከል ለማስወገድ የወጣ ደንብ | CONTENTS<br>Proclamation No. 64<br>A Regulation Issued to Control, Manage and Eradicate the invasion of *Prosopis* in the Afar National Regional State |

Figure 7: Photo indicating *Prosopis* regulation issued by Afar region (source: field Survey, 2019)

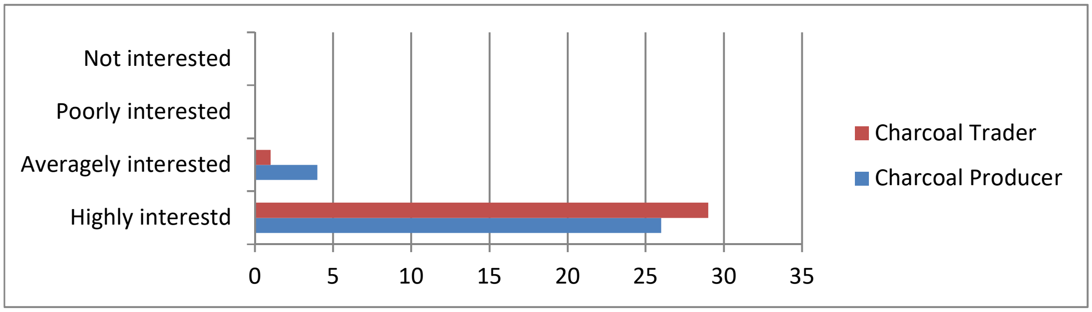
### 4.6.2 Community attitudes toward charcoal business




Source: authors' analysis of survey data

In general people attitudes towards charcoal production and trade acceptable while additional awareness and supporting intervention vital to better attitude changes to charcoal producing areas. As interview result illustrated that 60% of the respondents were answered to acceptable; 33% of the respondents were answered need a bit attitude change and 5% of the respondents were answered need a lot better attitude change. This attributed to charcoal business in the study areas are acceptable while it further requires to assess and carry on awareness creation especially to areas of charcoal producers as it is potential business mainly paired with other economic occupation. During community members group discussion; one participant/elder was quoted about afar attitude and trends to charcoal producers in their area: he said "before ten years the prevalence of charcoal production and trade was not known and understood by Afar people; charcoal production and trade was undervalued by afar culture and it simply the highlander were produced and sold. But know as result of recurrent drought/livestock lost and *Prosopis* expansion; Afar people aware about charcoal business/profit even they named as black gold in his areas".

### 4.6.3 Opinions on charcoal licensing system



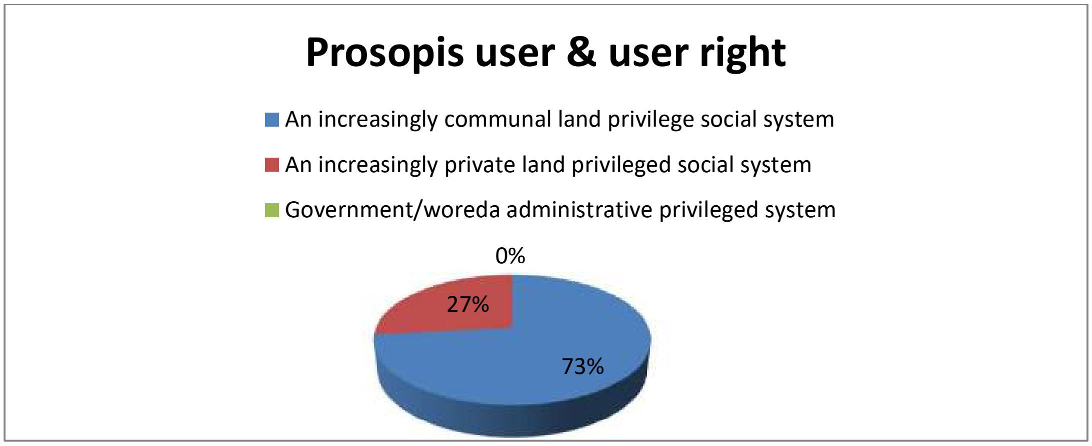

Source: authors' analysis of survey data

The interview was showed that 92% of the respondents were highly interested working through a licensing system and 8% of the respondents were averagely interested with a licensing system; amazingly nobody were respond to poorly interested and not interested. Correspondingly focus group discussions, all the participants were strongly interested if government was pilot a licensing system and scale up to all *Prosopis* invaded areas. As well as interview and focus group discussions were indicated that people who can represent their interests in negotiating with government; and majority of the producers were prioritized to clan leaders and chairperson with hardly to woreda administration and majority of traders were prioritized to elders, Kebele chairperson and woreda administration.

Generally these attributed to considerable numbers of people were interested charcoal business through a licensing system and piloting in few areas; people were very eager government to lift restriction and emplace helpful *Prosopis* regulation and licensing system. These opinions were also supported by two woreda officials while underlined government should attention to complexity and consequences of charcoal production to environment in particular to indigenous tree uses for charcoal production. Regarding regional BOLAND opinions; somewhat agreed to licensing system with underlining all proposed strategies and techniques should inclusive, tested and applicable to the context of areas, livelihood and also capacity of government as leading and regulatory. In all interview people; pilot charcoal business through providing license (producer, trader, retailer and wholesaler) in the study areas are encouraging as far as its complexity and consequences addressed very well; that considerable people are willing and ready to actively participate if government intend to pilot through licensing system.

### *4.7 Prosopis* user and user right

#### 4.7.1 Land tenure system related to Prosopis user & user right

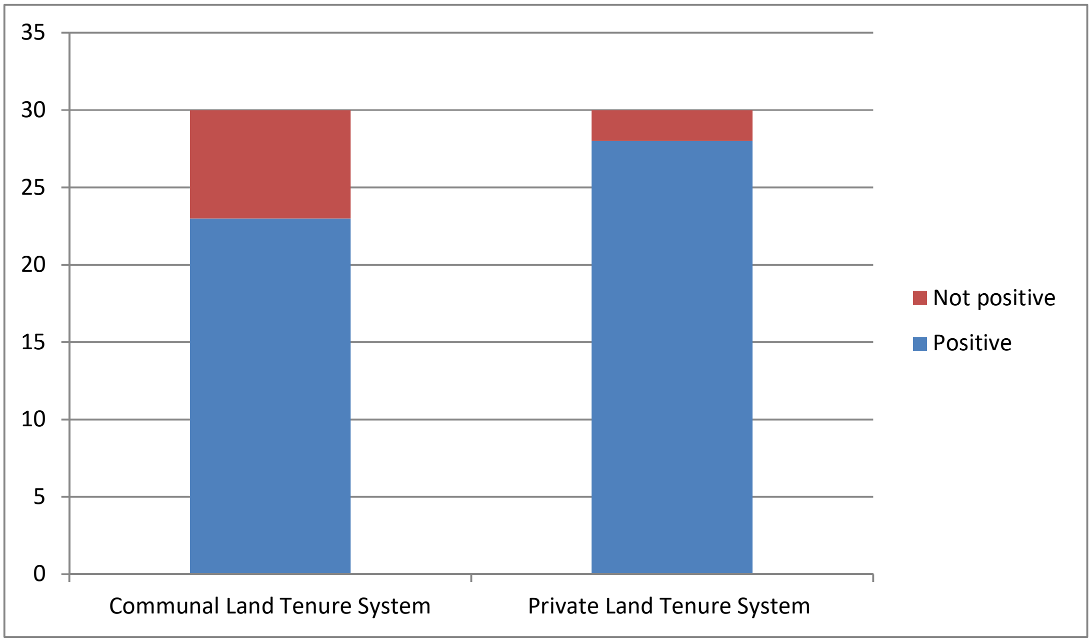



Source: authors' analysis of survey data

Normally the land tenure system practiced in the study areas mainly communal land tenure system and to some extent a private land tenuer system. On the subject of *Prosopis* raw materials user and user right interviews and focus group discussions; interview illustrated that 73% of the respondents were replied an increasingly communal land tenure system; 27% of the respondents were replied to an increasingly private land tenure system and no one replied to government privileged system while national government land policy reclaimed land under the custody of government. Similarly community member's discussion; majority of *Prosopis* raw materials are an increasingly communal land tenure system except some areas a private land tenure system. This can attribute to *Prosopis* raw materials are mainly communal land tenure and to some extent private land tenure system especially when land used or proposed to crop. Consequently, charcoal production mainly harvested in the form of communal land tenure system and charcoal production moderately harvested in the form of private land tenure system. Therefore, for any intervention related to *Prosopis* charcoal production and trade, attention to land tenure system related to *Prosopis* raw materials user and user right understanding very important to *Prosopis* regulation and charcoal licensing system.

This also associated to land policy issues that the region have policy but not aware and adopt since last five years! All natural resources available are working haphazardly. The land is simply communal and/or owned by clan leaders and chairperson. One of the reason to an increasingly illegal charcoal business is the region has not consider and adopt land use policy related to natural resource management including *Prosopis* invasion. Thus charcoal producer has not specific area to make charcoal that created ideal environment for charcoal producer to cut the indigenous tree resource as they want.

### 4.7.2 Communal and/or private land tenure system versus charcoal licensing system




Source: authors' analysis of survey data

When we are looking for land tenure system related to charcoal production licensing system; 77% of the respondents were promising to communal land tenure system and 93% of the respondents were promising to private land tenure system, as well as 23% of the respondents were not promising to communal land tenure system ad 7% of the respondents were not promising of private land tenure system. This attributed to study areas; land tenure system related to *Prosopis* raw materials are factors determines how *Prosopis* regulation and charcoal licensing system could initiated and possibly will piloted. In particular to communal land tenure system, some respondents were expressed their reservation to licensing system may complicated and important pay attention before beginning of licensing system. It similarly community members interview; were described both land tenure system are promising working through licensing system as far as existing realities are well captured and included in *Prosopis* regulation and charcoal licensing system.

## 4.8 Aspect of government officials to illegal charcoal production

### 4.8.1 Prosopis control and management regulation

It was tried to have interview and discuss with regional government officials such as head of BOLAND and woreda PADO's, on their perspective regarding on *Prosopis* regulation and an increasingly illegal charcoal production in the region and respected woredas. And findings presented as follow:

Largely and formally charcoal production was started in Afar since 2004/05. It was initiated by NGO with established cooperatives and giving them different material for the production of charcoal from the *Prosopis* tree invaded all grazing area, settlement area and crop land. Overall objective was to benefit or give some sort of solution to pastoral people in finding alternative choice to use *Prosopis* products i.e. charcoal and to reclaim *Prosopis* invaded potentials rangeland and farm lands. At that time thinking was production of charcoal in a way that not polluted the environment and only produced charcoal from *Prosopis* tree. However, charcoal business became out of control and indigenous trees were destroying by charcoal producers under the name of *Prosopis*. As a result of this, the government tried to ban the charcoal business at all but couldn't possible. The government was struggling to minimize the scale of production through forbidden charcoal business. The government was tried to take measure on the charcoal producer by confiscate and bring their produced charcoal to prison.

Continuously the government in collaboration with Farm Africa (was played a key role) were developed draft *Prosopis* control and management regulation that was approved by the Afar regional government. The regulation set out responsibilities of different government offices in controlling *Prosopis*, including charcoal production and clearing it to establish cropland and pasture. The regulation also set out legal prohibitions on several activities; including failing extract the roots of a *Prosopis* tree when cut, making charcoal from indigenous trees and interfering with *Prosopis* clearing activity. Violations may be punished with fines of up to 5,000 birr or prison sentences of up to 2 years.

The approval of the draft regulation were marks a big step in the government taking on responsibility for *Prosopis* and embedding effective *Prosopis* management techniques within policy. However, after very tough events of charcoal business and remarkable approval of the draft regulation; since now with unknown reasons and evidences, regulation couldn't fully applied and used only for shelf purpose. However, from depth interview and discussion this study tried to understand general reasons and possible suggestion to provide as follow:

- ✓ ***Government reaction***: until now government have no measure taken in place to address the cause's of illegally charcoal production and trade than try to apply that rules and regulation. As result, government couldn't control illegal charcoal production and trade in the region.
- ✓ ***Familiarity***: there are significant gaps on understanding and perception at different levels of government structures such as region, zones, woredas and kebeles. As well as relevant sectors and stakeholders perception and understanding are also highly varies. Awareness creation and panel discussion were not done as require or completely to adopt and cascade regulation at different levels of government structures and community members.
- ✓ ***Political commitment***: as regional government is a leading actor and politically committed and prioritized to *Prosopis* control and management as strategic direction, it extremely difficult to see regulation progress and achievement. Except government didn't allocate resources that supporting too aware, cascade and adopt at all levels of government structure and community members.
- ✓ ***Coordination and networking***: in general there is no any efforts by government established coordination and networking activities related to *Prosopis* management that could emplace regulation with relevant stakeholders.
- ✓ ***Approach***: the regulation takes a command and control approach to regulate the charcoal business; it helps the cause of controlling and eventually eradicating *Prosopis* than address to challenges, which is unlikely to work on its own.

- ✓ ***Capacity***: additional to political commitments, capacity is a demanding issue in particular to Woreda and kebeles levels as they are shoulder to the responsibility of monitoring and enforcing prohibitions against illegal charcoal production.
- ✓ ***Economic incentives***: the regulation not provides answers on how to address the economic disincentives for private charcoal producer to properly extract the *Prosopis* roots when they cut the tree, and to trade only charcoal made from *Prosopis* trees.
- ✓ ***Harmonize/update with government structures***: since regulation preparation and approval of the draft regulation to until now; the regional government structures have been changed repeatedly and this could affect regulation to apply and successful.
- ✓ ***Supplementing policy***: the region has no specific forest protection policy that can supplement to *Prosopis* control and management regulation and indigenous tree. As well as the region couldn't fully apply land use plan and cover policy that very relevant to *Prosopis* control and management and utilization.
- ✓ ***Harmonize with federal policy/Prosopis-IAS***: following *Prosopis* control and management regulation approved by Afar national regional state, federal Ministry of Agriculture and Natural Resource similarly prepared and approved National *Prosopis* Control and Management policy. And so far nobody reassessed to complementary with national policy and possible applicable.
- ✓

### 4.8.2 Government perception towards illegal charcoal production

The perceptions at all levels are comparable to observable facts of "an increasingly illegal charcoal production and trade in the region". Initially people were started charcoal production and level of the society increased throughout in the region. Then after, the charcoal producer changes their focus because of their selfishness (well paid money to acacia tree) started to destroy the indigenous tree resource. When the government understands the expansion of and negative side of charcoal business; government was established rules and regulation on the *Prosopis* control and management. But regulation was not applied and successful; the consequence was an increasingly illegal charcoal production that by the name of *Prosopis*, significant people cutting indigenous tree for charcoal production. It broadly observed in afar region that illegal charcoal production and trade could lead into the destruction of indigenous tree and also *Prosopis* coppicing.

Except community members are accepted and respected regulation and equally government officials should politically committed and equip with require resources; an increasingly illegal charcoal should be ignored and finally becoming severe natural resource disaster and uncontrolled event of government. If we take Kenya as an example use *Prosopis* for different purpose and named as "our mother". In Kenya they use *Prosopis* pods for different purpose, they use *Prosopis* wood for charcoal and timber, also they have different cooperatives that have license for their activity and give tax to the government. They also have a system of collecting some percent their profit in the bank and refund again on replanting tree on the place to *Prosopis* plant. Even they produce chairs from *Prosopis* wood and Keck/Bread from *Prosopis* pods, so it has its own role in increasing and expanding the income of pastoral peoples if they have used in proper manner.

The case of afar region, the process of charcoal production which was started to remedy the rapid expansion of *Prosopis* tree and reclaim potential grazing and farm lands, consequence to reached the situation of stopping charcoal production from prohibited tree. The charcoal owners prefer prohibited trees for the production of charcoal for improved profit while the government encourage charcoal production only from the invasive *Prosopis* tree. In most interviews, generalized and reached to the point where illegal charcoal producers are unable to stop the business as it this more survival and alternative income sources contributed to the life changing benefits and coming out of charcoal business difficulty.

In summary, we could understand from government and community members interview that, in the first place charcoal production was formally began with help of an NGO whose intention to control the invasion of *Prosopis* tree. However, the local communities turned their money to expanding engagement into the charcoal production out of the indigenous trees after they realized the difference in terms or demand and market price of charcoals made of *Prosopis* and other trees such as acacia. Thus, the production of charcoal that benefited and/or changed welfare of people are progressing business while regional and local officials which completely failed timely to react and unable to control an increasingly illegal charcoal production holding *Prosopis* regulation that was developed and approved by themselves.

## 4.9 ORGANIZATION FOR SUSTAINABLE DEVELOPMENT

As per recommendation of Aysaita woreda PADO to discuss with Organization for Sustainable Development (OSD); the study team had interviewed and visited project's field site and *Prosopis* briquette's factory. Organization for Sustainable Development is a local non-government organization that since last 3 years was operating in Aysaita woreda of Eritrean refuges camp in supplying of briquettes energy to refugees. The DKH is donor for the supplying of machinery, installation, trainings and other related cost in order to produce and distribute to refugee's domestic energy. UNCHR is refunding organization to briquettes cost of production in order to maintain deforestation of hosting community and also protect women/children violation during faraway travelling to collect domestic fuel woods. To this end; firstly OSD had deal with woreda PADO how to get official permission to access *Prosopis* invaded land and raw materials to produce and trade charcoal briquettes. During discussion OSD encountered challenges to get permission for *Prosopis* land/raw materials as result of government charcoal ban while after further briefing its purpose and benefit to supplying of briquettes to refugee, woreda PADO was permitted 100 hectare of *Prosopis* invaded land to produce briquettes and cleared land to use for rangeland or crop farm. Consequently cooperative established with member of 50 youth to burn charcoal from *Prosopis* in metal kilns and inputs to briquettes production. During *Prosopis* clearing and payrolosis to charcoal; SOD will paid 150 birr per day to cooperative member and provided equipments to cooperatives such as tools and metal kilns. And the unit price is four birr/briquettes that UNCHR refunding to OSD. Machinery has a capacity to crush 16 Qt per day and produce 2,700 briquettes per hour. A briquette provides heat for 3 hours.

The finding to *Prosopis* charcoal briquettes that were operating by OSD is important with respect to control *Prosopis* invasion. Utmost advantageous are not preferred *Prosopis* stages, easer to transport and store, avoids air pollutions/greenhouse gases, inclusive economic job opportunities and creates market to charcoal producers. If local charcoal producers linked with *Prosopis* briquettes enterprises, charcoal production impacts to environment issues will reduce and its commercial viability will be very high. The study recommends further studies carry on such as economic feasibility, supply chain, market chains and business designs and promote private sectors involvement through licensing system of government provide.

Figure 7: Photo indicating briquettes machinery and *Prosopis*charcoal briquettes

## 4.10 AFAR PASTORAL AGRICULTURE RESEARCH INSTITUTION

The study team had interview with APARI Natural Resource Management researcher that has been conducting research works related to *Prosopis* controlling techniques, distribution and impacts. The researcher informed that controlling techniques had tested and findings can be provided officially. As well as they are working on *Prosopis* invasion/distribution mapping in collaboration with Addis Ababa university that already raw data collected and GIS working ongoing to release very soon. Therefore, the study recommends collaborating with APARI to include research based findings such as controlling techniques, invasion/coverage map and so on; as this information is central for charcoal production and trade in order to ensure economical and environmental sustainability.

## 4.11 COMMON POINTS ARGUED BY ALL RESPONDENTS

All producers, traders, and government officials were asserted that the reasons for an increasingly illegal charcoal production were lack of encouraging government policy/regulation and ever increasing *Prosopis* distribution and impacts. In addition, they stated that if there is an alternative income source, economic job opportunities and lesser *Prosopis* impacts; people were not involved in charcoal production and illegal charcoal businesses were also not increased.
Their responses explicitly indicated that almost all respondents agreed that:

1. *Prosopis* charcoal business is economically benefit and support to better income sources and household expenditures.
2. *Prosopis* charcoal business is recent and upcoming element of local people livelihoods and alternative sources of income throughout years and/or tough seasons, financial stress.
3. *Prosopis* charcoal business is inclusive economic jobs as result of raw materials abundant, low investment cost, high market and can trigger to economic job opportunities.
4. Attitudes about charcoal business are similar while more awareness, skills and knowledge are substantial at all levels.

5. Perception and understanding about *Prosopis* control and management regulation is very poor including government administration units such as woreda and kebeles.
6. Favourable conditions avail to charcoal production licensing system and pilot
7. *Prosopis* expansion and implications were progressively affected local livelihoods and biodiversity. And requests to government should have systematic responses very soon.
8. Government should organize frequent meetings, workshops, forum related to *Prosopis* management and utilization

## 5. CONCULSIONS AND RECOMMENDATIONS

### 5.1 Conclusions

1. *Frustration*: during the interview there were very high frustrations to talk about charcoal issue that 22% of the respondents were rejected interview. Most of the frustrations are common to their charcoals were detained by government and fear to be in prison. The degree of frustration high in urban than rural; and this could directly related government supervision focused on urban areas.
2. *Illegal charcoal production:* is an increasingly and a major cause of deforestation in the study areas that government should emplaced strategic and systematic Prosopis management and utilization policy and program that by name of Prosopis charcoal hardily available indigenous trees are burning.
3. *Gender mainstream*: study confirmed gender is an important factor to charcoal production and trade intervention that women have little involvement into production aspect while very high into trading aspect.
4. *Complementary livelihoods*: study confirmed an overall assumption that charcoal businesses are frequent source of income paired with other livelihood in the study areas. In rural area, significant people livelihoods are complementary with charcoal business especially during drought period, dry season and agriculture lean season. The charcoal businesses in the study area are an element of livelihoods to fulfil family basic and economic needs; and also it is a primary option to fill income gaps when the event of disaster/drought provoked their main livelihood.
5. *Business orientation*: finding indicates degree of business oriented and exploiters to charcoal production and trades are great numbers to commercial and intermediate exploiters. Thus charcoal business for producers are more to intermediate exploiters and traders are more to commercial exploiters while subsistence exploiters were very small to both producers and traders.
6. *Household expenditures*: findings to household expenditure used from charcoal earn is large in particular to charcoal producer of rural people than trader. In general Charcoal business was contributing a lot for household expenditure and well-being of the people who involved in charcoal production and trade. It normally contributed to household foods, goods, medicals, schools etc expenditure and part of remained money was also used to fixed asset and save to bank.
7. *Household basic needs*: findings on household basic and economic needs have showed charcoal business well pleased economic supports into better income sources with degree to comprehensively and spontaneously helpful. It obviously known that in the study areas

there are very abundant *Prosopis* raw materials that available throughout a year, increasingly in communal land, low investment cost, high market; these all enforces charcoal business to be energetic economic support to better income sources and entering points to economic jobs opportunities.

8. *Charcoal burning area*: findings confirmed there was no charcoal production/burning areas that were allocated by concerned bodies that charcoal producers were used area's selected individual based on raw material nearness and other preferable conditions. Regarding to production/burning area importance, more respondents were believed that specific areas allocate to charcoal burning is important associated with environment and health issues. While some of the respondents were contrarily believed not important associated with uncertainty of specific areas possibly will far away from their residence, *Prosopis* raw materials, selling points and incurred additional cost.
9. *Charcoal maker/producer*: scenario to afar local people were not practicing charcoal production; these days it seems such scenario were completely changed and trends to partnership is declining through time as production skills & knowledge were gaining throughout and major livelihoods were weakening to cope with the recurrent drought and basic assets lost; corresponding to abundant availability and low investment cost of *Prosopis* charcoal production could factors to afar local people involvements an increasingly observed in the study areas.
10. *Mainly burning trees:* findings to mainly burning tree and security to indigenous trees; individual respondents illustrated more charcoal were from *Prosopis* and few also from indigenous tree acacia/keselto. While community members were described presently in their areas nobody used indigenous tree except *Prosopis*, this assumption might in question if we associated to individual respondents. In general the government control and charcoal forbidden couldn't stop charcoal production either from *Prosopis* and/or indigenous tree. These associated to very poor control and increasingly illegal charcoal productions and trades are reason for hardly available indigenous trees lost by now and previously.
11. *Government approach*: Encase of the study area's scenario "existing government approach to control charcoal businesses are grounds to aggravating incidence to indigenous tree burning as result of increasingly illegal charcoal production.
12. *Clearing & cutting methods*: findings confirmed that most of charcoal producers were used coppicing method; some were used extraction method particularly to intending land for farming/settlements and few were used also both methods. As coppicing method greatly applied that charcoal producers are more expanding *Prosopis* than controlling; except necessary awareness creation, conducive regulation, licensing system, incentives and associated with land cover/mapping activities are emplaced and to reinforce charcoal producers significantly to practice and use extraction method. Occasionally coppicing method's may recommended based on land covering and community mapping corresponding and reached consensus to *Prosopis* lands are marginal and demarcated only for charcoal production; it possibly will use coppicing method. At least it will have implication to flowering and seeding stage that will brakes seed spreading and reseeding into potentials land such as rangeland, farm lands, settlements and water points.
13. *Techniques for managing*: study identified five control techniques and supporting to three control types such as mechanical, utilization and cultural/Prosopis standing management, study confirmed an overall assumption that using these three control types are more applicable and tested by Ethiopia forestry research institution, Melkaworer agricultural research centre and Farm Africa at Afar region.

14. *Prosopis stand management*: the experiments carried out at Aysaita and Amibera woreda have proved the invasive species *Prosopis* Juliflora can be managed using the different techniques such as cutting, burning and stand management; that very vital to consider and include in *Prosopis* regulation and guidelines of *Prosopis* management and utilization. The stand management trial has verified that if continues follow up and supervision is carried out in managing an established *Prosopis* stand, the rate of invasion and expansion of *Prosopis* can be controlled.
15. *Conducive regulation*: more people were underlined regional government should facilitate conducive regulation and lift restriction; community members expressed by quoting to "at present nobody can judge about our people fate and outcome except ourselves as past 5-10 years nature itself educated us, what was natural and manmade threats and also how we could mitigate with threats". In all community member interviews were strongly expressed now time to negotiate with government and look for organized response to *Prosopis* management and control through potential economic benefits and respectively to reclaim potentials land to regenerate indigenous tree, pastures and water points soon.
16. *Community leading role*: exacting of joint community proactive rules for management and control of *Prosopis*, it is unlikely that individuals will invest in proper controlling and/or utilizing *Prosopis* in the communal land tenure such as rangelands, water points, settlements and so on.
17. *Cost-benefit analysis*: findings of this study confirmed an assumption that charcoal production and trade has significant economic benefits for better and alternative income sources. A cost-benefit analysis of charcoal production for the study area shows, that it is feasible even when the roots are fully extracted to prevent rapid re-growth. Although production costs per hectare are roughly increased on average 70% when properly extracting the roots, the roots can be turned into charcoal and increases the number of bags per hectare on average by approximately 41%. The cost benefit ratio is therefore still above 1:3 for all three categories of *Prosopis* invasion.
18. *Markets and marketing*: many people that met on the study visit remarked that to control *Prosopis* there is only thing that needs to be done, that is to attach a value to *Prosopis* and by extension its products. And this is clearly a function of markets and marketing issues to management/control and utilization of *Prosopis* in the study areas.
19. *Perception to regulation*: *Prosopis* control and management regulation in the study areas were not aware and known by significant number of people including lower government administration units. And resulted regulation not tested/adopt at all level of government structures and community members.
20. *Licensing system*: considerable numbers of people were interested charcoal business through a licensing system and piloting in few areas; that people very eager government to lift restriction and emplace helpful *Prosopis* regulation and licensing system.
21. *Land use & cover*: As afar natural resources base/available are on land and people are against to land use and cover policy that working haphazardly. It resulted an increasingly illegal charcoal business in the areas and has not considered and adopt land use policy related to natural resource management including charcoal production and *Prosopis* invasion. Thus charcoal producer has not specific area to make charcoal that created ideal environment for charcoal producer to cut the indigenous tree resource as they want.
22. *Experiences in Africa*: it shows that some changes may require to Prosopis management and utilization, such as lobbying for more active involvement and proactive participation of the private sector in *Prosopis* product development and marketing; a package of new

technologies that would improve the process of charcoal production (for wood harvest and efficient charcoal production); special labelling of the charcoal as being produced from *Prosopis* for market establishment and penetration, this would also entail provision of in situ testing kits to government for random sampling; and local marketing organizations to manage production, marketing, sale and distribution of proceeds.

## 5.2 Recommendations

1. Since the benefit of *Prosopis* Juliflora assured as potential charcoal energy source referenced to relevant literatures and this study confirmed assumption to economic viability; its management and utilization mechanism should be established between concerned institutions and community members within Afar region and/or study areas.
2. To reduce the negative impacts and control the wide spread of *Prosopis* Juliflora, business oriented *Prosopis* charcoal should use the species as alternative livelihoods and demanding domestic fuel. It can be achieved through developing encouraging regulation, technical guideline & licensing system. There is high potential to plan for employment opportunities at regionally by assessing *Prosopis* using a remote sensing and GIS.
3. There is a need to form regional and local/woreda *Prosopis* taskforces to discuss the issues including all stakeholders, pastoralist, elected public representatives/pastoralist standing committee, private entrepreneurs, NGO's and research institutions.
4. As *Prosopis* Juliflora very abundant and potential to charcoal business and economic job opportunities; it has significant advantages of being add value into locally produced charcoals such as formed into briquettes. A formed briquettes easer to transport, store, avoids air pollutions, not factor *Prosopis* character (sparsely, moderately and heavily: briquettes unlike charcoal producer and trader). Therefore, further studies are suggested
   - Carry out assessment to the present status of the charcoal production activity by OSD and understand a wider business environment for trading charcoal
   - Conduct feasibility, supply and market chain analysis and make sure production and trade of charcoal briquettes are successful business investment.
5. Growing demand of *Prosopis* charcoal from escalating urban and pre urban population that charcoal business could make it more economically feasible. However, as production of *Prosopis* charcoal scales up; it may suppress charcoal prices as well as depletion of large *Prosopis* areas lead to raw material constraints. Analysing these two elements of charcoal business and *Prosopis* resource base is important for the long-term economic sustainability of *Prosopis* reclamation.
6. The regional government should review *Prosopis* control and management regulation to find ways addressing the economic disincentives for private/individual charcoal producers to properly *Prosopis* dig up (use extraction method) when they cutting *Prosopis* tree. The regulation focused only trade charcoals from *Prosopis*.
7. Establish demonstration sites or model *Prosopis* villages and demonstrate *Prosopis* management and utilization techniques. As well as demonstrate and introduce low priced and improved technologies (kilns for charcoal production).
8. *As Prosopis* Juliflora control, management and products are part and mechanism of natural resource management; rely upon forestry education and land use plan and land management and land cover/mapping vital to *Prosopis management and* utilization.

9. Nature of *Prosopis* weed and rate of distribution very high and complex; largely political commitment, coordination and resource mobilizations are elements to manage and control through utilization.
10. Whenever *Prosopis* charcoal production and trade projected; determining factors should always considers such as commercial viability, control techniques, regulation/policy/forum, land use/cover, *Prosopis* mapping, value adding, supply & market chain and technical capacity.
11. There should be very strong and applicable criterions and requirements for *Prosopis* commercial charcoal production, transportation and trade; such as to be a charcoal producer and trader, to obtain a licence (production and transportation), restructuring trade in, land cover and map, define tree species/number/volume to be used for charcoal production, sustainable harvesting of plantation, sustainable charcoal production harvesting and methods of charcoal production and etc.
12. Local people should learn methods of charcoal production and are able to cope with recurring drought conditions prevailing in the study areas. This adaptation method could build resilience and adaption to extreme climate/disaster and also arrest migration of people to some extent particular to women and children.
13. The Afar people's opinion about charcoal is that for the future there would be a huge demand for the charcoal and in the last two years there is a great increase to charcoal makers and also charcoal price.
14. Finally study proposes one year pilot project on management, marketing and utilisation of *Prosopis* products such as charcoal, animal feed, honey production etc that will focus on few woredas as a pilot area. The objectives of the project will be: evaluating techniques of management (regulation & licensing system), evaluating the relative contribution of *Prosopis* to the charcoal and animal feed market, the merits/demerits of *Prosopis* charcoal (livelihood, availability, regularity, calorific values), training on best carbonisation techniques, introduction of technologies, strengthening the capacity of production groups in marketing of *Prosopis* products, as well as assisting the stakeholders in the business to come up with viable market led programs on *Prosopis* management and utilisation.

**APPENDIX 1:** Location/coordination points

| GPS LOCATION POINTS TAKEN DURING STUDY INTERVIWE & FGDs CARRIED | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| REGION | ZONE | WOREDA | KEBELES | VILLAGE | GPS CODES | GPS POINTS | ELEVATION | DISTANCES |
| | | | Aysaita bus station | Bus station | 23 | N 11°34.070´ E 041°26.217´ | 337 m | SE 0 km |
| | | | Galifage | Glatoburii Primary school | 30 | N 11°39.767´ E 041°21.567´ | 354 m | NW 12.32 km |
| | | | Oromoyta | Amerdura Primary school | 45 | N 11°34.574´ E 041°23.572´ | 553 m | W 4.23 km |
| | | | Kebele 02 | Charcoal marketing center | 60 | N 11°34.126´ E 041°26.222´ | 363 m | SE 1.14 km |
| | | Aysaita | Kebele 01 | Charcoal marketing center | 68 | N 11°33.870´ E 041°26.485´ | 363 m | SE 1.81 km |
| Afar | One | Afambo | Alasabulo | Fatuma primary school | 85 | N 11°31.536´ E 041°32.475´ | 338 m | SE 13.29 km |

## **APPENDIX 2:** Man-days per Hectare & Yield per Hectare Monitoring Data

1. OBJECTIVES

   - ✓ To assess *Prosopis* charcoal production man-days per hectare in the course of 3 levels (sparsely, moderately & heavily) invaded land & 2 cutting methods (coppicing method & extraction method)
   - ✓ To asses *Prosopis* charcoal production yield per hectare in the course of 3 levels (sparsely, moderately & heavily) invaded land & 2 cutting methods (coppicing & extraction method)
   - ✓ To monitor progress, collect data and report to GIZ office and consultant

2. METHDOLOGY

   - ✓ Sparsely invaded lands (20m*20m plot)
     - 10m *10m plot charcoal production in the course of coppicing method
     - 10m*10m plot charcoal production in the course of extraction method
   - ✓ Moderately invaded lands (20m*20m plot)
     - 10m *10m plot charcoal production in the course of coppicing method
     - 10m*10m plot charcoal production in the course of extraction method
   - ✓ Heavily invaded lands (20m*20m plot)
     - 10m *10m plot charcoal production in the course of coppicing method
     - 10m*10m plot charcoal production in the course of extraction method

| **Indicators** | | **Observation notes** | | **Remarks** |
|---|---|---|---|---|
| | | **Man-days**[1] | **Yield**[2] | |
| 1. Sparsely invaded plot (20*20 meter) | Coppicing method[3]; 10*10 meter | | | |
| | Extraction method[4]; 10*10 meter | | | |
| 2. Moderately invaded plot (20*20 meter) | Coppicing method; 10*10 meter | | | |
| | Extraction method; 10*10 meter | | | |
| 3. Heavily invaded plot (20*20 meter) | Coppicing method; 10*10 meter | | | |
| | Extraction method; 10*10 meter | | | |

[1] Man-days which means total number of people/labour deployed *Prosopis* turn into charcoal such as clearing, pyrolisis & packing charcoal into bags
[2] Yield which means 50 kg bag unit
[3] Coppicing method which means cutting the stumps just above ground level
[4] Extraction method in which the roots are extracted down to 30 cm underground

## **APPENDIX 3:** Cost benefit analysis of charcoal production

| COPPICING | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Prosopisstand*** | ***Labour to clear (man-days/ ha)*** | ***Pyrolisis (man-days/ ha)*** | ***Packing bags (man-days/ ha)*** | **Total labour (man-days/ ha)** | ***Opportunity cost labour (birr/ man-day)*** | **Total production cost (birr/ ha)** | ***Charcoal yield (bags/ ha)*** | ***'Farm gate' price (birr/ bag)*** | **Revenue per ha (birr/ ha)** | **Cost-Benefit ratio:** ***For every one birr invested, producers get this much birr in return*** |
| **Sparse** | *40* | *8* | *2* | 50 | | 6000 | *150* | | 25500 | 4.25 |
| **Moderate** | *45* | *8* | *7* | 60 | | 7200 | *200* | | 34000 | 4.72 |
| **Heavy** | *90* | *15* | *15* | 120 | *120* | 14400 | *500* | *170* | 85000 | 5.90 |
| | | | | | | | | | | |
| **EXTRACTION** | | | | | | | | | | |
| ***Prosopisstand*** | ***Labour to clear*** *(man-days/ha)* | ***Pyrolisis*** *(man-days/ha)* | ***Packing bags (man-days/ha)*** | ***Total labour*** **(man-days/ha)** | ***Opportunity cost labour (birr/man-day)*** | ***Total production cost (birr/ha)*** | ***Charcoal yield (bags/ha)*** | ***'Farm gate' price (birr/bag)*** | ***Revenue per ha*** **(birr/ha)** | ***Cost-Benefit ratio: For every one birr invested, producers get this much birr in return*** |
| **Sparse** | *75* | *8* | *7* | 90 | | 10800 | *200* | | 34000 | 3.15 |
| **Moderate** | *90* | *15* | *15* | 120 | | 14400 | *300* | | 51000 | 3.54 |
| **Heavy** | *120* | *30* | *30* | 180 | *120* | 21600 | *700* | *170* | 119000 | 5.51 |

Notes:

1. The main alternative source of income is selling labour on private farms and sugar farm, which pays 120 birr/day (opportunity cost of labour).
2. Charcoal yield per hectare are averages of figures reported in the interviews and field plot trails. The range is somewhat observed.
3. Farm gate price of a single bag of charcoal is also average; at present in interview areas, a single bag is 170 birr.
4. Estimate for the number of days required to pyrolise a hectare of *Prosopis* are averages of figures reported in the interviews and field plot trails. Similarly the range is somewhat observed.
5. Estimate for the number of days required to packing a hectare of *Prosopis* are averages of figures reported in the interview and field plot trails. The range is somewhat observed.

## **APPENDIX 4:** Case Study

Name: Mr. Ahmed Ali, Oromoyta Village, Aysaita Woreda.

Mr. Ahmed Ali aged about 60 years is a pastoralist, having 6 family members. He is having some shoats that used for his family basic needs and around 1 hectare of private land; earlier he owned enough cattle and shoats used to his family demands as main income source. Because of the recurrent drought and lot of livestock lost, he was getting less extent of livestock production and productivity. Earlier he was suffered a lot for fulfilling of family basic and economic needs and he was not having any dream and experience in charcoal production and he was also not interested. About 5 years back a person called Mr. Yimam came to his village and met him for his support in charcoal production from *Prosopis* Juliflora which was abundantly available in his village. He expressed it is okay for your support request; as I know that *Prosopis* charcoal could earn too money and benefit to people and moreover I have private lands heavily invaded *Prosopis* tree as well as communal lands while how we can work together and what I could benefit working with you and allowed *Prosopis* raw materials for charcoal production and sells. Then Yimam similarly replied that he had well experience and skills on charcoal production and asked Ahmed to work as partner through 50% profit share each other. He joined him as one of the partner and got involved in the production and sells of *Prosopis* charcoal. Having worked with Yimam for more than 6 months, he gained experience in both production and sells of charcoal on his own and started to earn money from *Prosopis* charcoal production and sells later 6 months working with Yimam. Instead of engaging with Yimam, Ahmed was started to mobilize his close relatives and lower income source people of the village. As a coach he provided induction how to cut and payrolsis charcoal that initially work of cutting the wood and production of charcoal was completely done with his close supervision and they would produce charcoal for few months. For 2-3 months as agent he was provides them food for eating, domestic/tools use and for charcoal production apart from providing coach and skills for their production of charcoal. He also gives loans for some people to repay during sell charcoal. In this way apart from making his own livelihood diversify, he is also able to provide alternative livelihoods for many people.

Mr. Ahmed expressed confidently that majority of the local people are getting assured income as result of his initiative and driving force to people who had lower/non income source that didn't have skills and interested in the charcoal production activity. Nowadays the *Prosopis* available in the communal lands is exploited first and then they shift to private lands. Even the private lands having high density and good quality of *Prosopis* Juliflora is let to cut for a nominal charge i.e., 10-25% of the value of *Prosopis* charcoal produced and sold. Mr. Ahmed makes a profit of about 1000 to 2500 birr from each cycle of charcoal production and sold. As per his opinion, as long as there is *Prosopis* Juliflora existing in the village, there is scope for better income sources and economic job employment. Mr. Ahmed is an inspiration for many villagers in production and sells of charcoal. Usually charcoal produced in village is being sold on highway, retailers and wholesaler that transported to Aysaita and different parts in the region and country. This activity is generating additional employment for local people including youths of his village. In the last two years people from his village has been engaged an increasingly in the production and sells of charcoal while there are not conducive environment and active government restrictions. The climate change, recurrent drought, *Prosopis* expansion, domestic energy/charcoal demands, and the adaptations by communities to these changes are a reality. When expressed since last 10 years this is the new situation prevailing in Afar community of his area. Finally when I am asking his opinions about produce charcoal largely and make afar people livelihood? He answered "Charcoal production has become a very popular activity and numbers of makers increasing would be doubling from months to months except Allah completely eradicate *Prosopis* and Afar could recover their main livelihood of livestock; I am not sure whether encourage community to largely involved and/or make main livelihood while I recommended charcoal business as complementary to livestock income sources as it is the only available alternative income source and low investment cost to better income and response to their current economic problems.”

APPENDIX 5:

APPENDIX 6:

APPENDIX 7: