Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.6, No.3, 2015

Exploitation of Prosopis Juliflora (SWARTZ) DC. and its Implication towards Controlling the Current Spread Rate at Gewane District, Afar Regional State, North-Eastern Ethiopia

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ACRONYMS AND ABBREVIATIONS

ASTER	Advanced Space born Thermal Emission and Reflection Radiometer
CBA	Cost-Benefit Analysis
CSA	Central Statistics Authority
ETB	Ethiopian Birr = 1/13.5 USD ($) = 1/17.9 Euro (€) (November 2010 exchange rate)
FARM-Africa	Food and Agricultural Research Management-Africa, UK based International Non-Governmental Organization
FRC	Forest Research Center
GIS	Geographic Information System
GPS	Global Positioning System
Ha	Hectare
HDRA	Henry Doubleday Research Association
HHs	Households
IAS	Invasive Alien Species
Kebele	The smallest administrative unit in the government structure which covers several villages
LU	Land Use
LC	Land Cover
LULC	Land Use/Land Cover
M. a.s.l	Meter above sea level
MOA	Ministry of Agriculture
NPV	Net Present Value
P. juliflora	Contextually denotes the invasive species known as *Prosopis juliflora* and locally named as *Dergihara or Woyane-zaff*
Scenario A	Current situation of *P. juliflora* externalities
Scenario B	Current situation of non- *P. juliflora* land uses under the presence of *P. juliflora*
Scenario C	Current situation of non-*P. juliflora* land uses under the absence of *P. juliflora*
TEV	Total Economic Valuation
SPSS	Statistical Package for Social Science
WARC/I	Worer Agricultural Research Center/Institute
WAS	Worer Agro-Meteorological Section
Wereda	A local government structure commonly referred to as district and which is immediately next to (above) the Kebele administration
WTP	Willingness to pay

Abstract
Prosopis juliflora, an evergreen tree/bush, is a powerful exotic invader in Ethiopia. The overall aim of this work was to develop scientifically verified sustainable solutions for the controlling the spread of P. juliflora through quantification of impacts of economic exploitation. This study was undertaken in Gewane district of Afar National Regional State. The study was commenced with analyses of its list of potential impacts in the area. In order to get the land use land cover information, maps developed from ASTER image 2007 were obtained and used. Furthermore, structured and semi-structured questionnaire were used to collect data about socio-economic impacts. Total sizes of 124 sample respondents from different exploiter groups living in 3 ranges of invaded area were participated in this study. The research methodology primarily consisted of a problem-based approach that emphasized analyses of the percived economic values of the study sites supplemented by secondary data from

various sources. Individuals' perception on P. juliflora was strongly influenced by impacts of the species by weighting of the costs against the benefits of living with P. juliflora. Local people are aware of the benefits from P. juliflora but the aggregate loss outweighs these socio-economic and ecological benefits. A Total Economic Valuation (TEV) of the overall analysis of monetized impacts of P.juliflora shows that the calculated NPV still proved profitable. However, this value still excluded several additional impacts of P.juliflora that were difficult to monetize credibly within the current research work. For commercial exploiter households the beneficial impact can be seen as completely outweighing the costs of P.juliflora while the result confirmed negative NPV for intermediate and subsistence exploiters. The result further indicated that commercial exploiter category shared 81 percent from the overall benefit while sharing only 28 percent the overall cost. Subsistance exploiters shared only 4 percent of the over all benefit obtained from P. juliflora while sharing 47 percent of the overall cost. Furthermore, the value of livestock production with the absence of P.juliflora was 94.4 % higher than the value of livestock production with the presence of P.juliflora and the TLU collapsed to about 81.9 %. 100% of commercial exploiters and 70.8 % of intermediate exploiters involve in controlling intervention with the direct intention of economically use the harvested P. juliflora productes. While 92 % of subsistence exploiters involved without. However, only 6.5 % remove P. juliflora without allowing its regrowth. From the overall result, 41.9 % of the respondents believed exploitation of valuable product would promote for further invasion. The current correlation between exploitation and controlling of invasion in the study area revealed that exploitation for charcoal making and pods for livestock were stated good and greatly risky in reducing the threat of P. juliflora, respectively. The overall implication of exploitation versus controlling the current spread rate of P. juliflora in the study area was found least. Therefore, identifying, evaluating, and understanding those components of exploitable items that are accountable for invasion or control of P. juliflora would helps guide policy decisions, appropriate interventions and integrated efforts to combat further invasion of P. juliflora at the infested and potentially exposed districts.
Keywords: Prosopis juliflora; Impacts; Economic exploitation; valuation; controlling current spread rate.

1. Introduction

Exotic plant species have been purposely and/or accidentally introduced throughout the world due to their economic, environmental or aesthetic values. Nonetheless, introduction of new species is not always a success and brings about the possibility of invasiveness of the species which in turn result in negative impacts (economic, environmental and social) (Stefan Andersson, 2005). In the late 1970s and early 1980s, concern about deforestation, desertification and fuelwood shortages prompted a wave of projects that introduced *P. juliflora* and other hardy tree species to new environments across the world (Mwangi and Swallow, 2005) that it did not take *P. juliflora* a long time to be registered as one of the first top 100 invaders. During its introduction from its natives, South America, Central America and the Caribbean, the indigenous knowledge of its management and use have rarely followed direct *P. juliflora* to remain under-utilized and unmanaged (Pasiecznik *et al.,* 2003).

P. juliflora is a paradoxical exotic invasive plant in Ethiopia among the agro-pastoralists, pastoralists, mechanized farmland owners, and economists and ecologists (Abiyot Berhanu and Getachew Tesfaye, 2006). This species is now commonly found in Afar National Regional State (ANRS) and spreading to Oromia, Amhara, Somali, and Diradawa regions. Nowadays, it is repeatedly reported to be one of the invasive and problematic trees in the Afar region as well as in the country (Rezene Fessehaie, 2006; Shetie, 2008). Local residents complain about its aggressive colonization of useful habitats and its negative effects on animal and human health. Conversly, in recent decades *Prosopis* has quickly become one of the most important tree genera in many tropical and subtropical regions of the world (Geesing *et al.,* 2004). Provide a comprehensive account of uses of *P. juliflora* as they are capable of growing on degraded land under arid conditions and being a multipurpose tree (Pasiecznik *et al.*, 2001).

Many people in the drylands are calling for its eradication. Yet experiences from other countries show that *P. juliflora* is extremely difficult and costly to eradicate once it takes root. In Ethiopia, the socio-economic and ecological impacts of *P. juliflora* are becoming serious and controversial. Some groups of people are needy for the survival of this multipurpose tree/shrub species whereas other groups are desperately looking for systems that can eradicate the species from the area. This has led to conflicts of interest that are fuelled partly by the general lack of quantitative information on the determinental impacts of *P. juliflora*. Such conflicts are compounded by a general complexity of making such an impact evaluation. For that reason, there need to look for an urgent approach focusing reasonable and sustainable controlling alternatives, particularly in developing countries like Ethiopia, where there is no considerable capability in handling such challenges (HDRA 2005a; HDRA 2005b; Mwangi and Swallow, 2005) and support rural livelihoods in the dry lands through making use of *P. juliflora* as a valuable resource. These approaches will in the long term significantly contribute towards controling its spread.

Eventhough these divisive issues do exist in Ethiopia particularly in Afar region, the economic value of the plant

and related outcomes are not well documented. Thus, this study focused on Afar National Regional State where the plant has created many social and environmental impacts and thought to be the first place of introduction to be part of the on-going effort in developing cost-effective, socialy acceptable and ecologically sustainable approach for controlling the spread of *P. juliflora* through providing scientifically verified information.

Therefore, the general objective of the study was to provide potential support for decision makers in choosing appropriate controlling and management strategies through analysis of impacts of economic exploitation of *P. juliflora* towards controlling the existing expansion rate in Gewane Wereda, Afar regional state. The specific objectives of the study were to: (1) analyse the economic contribution of *P. juliflora*; (2) compare the net value among other major alternative land uses with and without the presence of *P. juliflora*; (3) determine the extent to which an economic exploitation reduces the existing *P. juliflora* spread and present policy recommendations.

2. Materials and Methods

2.1 Study area

This study was conducted in Gewane district of Afar Regional State of Ethiopia. Gewane Wereda is located in the Middle Awash Valley; Zone III of the Afar National Regional State located at a distance of 370 kms from Addis Ababa towards East along the main road that connects Addis Ababa to port Djibouti. It is also located between degrees 40° 43′ – 41°15′E and 9°71′ – 11°20′N (Figure 1). From the total area of Zone three of Afar Region 1,680,057 hectares, Gewane Wereda covers 826,573 hectares, constitutes 49.20% of the total land area in Zone III of Afar Regional State (Abdurehman, 2004). The study area lies at an altitude of about 626 meters above sea level (MoA, 1997). The Wereda is administratively divided between 8 rural and 2 urban kebeles/PAs.

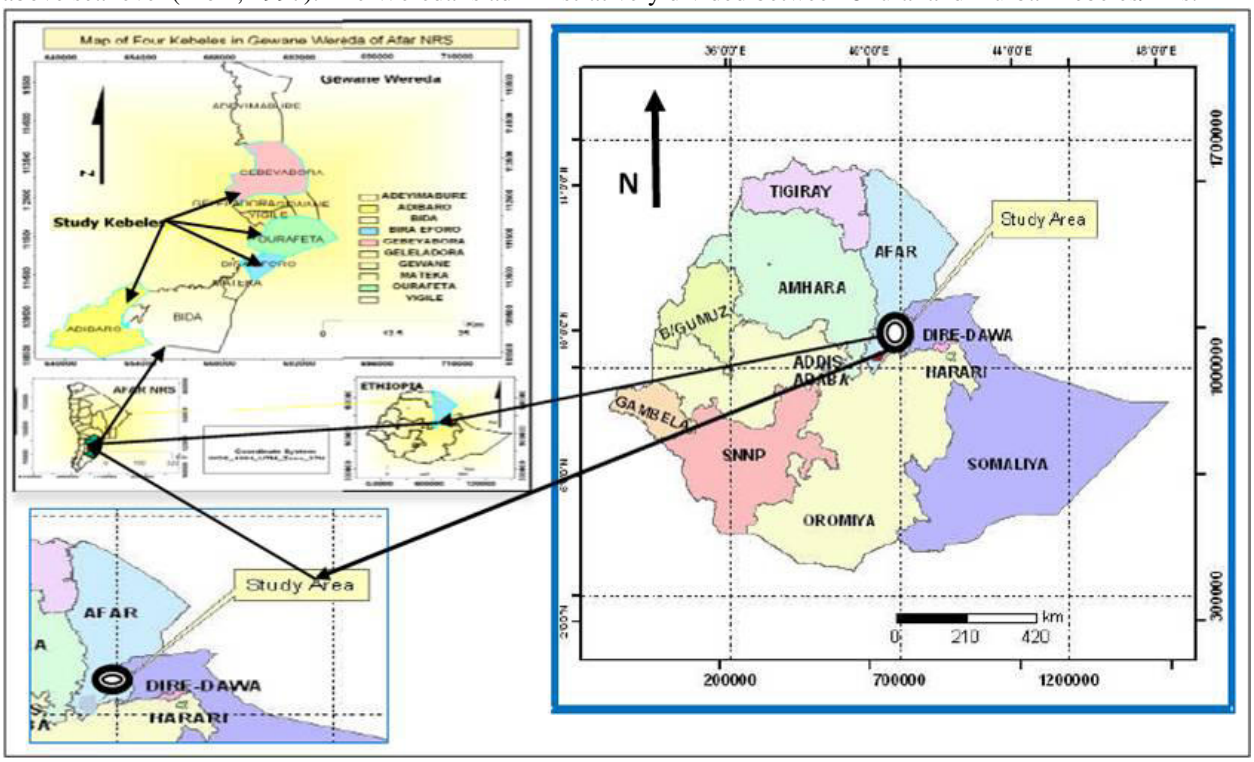

Figure 1: Map of the study area (Source: FARM-Africa, 2009)

The Physiography is mostly plains and undulating side-slopes with 0-8% slopes (MoA, 1997). The study area is characterized by high temperature. According to forty-years 1967 to 2007 meteorological data obtained from WARC, WAS (2010); temperature varies from mean monthly minima of 14.8 to 23.6 ºC to mean monthly maxima of 31.3 to 37.5 ºC. Mean relative humidity varies from 38.9 % to 59.3 %. Usually, the mean annual precipitation is less than 600 mm.

Vegetation type composed of woods or bushes found along the major perennial rivers, mainly the Awash River. Gewane Wereda is largely covered by bushes, shrubs and predominantly swampy vegetation. Nowadays, most lands with indigenous vegetation invaded and replaced by *P. juliflora.* The rest is being a mosaic of other forms of riverine forest. The majority of the areas away from the River are covered with scattered clumps of short and thorny acacia trees and small bush shrub and scrub of different species with few grasses (Hailu Shiferaw *et al*., 2004). The agro-pastoral way of life in the Wereda determines the pattern of settlement.

The 1996 Centeral Statstics Census (CSA) result exhibited that the population sizes of Gewane Wereda was 31,313, out of which 17,167 male and 14,146 female from the total population 19% dwell in urban areas while 81% are rural residents. The report also revealed that an average family size was 5.7 individuals per household. According to the regional atlas in the year 2006, Gewane has the least density of livestock in the region with an average of less than 50 livestock per one square kilometer of land /50 per km^2/.

2.2. Study species

Prosopis juliflora was described by De Candolle under the name of *P. juliflora* (Havard, 1884). The specific name *juliflora* comes from julus meaning whip-like; referring to the long inflorescence, and flora being flower (Havard, 1884). Its respective varieties and forms were taken from Burkart (1976) and Díaz Celis (1995).

The genus *Prosopis* was systematically described and organized by Burkart (1976) in to five sections that together contains 44 species and with many varieties (Pasiecznik *et al.,* 2001). *P. juliflora* belongs to the family Leguminaceae (Fabaceae) and subfamily Mimosoideae, particularly closely connected to *P. pallida*. It is a tree or shrub sized woody perennial plant found mainly in the arid and semi arid regions (Pasiecznik *et al.,* 2001; Geesing *et al*., 2004). The plant is predominantly xerophilous spiny and sometimes unarmed evergreen tree with height of 3-15 meters depending on genetic difference and other environmental factors, but under favorable environmental conditions may reach up to 20m (Pasiecznick *et al.,* 2003). *P. juliflora* landraces often have multi-stemmed, coppiced and prostate shrub forms with long branches and a crown that even touches the ground and have erect, flat topped and decumbent tree forms. *P. juliflora* produced coppices except those stumped at 10 cm below the ground (Hailu *et al*., 2004).

Documentation is lacking regarding when, from where, how and by whom *P. juliflora* was introduced to Ethiopia, but some speculations exist. The earliest time of notice is believed to be in the late 1970s (Hailu Shiferaw *et al.,* 2004; Rezene Fessehaie, 2006). It was planted over a large area of the Middle Awash rift valley by local people in 1980s around their village. Since 1980s the plant has spread rapidly in eastern Ethiopia. The spread of *P. juliflora* in Ethiopia has increased in the last decade, both in terms of area coverage and plant density (Demissew Sertse, 2005). According to FRC report to FARM-Africa, in Afar, more that 11 weredas were already invaded so far (Figure 2).

2.3 Data Source

In this study, to comprehend the distribution and rate of invasion of *P. juliflora* and the socio-economic impacts of the plant, both primary and secondary data sources were required. Primary data were generated from the analysis of satellite images, participatory resource mapping, and responses of the local people, agricultural experts and development agents who involved directly or indirectly with the plant. On the other hand, secondary data were obtained from the study area satellite images and topographic maps alongwith conducting extensive literature review to cover issues in relation to the study.

2.4. Methodology

The study employed satellite image and socio-economic data collection and analysis in order to address its objectives. The study involved a combination of six major methodological approaches: household interview, group disscusiion, participatory resource mapping, field observation, geographical information system and secondary data analysis. In addition, as the research implimented different valuation methodologies, carfeful identification and application of decads data were implimented to reduce critical limitations associated with valuation theory. Moreover, careful design and pretesting of questionnaires were applied to work out those challenges.

2.4.1. Study design and data collection process

The research was conducted from November 2009 to end of November 2010. At the outset an extensive literature review was conducted to cover issues related to the study to determine how the proposed research can be handled and carried out.

The topographic map with a scale of 1:50,000 were obtained and the study area was delineated. The concrete research work started with the preparation of a list of potential impacts of *P. juliflora* compiled from various sources. Consequently, in the field the actual benefits and costs encountered were ticked off from the list.

To support selection of sample plotes and representative householdes, the recently available and analysed ASTER satellite image mapes dated 2007 were acquired from FARM-Africa with special permission (Figure 2). The maps were used to extract meaningful preliminary information about LULC information's or extent of *P. juliflora* invasion. These maps were groundly verified and crosschecked using Garmin *GPS72*. Moreover, the maps were supported by participatory vegetation mapping on the nature of distributions to consider local people views and stalkholders evidences from (Figure 2).

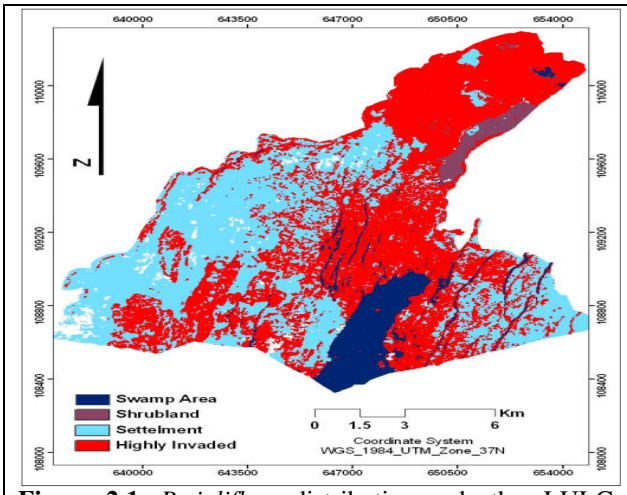

Figure 2.1: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

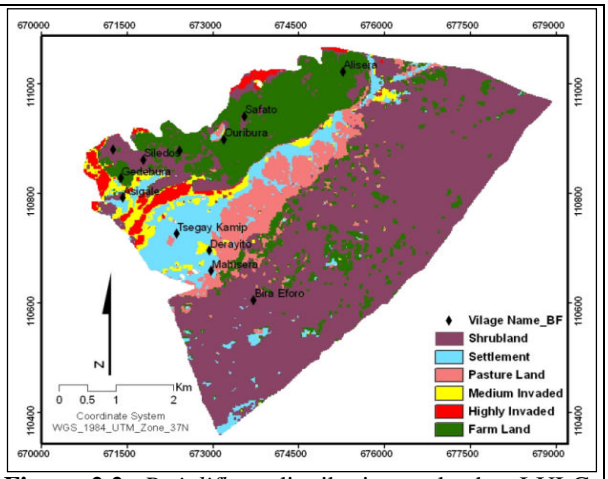

Figure 2.2: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

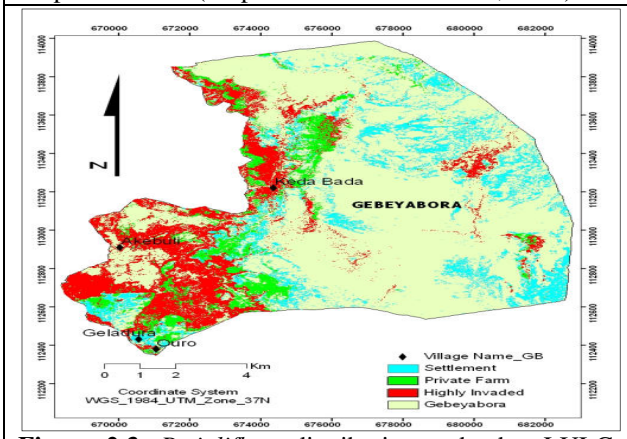

Figure 2.3: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

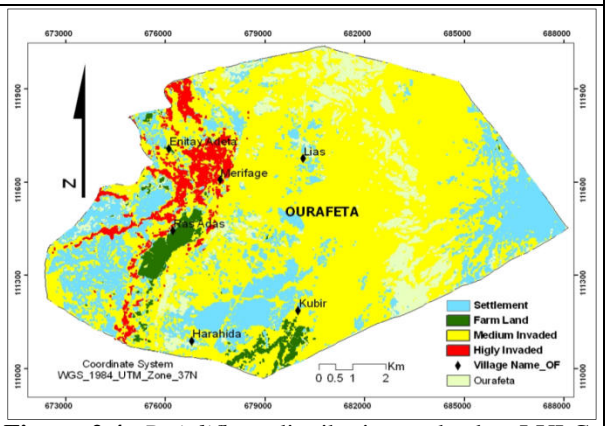

Figure 2.4: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

Figure 2: *P. juliflora* distribution and other LULC Map of the study area (Modified from FARM-Africa, 2009).

2.4.2. Sample Size and Sampling Technique

Depending on the severity of the invasion, the districts were classified into highly, moderately and sparsely invaded areas (Figure 2). Subsequently, four representative kebeles from the total of ten kebeles were purposefully selected (Figure 2). Consequently, major occupational categories were identified based on the information obtained from of each Kebele's administrative records. Accordingly, each of the interviewed households from four different occupation groups could be further recategorized in to three *P. juliflora* exploiter group based on their status of market orientated explitation. These extra classifications were made based on the assumption that direct and immediate benefit and, scale and purpose of exploitation have had immense effect on people's perception on the plant and in achieving controlling and management actions (Figure 3).

Exploiter group (categories)

- *Commercial exploiters*[1]
- *Subsistence exploiters*[2]
- *Intermediate exploiters*[3]

Moreover, the representative sample households were allocated through exercising standardized allocation of households from different occupation and exploiter group who populate in different extent of invasion. Simple random sampling technique was employed for each combination of occupation with exploiter groups to select a

[1] Those who sales most of what they exploit; those who directly involve in *P. juliflora* related business; heavily engaged in *P. juliflora* exploitation activities and their source of income is heavily depends on *P. juliflora.*

[2] Those who consume most of what they exploit and there might have marginal or no production for sale or else; those marginally involve *P. juliflora* related business; insignificant or no engagement in *P. juliflora* business and their source of income is not or marginally depends on *P. juliflora*.

[3] Those who exploit partly for sale and partly for household consumption; those partly involve in *P. juliflora* related business; partly engaged in *P. juliflora* exploitation activities and their source of income is partly depends on *P. juliflora.*

total of 64 subsistence and 18 intermediate exploiter pastoralist sample households out of 1502; 6 intermediate and 18 subsistence exploiter agro pastoralist sample households out of 420; 12 commercial charcoal maker sample households out of 176; and 6 subsistence exploiter traditional mat maker sample households out of 82 households' **(Figure 3)**.

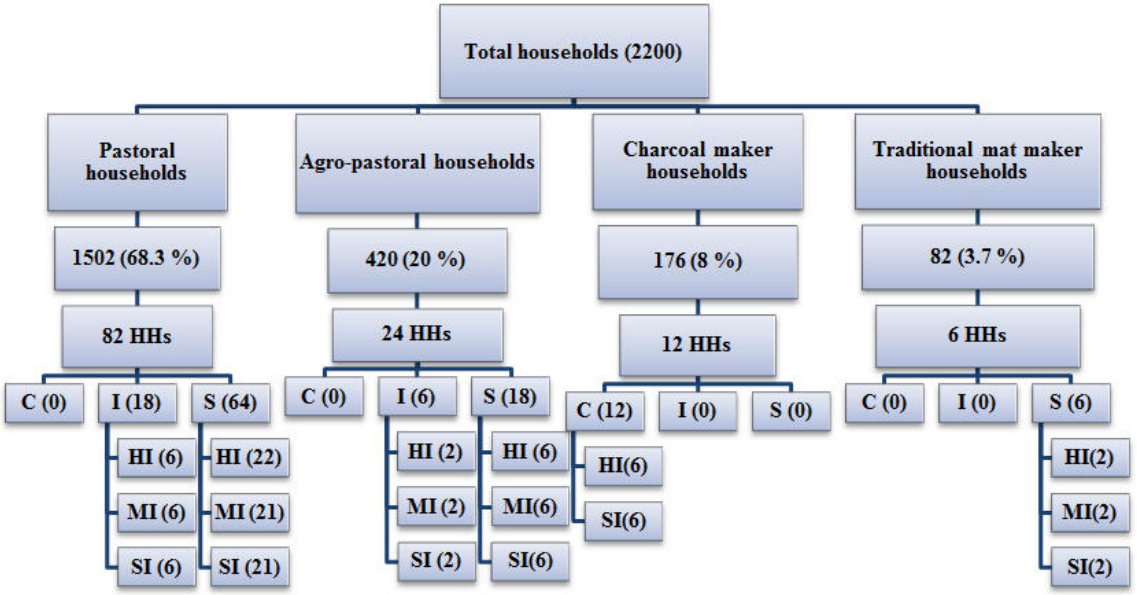

Figure 3: Flowchart of Sample Size and Sampling Technique
Note: HHs=households C=commercial I=intermediate S=subsistance HI=highly invaded MI=moderately invaded SI=sparecly invaded

2.4.3. Valuation of Components of Impacts in Annual Economic Cycle

2.4.3.1. Prerequisite Stages of Components Valuation

It is normally difficult to calculate the whole range of values needed in a TEV analysis, and this may even be meaningless from the outcome point of view (Abeygunawardena *et al*., 1999; Bishop, 1999). A more realistic approach is to focus on the dominant impacts, i.e impacts that were tangebly existing and purely identifying in the minds of the local people along with describing the remaining impacts under study in qualitative terms, without further monetizing. However, great level of care were taken to ensure that all relevant impacts are counted in as well as quantitative factors do not dominate important qualitative factors in decision-making.

The value of direct costs and benefits was estimated in Ethiopian Birr[1] for products harvested for direct use (both subsistence and trade) as well as for direct losses associated with *P. juliflora* invasion. For those impacts that would questionably difficult to be come up with monetized value were only qualitatively explained. Therefore, respondents were only requested to rate their opinion. The answers were then statistically analyzed on a normative scale and described without further monetizing. For the valuation point of view it can thus be concluded that a monetary value would in this case probably be fairly neglible, a zero value was therefore included into the BCA shown in table 2 and appendex I. The situation was revised so as to cover the hypothetical scenario that *P. juliflora* had been eradicated from the study area.

Three different Scenarios were considered for appraisal of substantial impacts of *P. juliflora*. Comparison analyses were conducted for main benefit/cost categories.

[1]At the time of the study, the average exchange rate was approximately 1US$ = 13.50 ETB.

Table 1: Scenarios considered for impacts comparison

Scenario	Considerable LULCs	Description	Remark
Scenario A	*P. juliflora* Exploitation	The current situation of *P. juliflora* externalities under market oriented and without market oriented economic exploitation	Existing scenario
Scenario B	Livestock Production	The current situation of non-*P. juliflora* land uses under the presence of *P. juliflora* externalities	Existing scenario
	Crop Production		
	Swampy Grass Exploitation		
Scenario C	Livestock Production	The current situation of non-*P. juliflora* land use under the absence of *P. juliflora* externalities	Hypothetical scenario

Comparison analysis of a TEV synthesis including main benefit/cost categories for Scenarios was calculated using Pierce's equation and the result is presented in section 3.3 table 2 and appendex 2. The argumentation on what would happen without *P. juliflora* was described based on the earlier literatures, group discussion, household surveys, field observation, and satellite images.

In a circumstance where there was no *P. juliflora* at some twenty years ago the practice of crop production in the study area was only restricted to large scale state owned farm operations. In this regard, FARM-Africa (2009) indicate that owing to the government's rural development strategy, through farmers training and providing technical support to the community, the number of small scale farmers has increased from only 5 individuals some seven years ago to 850 now. Thus, crop production is becoming an important source of income and food in the area in the last few years. Therefore, it is unrealistic to deduce values which are anthropocentric in nature in a situation where there is limited time frame and practical knowledge to observe variability in comparing Scenario B and Scenario C of crop production as economic values are the worth of goods or services to an individual or a group of likeminded persons in a given context. Thus**,** Scenario C of crop production was omitted in comparison analysis.

Similarly, even though the invasion of *P. juliflora* has been increased dramatically in the study area including natural swampy grass land where predominately harvested by traditional mat makers, the net effect of *P. juliflora* on this particular land use were not considered as a trouble in the view of the respondents. Accordingly, the values of items from natural swampy grass land were not significantly affected, as a consequence the values were assumed unchanged. In view of that Scenario C of natural swampy grass land was also omitted in comparison analysis.

Therefore, the only scenario considered for comparison analysis in Scenario C was livestock production and it was assumed that all items obtained from *P. juliflora* would be purchased.

2.4.3.3. Opportunity Costs of Land and Household Labor

Both household labor and land values might present high levels of opportunity costs in many geographic locations. However, the land tenure and ownership system in the study area makes land a less valuable commodity in an increasingly communal land-privileged social system rather than private land-privileged social system. At this juncture, the opportunity costs of land were not assigned values since the observed social and cultural norms of the area shows that the rate at which individual farmers would be able to lease out all or parts of his land is mainly determined by the community especially by clan leaders. Moreover, the extent of the area which an individual would be able to use particularly for grazing was complicated to estimate in terms of individual basis these derived the study to exclude the opportunity cost of land.

Input of household labor is a component that needs to be factored into any economic valuation. Opportunity cost of household labor is calculated as a function of time (Soumya Mohan, 2004). Considering all economically active population in the study area was affirmed equally productive. Thus, the time estimates were converted in to labor costs through the standard cost of labor in the study area, where **OCHL= *f (t*labor rate)***, where **t** is the time spent in each of four different occupation. No new valuation methods were introduced for the calculation of other Scenarios.

2.4.3.4. Computing Extent of Control through Economic Exploitation

The impact exploitation of *P. juliflora* on controlling invasion is computed from the area of land cleared or the number of *P. juliflora* stand removed through "allowing resprout" or "without allowing resprout", separately. Moreover, estimations were made from the local people's point of view on the exploitation verses controlling the expansion.

2.5. Economic Data Analysis

The method applied in this analysis is the conventional approach of CBA involving the calculation of Net Present Value (NPV). The NPV is derived by subtracting the sum of the Present Value (PV) of a cash flow of costs from the sum of the PV of a cash flow of revenues. Generally, an investment is accepted if the NPV is positive at a pre-selected discount rate. If a number of mutually exclusive options are being evaluated, the option with the highest NPV at a given discount rate is chosen.

$$NPV = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} \quad \text{----------(1)}$$

Explanation:

NPV = Net Present Value

t = the time horizon form year 1 to year n (in this study t=1)

B_t = total benefits in year t

C_t = total costs in year t

$\sum$ = a summation sign over the period of time

r = the interest rate or the discount rate, expressed as a decimal

Sensitivity analyses are important when evaluating the economic benefits of environmental goods in order to ascertain the extent to which these systems are susceptible to shifts in the prices of labor and market products. However, a majority of the surveyed households (89.5 %) in the study area reported that there was no specific factor to be the most restrictive aspect of managing these systems; even though charcoal and fuel wood were considered as the most economically important items of *P. juliflora*. Therefore, the attempted sensitivity analyses confirmed that these systems are rather economically stable, which did not dependent on any one item or factor, and that the respondents followed a customary approach for exploitation of *P. juliflora*.

2.6. Statistical Data Analysis

The data were analyzed using SPSS version 15 software programe along with MS-Excel 2007. All data were tested at 95 % of confidence interval. Moreover, land use/ land cover analyses were made using Arc GIS 9.2.

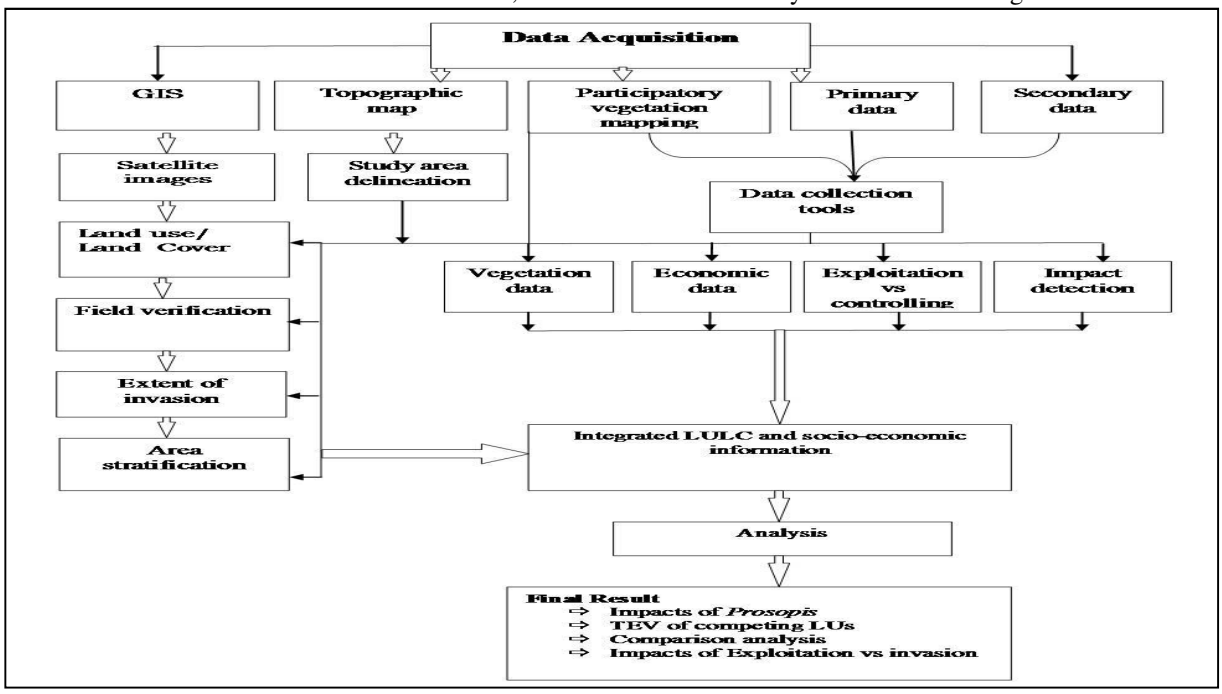

Figure 4: Flowchart showing the general study approach implemented in the study.

3. Result and Discussion

3.2. Determinental Perceived Impacts of *P. juliflora* in the study area

It is now close to two decades since *P. juliflora* were introduced in Gewane. Despite its stated benefits, portion of local communities bitter about its negative impacts while fractions appreciate. As the effect of *P. juliflora* to economic damage and benefit depends on the socio-economic environment of invaded land and its potential alternative uses (Geesing *et al*., 2004). Although *P. juliflora* is affecting the overall ecological and socio-economic environment of the study area, the local people are aware about its benefits. Figure 5 identifies main determinental impacts of *P.juliflora* from the community viewpoints in the study area.

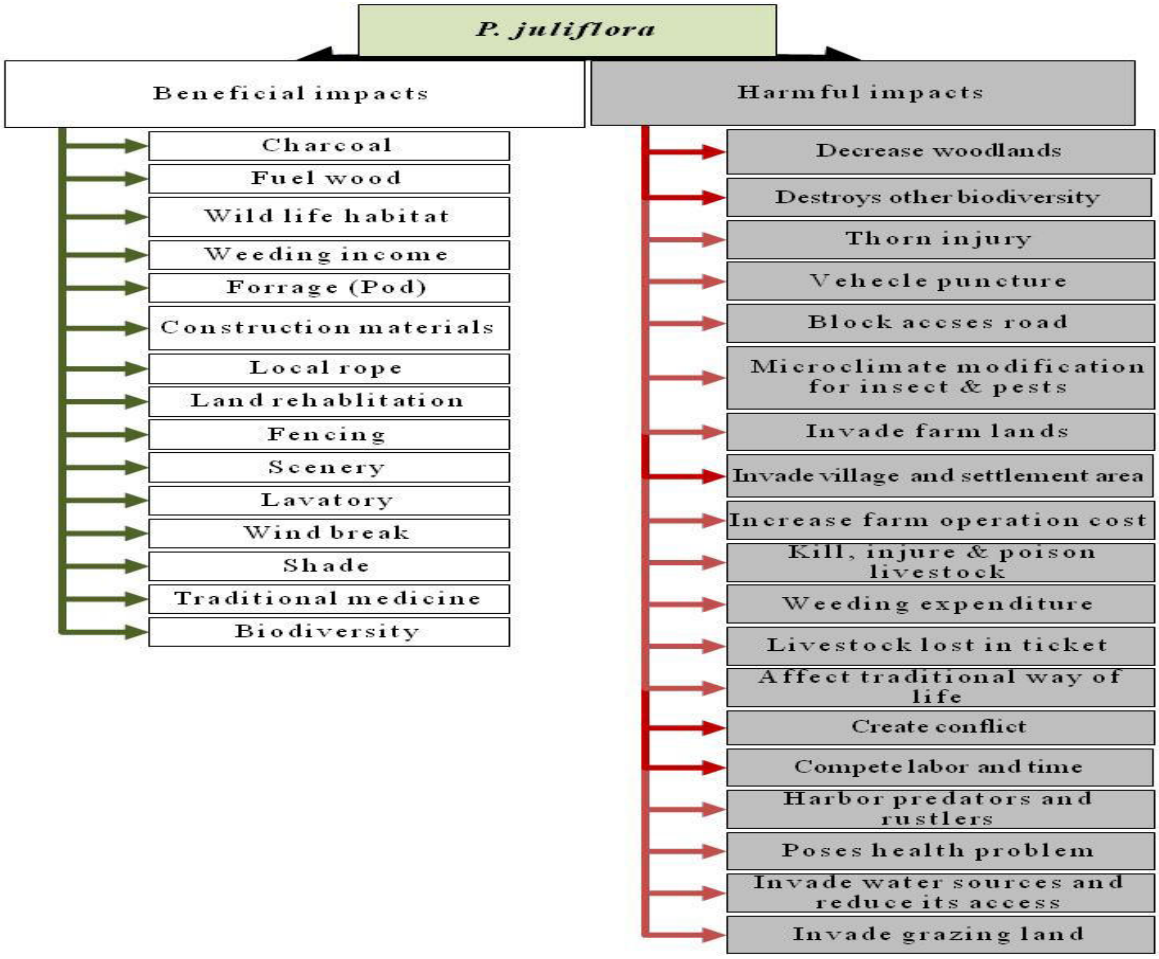

Figure 5: Community viewpoints of main impact of *P.juliflora* in the study area.

The overall evaluation indicated that even though the wide advantage and disadvantage of *P. juliflora*. It was found that 83.3% of commercial put *P. juliflora* under beneficial species. While 65.9% of subsistence exploiters stated as undesirable, which shows there is variability in reaction among exploiter categories. It was also stated that 58 % of subsistence exploiters were willing to contribute a maximum of six goats annually to help support eradication of *P. juliflora* from invaded areas. Whereas 83.3 % of commercial shown no willingness. These indicated that there were conflicting attitudes among the local people as almost all would like to gain more and expend less to *P. juliflora* which might in turn make any eradication activity difficult and complicated. Alternatively, 88 % of respondent stated they are willing to learn new method of using and controlling *P. juliflora.* Therefore, it is an indicative opportunity for the government and any development agents who are planned to implement new methods of exploitation and, controlling and management of *P. juliflora* in the study area. Hence, the dilemma still exists without clear decision or management plan is available.

3.2.1. Perceived Beneficial Impacts of *P. juliflora*

The respondents during the household surveys were invited to state *P. juliflora* by rating each of the considered beneficial impacts. The statistics was recorded on a scale from "best" to "least"; coded from +4 to 0, respectively. According to the respondent's fuelwood, forage, wind break and livefence were stated as top four ranking use values in the same order**.** Commercial and intermediate exploiters put charcoal on top; while subsistence exploiter put forage on top, since the formers directed at marketable products while the latter focus on subsistence. According to Mwangi and Swallow (2005), people's perceptions about invasive species depend on the economic level of individuals and their livelihood strategies.

The overall result shows that fuelwood (87.9 %), windbreak (85.5 %), and fodder (76.6 %) were mentioned as top frequent use items. The reasons for these are the indigenous plants that were used for firewood and fodder by the local people has been replaced by *P.juliflora*. Saxena and Venkateshwarlu (1991) in India; Díaz Celis (1995) in Peru; Lea (1996) in Haiti; Varshney (1996) in India; Shetie (2008) in Ethiopia, recorded high levels of uses for the stated items.

3.2.2. Perceived Harmful Impacts of *P. juliflora*

The respondents were also invited to state negative impacts of *P. juliflora* by rating each of the harmful impacts considered. The statistics was recorded on a scale from "Severe" to "least"; coded from -4 to 0, respectively.

According to the overall analysis respondent's response: destruction of biodiversity; kill, injur, poison and lost livestock in thicket; invasion of rangeland; and woodland encroachment; were stated as top four ranked harmful impacts, in the same order. While invade village and settlement area; mechanical injuries of human; hosting harmful insects and pests; and puncturing vehicle tire were the least four ranking negative impacts**.**
When we look at the overall frequency of harm occurrence: mechanical injuries of human by sharp and poisonous thorns (100 %) and formation of impenetrable thicket that blocked access roads and hinder easy movement (100 %) were frequently occurred**.** Related problems were also faced elsewhere (Al-Humaid and Warrag, 1998; Gavali *et al*., 2003; Nakamo *et al.*, 2003; Esther and Brent, 2005; Zeraye, 2008) Perhaps due to these and other reason, more than 90 % of the respondents would prefer eradication of *P. juliflora* either partly or completely from their sites.

3.3. Presentation Scenarios Based on the TEV

The present TEV study has been calculated from a local community valuation angle. As shown in table 2 and appendix I, the overall analysis of monetized impacts of *P. juliflora* shows that the calculated NPV still proved profitable. However, the result still confirmed negative NPV for intermediate and subsistence exploiter categories.

Moreover, the analysis of cost and berefit of *P. juliflora* revealed that subsistance exploiters shared only 4 percent of the over all benefit obtained from *P. juliflora* while sharing 47 percent of the overall cost. Commercial exploiter category shared 81 percent from the overall benefit while sharing only 28 percent the overall cost. This creat a significant perceptional difference among exploiters group and leads to conflict of intereset in implementing proper controlling and management practice (Figure 6).

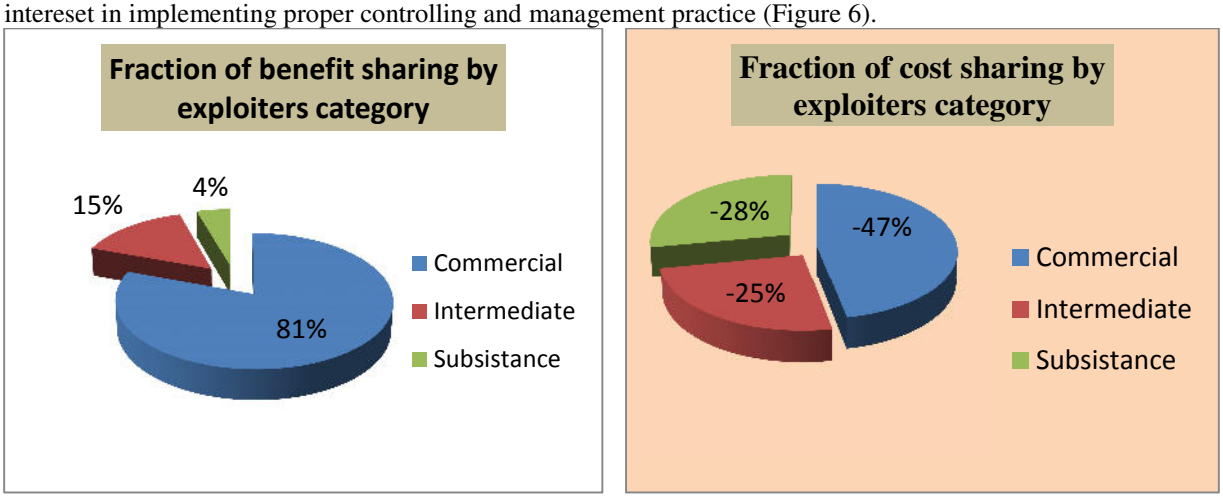

Figure 6: showing percentage share from total benefits and loses among exploiters categories

Moreover, except scenario B of swampy grass land and scenario C, in all land uses of scenario A and B, the overall mean impacts of unmonitized qualitatively explained values were negative (Table 2). The study further identified that in scenarios B of livestock production only 5.6 % the value from Scenario C would be attained, in which 94.4 % of values have forgone. In other word, the TLU in Scenario C was faund 81.9 % higher than Scenario B, represented a situation far from ideal (Table 2). Moreover, the over all qualitatively explained value confirmed that livestock production without *P. juliflora* (Senario C) got higher value than with the presence of *P. juliflora* (Senario B). This indicated that livestock sector is the most unsecured production system with impacts of *P. juliflora* (line B of figure 7). Similarly, over all qualitatively explained value of *P. juliflora* among exploter category indicated that positively progressive from substance, intermediate and commercial exploiter (line C of figure 7).

The result confirmed that there has been a dramatic decline in livestock holdings per household associated with shrinkage and degradation of grazing lands; death and missing of livestock; and increase in frequency of recurrent droughts in which becomes enormously challenging as the invasion increases which brought negative impacts on pastoral livelihood. Subsistence exploiters, who relatively have less diversified sources of income, lost much than those of other exploiters category. The reason may be explained as such households who lost more and gain less may be their rigid traditional ways of living, i.e. pastoralism. Wide ranges of impacts of *P. juliflora* has a on the lives and livelihoods of the pastoralists also indicated by (Geesing *et al.,* 2004; Esther and Brent, 2005; Tabosa *et al.,* 2006; Dubale Admasu, 2006).

Table 2: Monetized TEV and normative statistics of interviewed HHs of comparative LUs.

Scenarios	Land uses	Number of household considered		Monetized TEV in ETB	Overall mean of qualitatively explained values	Optional value	Bequest value	Existence value	Remark
Scenarios A	*P.juliflora*	Commercials	12	19,021.5	-0.22	1.92	0.83	0	+ NPV
		Intermediate	24	-2649.5	-0.85	1.25	0.83	0	- NPV
		Subsistence	88	-8538.3	-1.51	0.3	0.18	0	- NPV
		Mean (124)		**2611.4**	**-0.63**	**1.16**	**0.61**	**0**	+ NPV
Scenarios B	Livestock	106		5880.47	-0.25	3.38	3.24	3.13	+ NPV
	Farming	24		3986.36	-0.06	3.54	3.13	0	+ NPV
	Swampy grass land	6		1052.97	+0.60	2.11	2.1	0	+ NPV
Scenarios C	Livestock	106		**105,680.5**	+1.17	4	4	4	+ NPV

Optional, bequest and existence values can effectively be defined only from surveys of people's preference about their Willingness to Pay (WTP). However, such approaches may be difficult to apply in developing countries due to their high data requirements (Camille Bann, 1997). Therefore, the respondents were only requested to state whether the optional, bequest and existence values in their opinion very high or least[1]. Moreover, overall qualitatively explained values for the percivebly identified impactes were also calculated from the respondent's score rate[2]. The answers were then *statistically analyzed on a normative scale*.

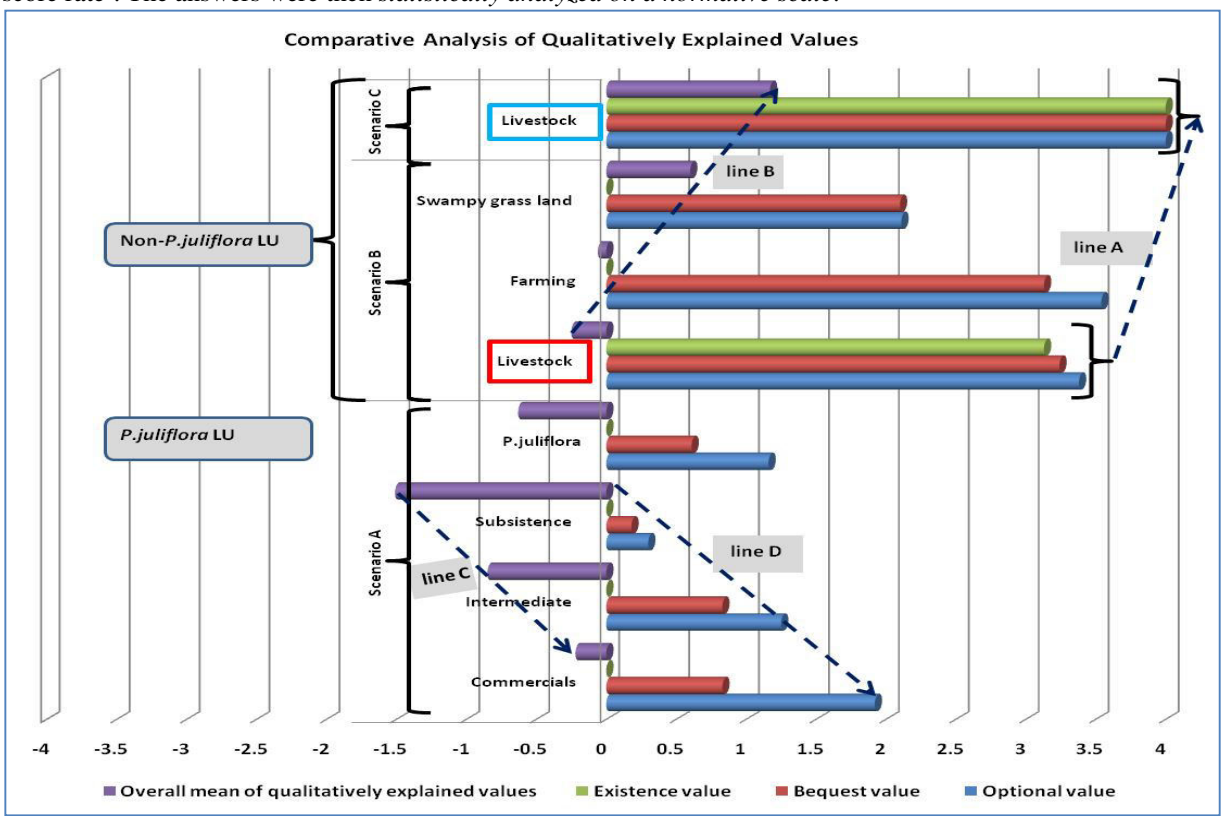

Figure 7: showing percentage share from total benefits and loses among exploiters categories

Consequently, 41.5 % of individuals in commercial, and 25 % of intermediate exploiters offer positive value with the overall moderate and least value for the options to be able to use *P. juliflora* sometime in the future, respectively. The reason may be their uncertainty about the future use value but believe it may be high.

[1] Respondents were only requested to state whether the optional, bequest and existence values in their opinion very high or least with the evaluation rate of very high, high, moderate, least, nothing and risky coded as 4 to -1, respectively.

2 Respondents also requested to state their openiopn on the unmonitized qualitatively explained values with the negative score value for harmful impacts (-4=severe; -3=very -bad; -2=bad; -1=fair; 0=least). And positive score values for useful impacts (4=best; 3=very good; 2=good; 1=fair; 0=least).

While 100 % of subsistence exploiters offer no value which is an additional low-grade placed on preserving *P. juliflora*. Furthermore, commercial and intermediate categories offer least value for conserving *P. juliflora* for future generations as a bequest, while subsistence category offers nothing. This is because the documented negative impacts and less consideration in value related to intangible benefits. Existence values are also difficult to measure as they involve subjective valuations by individuals unrelated to either of their own or others use, as it is derived from the pure pleasure in something's existence. However, several economic studies have shown the existence value constitute a significant percentage of TEV (Camille Bann, 1997). An individual in all of the exploiter households offer no existence value to *P. juliflora.* The overall result shows that *P. juliflora* has less optional, bequest and existence value as compared to other major land uses in the study area (Figure 7).

The study further revealed that the overall qualitatively explained value of livestock production without *P. juliflora* worth lower than that of with the presence *P. juliflora*. This may be because livestock production increasiningly become inadequate to cover households' expenditure for basic necessities as it heavily affected by the species.

3.4. Impact of Exploitation versus Controlling *P. juliflora*

Local people perceived that *P. juliflora* respond differently to controling methods; accordingly, the effectiveness of methods will vary depending on the size, density and location and types invaded LULC. Most individuals interviewed in the study area have undertaken some form of control intervention on land that is tangebly considered to be their belonging with and without the intention to economically use the harvested *P. juliflora* productes. Accordingly, all commercial exploiters and 70.8 % of intermediate exploiters involve in controlling intervention with the direct intention of economically use the harvested *P. juliflora* productes. While 92 % of subsistence exploiters involve in controlling intervention without the direct intention of economically use the harvested *P. juliflora* productes. Moreover, about 75% of the respondents reportedly allow resprout while involving in exploitation and controlling intervention. Wheras, only 6.5 % remove *P. juliflora* without allowing its regrowth (Table 3). This is becouse its labour demanding as well as fast invasion and regenerating nature with no promising reduction discouraged the local people to continue their intervention.

Table 3: Controlling intervention of interviewed HHs with respect to resprout.

Exploiters Category	N (124)	Mostly allowing resproute (%)	Rarely allowing resproute (%)	Not allowing resprout (%)
Commercial	12	83.3	16.7	0
Intermediate	24	66.7	20.8	12.5
Subsitance	88	76.1	18.2	5.7
Total	124	75	18.5	6.5

Moreover, respondents requested about their opinion on the current correlation between exploitation rate and invasion rate. Accordingly, all exploiter groups agreed that the current invasive rate was greater than exploitation rate at different extent.

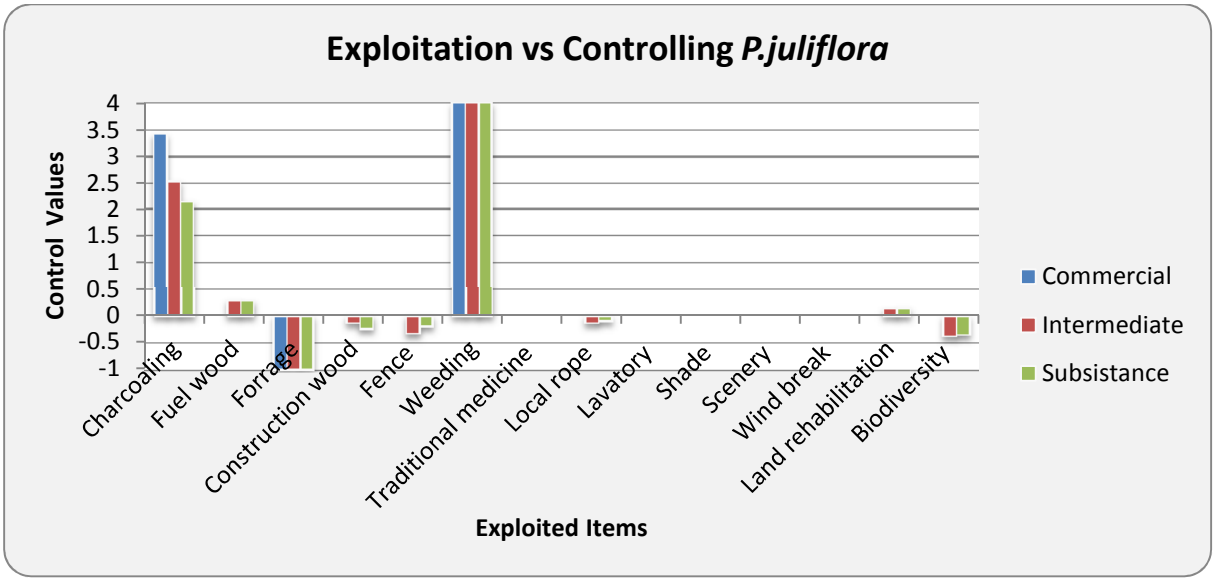

Figure 8: Opinion of respondents on impact of P. juliflora exploitation on controlling.

So far, charcoal production from *P. juliflora* has dual importance in the study area which is used as source of income and considered as an effective controlling method (Figure 8). It was estimated that an

individual commercial and intermediate exploiters cleared about 2.84 and 0.06 ha of invaded land, respectively. However, due to miss-implementation and its successful coppicing ability suppressing the role of charcoaling in controlling *P. juliflora*. Since, charcoal makers in the study area commonly cut the plant with allowing regrowth. Therefore, charcoal production is one of the feasible and even simpler approaches if and only if implemented under close supervision. Dubale Admasu (2006) cited in FARM-Africa (2008) also witnessed the invasion was worst after the removal of the mature trees for charcoal production.

Fuelwood has marginally positive contribution for controlling invasion of *P. juliflora* although their contribution still stated as least in controlling the invasion (Figure 8). 81.5 % of the respondents stated that they only collect *P. juliflora* branches from the ground which is left from charcoaling and clearing activities without any attempt to try to cut or uproot the plant since, showing fuelwood exploitation is not worth mentioning in controlling the spread.

Organized weeding is by far the best way the get rid of *P. juliflora.* However, weeding action is costy and mostly practiced by investors who intende to convert the invaded land in to commercial farm. Thus, this controlling practice is only limited to privately leased investemt lands in the study area.

All the remaining exploitable items were stated insignificant contribution in controlling its invasion. Thus, the overall result from the local people revealed that 85.9 % (Figure 8) of the respondents believed that exploitation of valuable product would either least in controlling or promote for further invasion due to its multiple, aggressive, heavily branched nature of the coppiced *P. juliflora*. All respondents stated its undesirable resprout nature and aware at least one method of avoiding regrowth, however, only 25 % of the respondents have experienced on removing the plant without allowing resprout, most whom were agro pastoralists (Table 3). From these findings we can conclude that the attempted controlling mechanisms practiced by the majority of the local people did aggravate rather than mitigate the invasion of *P. juliflora*.

Furthermore, the respondents requested to state the impact of engaging in different economic activities on controlling the current spread of *P. juliflora* with evaluation criteria (4=best; 3=very good; 2=good; 1=fair; 0=least -1=risky). Accordingly, the respondents stated the negative role of livestock production and neutral role of traditional mate making. Crop cultivation was stated as the best way to get rid of *P. juliflora* (Figure 9 and Table 4). This is becouse of frequent land preparation activity creates unsuitable situation for *P. juliflora* to coppice and prevent the seed from regeneration. But farming is only feasible on areas which are near to irrigation sources. This is also correlated with Hailu Shiferaw *et al*. (2004).

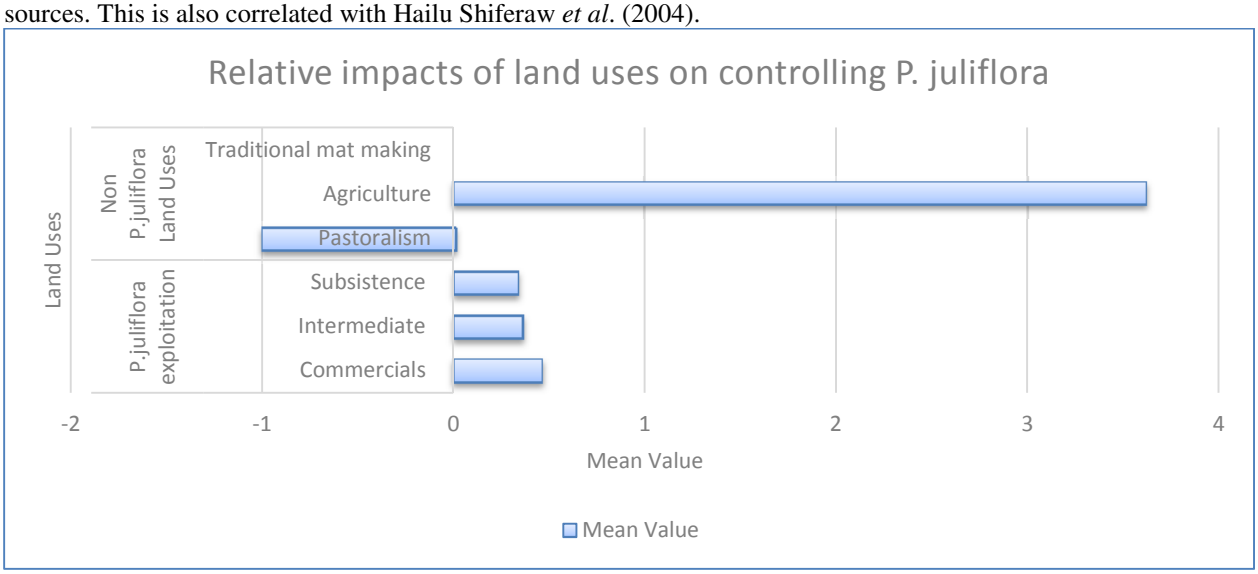

Figure 9: Showing the relative impacts of land uses on controlling *P. juliflora*

Table 4: Showing the relative impacts of land uses on controlling *P. juliflora*

Occupation	Respondents (N)	Average	Remark	Rank	% control	% neutral	% risky
***P.juliflora* exploitation**	Commercials(12)	0.46	Least	**2**	14.3	78.6	7.14
	Intermediate (24)	0.36	Least		15.8	67	17.3
	Subsistence (88)	0.33	Least		12.1	67.6	20.3
	Mean (124)	**0.35**	Least		**14.1**	**71**	**14.9**
Pastoralism	**106**	**-1**	**Risky**	**4**	**0**	**0**	**100**
Agriculture	**24**	**3.62**	**Best**	**1**	**100**	**0**	**0**
Traditional mat making	**6**	**0**	**Least**	**3**	**0**	**100**	**0**

4. Conclusion

The study confirmed an overall assumption that *P. juliflora* has different benefits and costs at different community group in Gewane. A TEV study for the study area shows, the benefits from *P. juliflora* were completely overshadowed by its detrimental negative effects. In the financial year 2009-2010 the NPV of *P. juliflora* for the area calculated were ETB +19,021.5, -2649.5, -8538.3 for individual commercial, intermediate and subsistence exploiters, respectively, with the overall mean value of ETB 2611.4 per household for impacts that could be monetized. *P. juliflora* negatively affecting intermediate and subsistence exploiter categories of pastoralists and farmers. The NPV of livestock production with the absence of *P. juliflora* was 94.4 % higher than the NPV with the presence of *P. juliflora* showing the persistence of the livestock sector is the primary victim of *P. juliflora* impacts and will in the long run be extremely costly for the populations living in the same condition. Individuals' perception of *P. juliflora* strongly influenced by how the beneficial effects of the species weigh against the less favored and costly characteristics and impacts of the species by their weighting of the costs against the benefits of living with *P. juliflora*.

The overall implication of exploitation verses controlling the current spread rate of *P. juliflora* in the study area was found least. Correspondingly, the overall correlation of land uses versus controlling *P. juliflora* indicated that the practice of Agropastoralism have had very good relative impacts on controlling *P. juliflora* with while sole pastoralism had risky practice of further invasion of *P. juliflora.*

Finally, Ethiopia is not the only country confronted with the problem of *P. juliflora* invasion. There are considerable methods and opportunities to learn from other countries where a *P. juliflora* threat has been turned into a resource through developing programs. Sole dependency on pastoralism has proved not feasible. *P. juliflora* is a low-investment abundant resource in the study area. Local people have to learn and take different measures to secure their livelihoods through diversification of income including economic exploitation of *P. juliflora*. Thus, it would be helpful encouraging scientifically verified proper utilization of the existing stands of *P. juliflora* while considering its unique characterstics of the species through extension, education, economic incentives and comprehensive legal framework.

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Appendices

Appendix I: ***Mean economic value comparison of magnitudes of impacts of* P. juliflora *among commercials, intermediate and subsistence exploiter category in 2009 – 2010.***

Monetized impacts of *P. juliflora*	**Commercial N=12**	**Intermediate N=24**	**Subsistence N=88**	**Total all group N=124**	**Percentage share**
***Prosopis* Benefit Items**	**Household Mean** (ETB)	**Household Mean** (ETB)	**Household Mean** (ETB)	**Total household Mean** (ETB)	**Percentage share of each benefit**
Charcoal making (exclude protector)	30,073.5	637.1	-	10,236.87	67
Fuel wood	2765.4	2134	1332.1	2,077.17	14
Produces pod for forage	30	272	254	185.33	1
Construction wood	6.25	18.4	9.95	11.53	0.00
Weeding income	3294	1728	-	1,674.00	11
Income from protecting charcoal maker	-	966.45	-	322.15	2
Fence	63	874.9	294	410.6	3
Traditional medicine	39.2	27.4	9.76	25.45	0.00
Local rope	358	21.2	21.25	133.48	1
Lavatory	41.6	38.5	21.9	34.00	0.00
Wind break	36.25	85.4	105.5	75.72	0.00
Total *P. juliflora* Benefit	**36,707.20**	**6803.4**	**2048**	**15,186.3**	**100**
***Prosopis* Cost Items**	**Household Mean** (ETB)	**Household Mean** (ETB)	**Household Mean** (ETB)	Total all group N=124	**Percentage share of each cost**
Tools and Equipment	-315.4	-66.33	-57.2	-146.31	1.16
Sacks	-2615	-55.4	-23.4	-897.933	7.14
Transportations	-6864.4	-107.6	-	-2324	18.45
Local duty	-239.2	-138.3	-	-125.833	1.00
Paid labor including guard	-1714.6	-9.3	-	-574.633	4.57
Theft of charcoal	-328.9	-80.96	-	-136.62	1.09
Livestock (death & lost showing identified symptoms) including Theft and Rustlers	-153.9	-5533	-8410	-4698.97	37.4
Labor on-duty	-4992	-2875	-1466	-3111	24.7
Labor off-duty (sick & taking care of sick)	-233.4	-358	-462	-351.1	2.79
Human health expenditures(injured, poisoned)	-116.25	-48.6	-19.6	-61.4833	0.49
Animal health expenditure (injured, poisoned)	-	-43.4	-48.4	-30.6	0.24
Weeding expense	-	-21	-16.5	-12.5	0.10
Miscellaneous: Puncturing vehicle tires, informal tax---	-112.6	-116	-83.2	-103.933	0.83
Total *P. juliflora* cost	**-17685.7**	**-9452.9**	**-10586.3**	**-12574.9**	**100**
Net present value	**+19,021.5**	**-2649.5**	**-8538.3**	**+2611.4**	

Appendix II: Conversion Factors to Estimate Tropical Livestock Unit equivalents.

Animal Category	TLU	Animal Category	TLU
Calf	0.25	Donkey (young)	0.35
Weaned Calf	0.34	Camel	1.25
Heifer	0.75	Sheep and Goat (adult)	0.13
Cow and Ox	1.00	Sheep and Goat (young)	0.06
Horse/Mule	1.10	Chicken	0.013
Donkey (adult)	0.70		

Source: Storck *et al.,* (1991)

Appendix III: Conversion Factors Used to Compute Adult-Equivalent (AE).

Age group (Years)	Male	Female
<10	0.6	0.6
10-13	0.9	0.8
14-16	1	1
17-50	1	1
>50	1	1

Modified from Storck *et al.* (1991)

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