Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.6, No.5, 2015
www.iiste.org

Impacts of Utilizing Invasive Prosopis juliflora (SWARTZ) DC. on Rural Household Economy at Gewane District, Afar Regional State, North-Eastern Ethiopia

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Abstract
Invasive species cause socio-economic and ecological impacts and are part of key challengers of global intervention. Prosopis juliflora, an evergreen tree/bush, is a powerful exotic invader in Ethiopia. The overall aim of this work was to assess the impacts of P. juliflora on household income share derive. This study was undertaken in Gewane district of Afar National Regional State. Total sizes of 124 sample respondents from different user groups living in 4 ranges of invaded kebeles were participated in this study. The research methodology primarily emphasized on analyses of the perceived economic values of the study sites. The study was also supplemented by secondary data from various sources. Accordingly, 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. The overall result shows that fuelwood, windbreak, fodder and fence were mentioned as top ranked items while mechanical injuries of human by sharp and poisonous thorns; formation of impenetrable thicket that blocked access roads and hinder easy movement; kill, injure, poison and lost livestock in thicket; create conflict; invades rangeland; decrease woodlands, and invade village and settlement area were among tope harmful items. The household economy shows that, the share of forest environmental income ranges from an average of 96 % among the commercial households to an average of -240 % among the subsistence ones. P. juliflora constituted about -25 % of the absolute total income for the intermediate households. The subsistence exploiter population group spent more than their absolute income as P. juliflora-related income, while for intermediate population group the P. juliflora-related income accounted for -25 % on average of all the income, which was only 10.4 % of what the subsistence exploiters lost. Therefore, exploitation of P. juliflora would give back expenditures and reduce burdens loaded in relation to P. juliflora impacts. For the study area the Gini coefficient for the absolute forest environmental income was 0.63 which was greater than twice the national average. The overall result from the local people revealed that 85.9 % of the respondents believed that exploitation of valuable product would either least in controlling or promote for further invasion. All respondents stated their awareness at least one method of avoiding regrowth, however, only 27.4 % of the respondents have experienced on removing the plant without allowing resprout, most whom were agro pastoralists.
Keywords: Prosopis juliflora; Impacts; Income; Utilization; Control.

1. Introduction

Prosopis species is one of the highly invasive plants in the world. Among the 45 recognized *Prosopis* species (Felker, 2005), *Prosopis glandulosa, P. velutina, P. juliflora and P. pallida* are reported to be generally problematic (Pasiecznik, 2001). *Prosopis juliflora (P. juliflora)*, an ever green tree native to South America, Central America and Caribbean was first introduced to many tropical areas in the 1970s and 1980s as a response to the global concern of deforestation, desertification and fuel wood shortages. It is fast growing, nitrogen-fixing and tolerant to arid conditions and saline soils (EARO and HDRA, 2005). *P. juliflora* is in IUCN's new list of 100 world's worst invasive alien species (Mwangi and Swallow, 2005) and its invasiveness is also factual from economic point of view because they are in conflict with other human land use (Geesing *et al.*, 2004).

In East Africa, *P. Juliflora* was introduced in the 1970s through collaborative projects involving local governments and outside agencies (Coppock *et al.*, 2005). In Ethiopia, it was first introduced in the Afar region in the 1970s by the Ministry of Agriculture from India in an effort to improve water and soil conservation and fight desertification (EARO and HDRA, 2005). Although *P. Juliflora, P. Pallida and P. Chillines* are present in neighboring Sudan and Kenya (Choge *et al*., 2007; Sallah and Yagi, 2011), only *P. juliflora* has been reported in Ethiopia. *P. juliflora* is having dramatic impacts across the landscape of the Afar region of Ethiopia; where, its spread and impacts on resources and has been ranked as one of the leading threats to traditional land use, exceeded only by drought and conflict (EPP, 2006). Nationally, *P. juliflora* has been ranked as the most problematic plant invader in Ethiopia (Tessema, 2007).

Conversely, in many countries where *Prosopis* species have been introduced to fight desertification, they are not particularly recognized for their economic value. In recent decades *Prosopis* has quickly become one of the most important tree genera in many tropical and subtropical regions of the world as a result of intentional or unintentional introductions (Geesing *et al.* 2004*). P. juliflora* is plant which often negatively

perceived having many potential commercial uses. It is as an economic resource as reported by Mwangi and Swallo (2005), Pasiecznik *et al.* (2001) and Pasiecznik (1999) have provided a comprehensive account of the generic uses of this plant. Being a multi-purpose tree, *Prosopis* could also play a leading role in the arid lands (Bokerzion 2008). These will have a great role to diversify income earning strategies as the rural households throughout the developing world via meeting their subsistence needs and generate cash income (Byron and Arnold, 1999; FAO, 2008; Kaimowitz, 2003; Sunderlin *et al*., 2005).

Prosopis invasions generate environmental, social and economic benefits as well as harm (Chikuni *et al.,* 2004; Geesing *et al.,* 2004; Wise *et al.,* 2012). This has led to argumentative issues surrounding the genus (Richardson 1998b; van Wilgen and Richardson, 2014). Some advocates promote it as a 'wonder plant' while others call for its eradication, or contrast its positive and negative aspects (Tiwari, 1999). As some believes, the economic damage or benefit of new *Prosopis* stands depends on the socio-economic environment of the invaded land and its potential alternative uses (Geesing et al., 2004). Thus, the issue of the usefulness of different *Prosopis* species versus their status as weeds is a matter of hot debate around the world (Pasiecznik *et al.,* 2001). Contrasting views, contradictory perceptions and unclear policies are limiting options for constructive dialogue between different parties. This is exacerbated by a general lack of knowledge on the foundatal impacts and effective management approaches (Shackleton *et al.,* 2014).

Many different approaches for managing and eradication of *Prosopis* have been tried out in many places around the world. In most cases the attempt has not been found very successful, and in some cases it has even made the situation worse (Habte 2000; Pasiecznik *et al.,* 2001; Geesing *et al.,* 2004; Shackleton *et al.,* 2014). It is not only for economic reasons that eradication of *Prosopis* may be inexpedient. It is conceivable that the short-term benefits of successful eradication could create additional problems that are worse over the long term (Geesing *et al.,* 2004). A successful option to control *Prosopis* is also to promote its heavy utilization (Felker 2003, 2004; Geesing *et al.,* 2004). In this regard, quantifying the relative and absolute contribution of environmental income to total income portfolios is important for understanding the livelihoods of rural people, the extent and determinants of poverty and inequality, the welfare implications of the degradation of natural resources, and for designing effective development and conservation strategies (Angelsen and Wunder, 2003; Jagger *et al.,* 2012; Oksanen and Mersmann, 2003 and Vedeld *et al.,* 2004). Overcoming current knowledge gaps in these areas requires moving beyond the current primarily case study-based state of knowledge on the importance of natural resources to overall livelihoods strategies.

The aims of this paper are thus to (1) identify and rate perceived impacts of *P. juliflora* (2) assess the impacts of *P. juliflora* on household income share derive, (3) estimate the impacts of *P. juliflora* on rural income inequality, (4) estimate impacts of utilizing *P. juliflora* on controlling the extent of invasion.

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.

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 Worer Agricultural Research Center (WARC), Worer Agro-Meteorological Section (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 Central Statistics 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/.

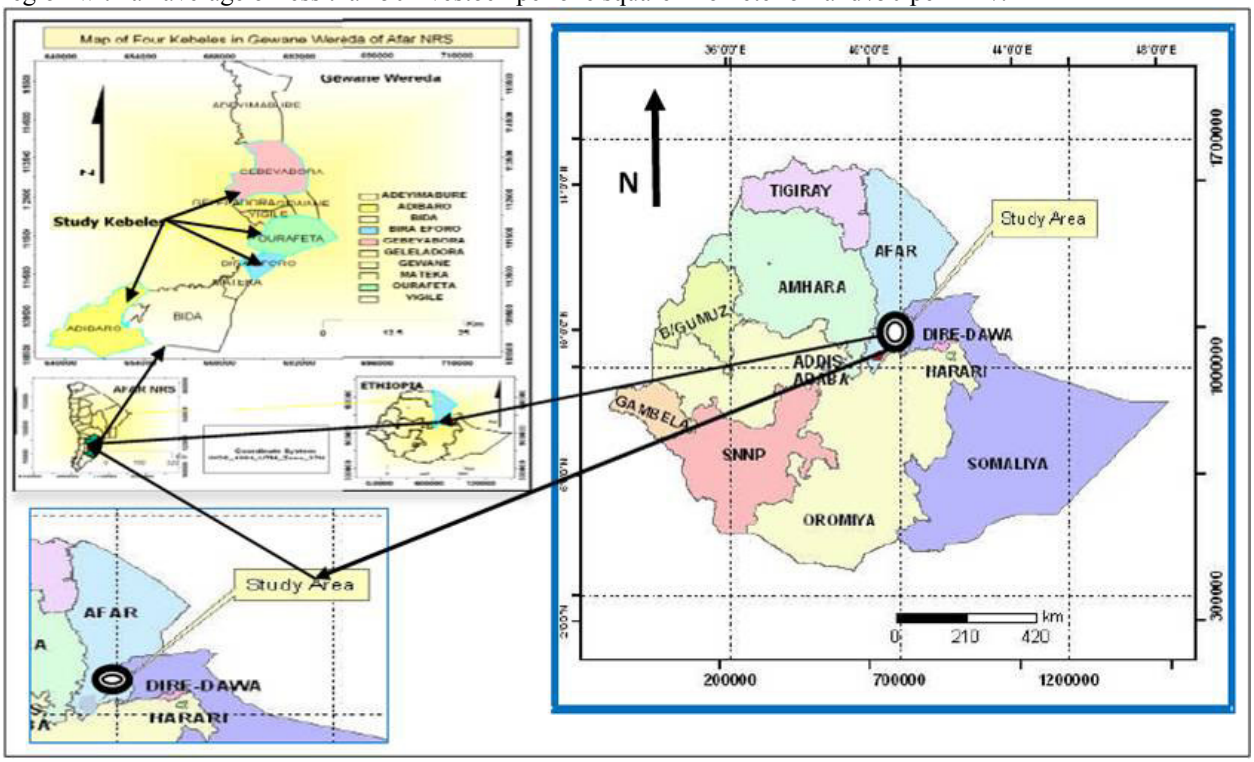

Figure 1: Map of the study area (Source: FARM-Africa, 2009)

2.2. Study species

Mesquite (*Prosopis juliflora* (Sw.) DC), one of the 44 species of *Prosopis*, is an evergreen leguminous tree, typical of arid and semi-arid regions, growing up to 10-15 m high. The crown is large and the canopy is open. Mesquite is a phreatophyte (Ecoport, 2010; Riveros, 1992). *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 Forest Research Center (FRC) report (2009) to FARM-Africa, in Afar, more than 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 along with 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. Evaluation of income primarily require identification of potential impacts of *P. juliflora*, therefore,

extensive review of literature was conducted to tap its potential impacts and pinpoint economic measurement. Moreover, the study was extensively supported by five methodological approaches: household interview, group discussion, participatory resource mapping, field observation and geographical information system (GIS). In addition, as the research implemented different valuation methodologies, careful identification and application of previous data were implemented to reduce critical limitations associated with valuation theory. Likewise, 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. To support selection of sample plots and representative households, the recently available and analyzed Advanced Space born Thermal Emission and Reflection Radiometer (ASTER) satellite image maps dated 2007 were acquired from FARM-Africa with special permission (Figure 2). The maps were used to extract meaningful preliminary information about Land Use/Land Cover (LULC) information's or extent of *P. juliflora* invasion. These maps were graundely 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 stallholders evidences from (Figure 2).

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.

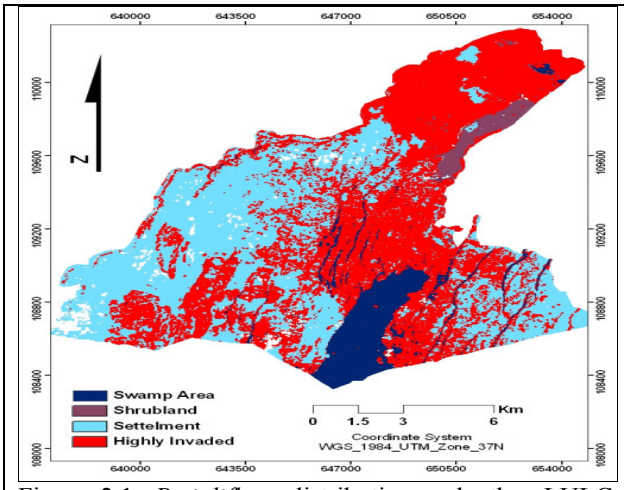

Figure 2.1: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

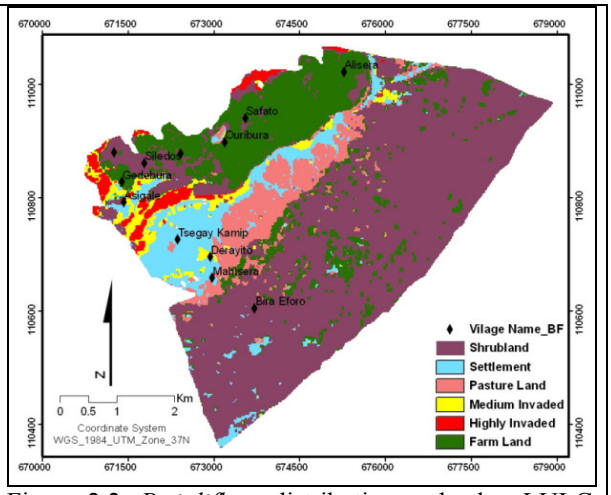

Figure 2.2: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

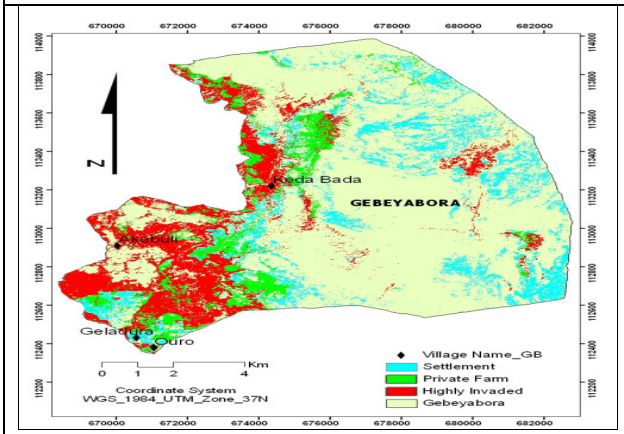

Figure 2.3: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

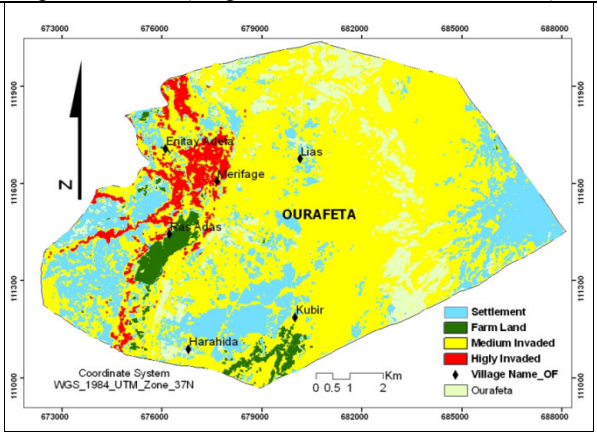

Figure 2.4: *P. juliflora* distribution and other LULC Map of Adibaro (Map source: FARM-Africa, 2009).

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 exploitation. 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 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).

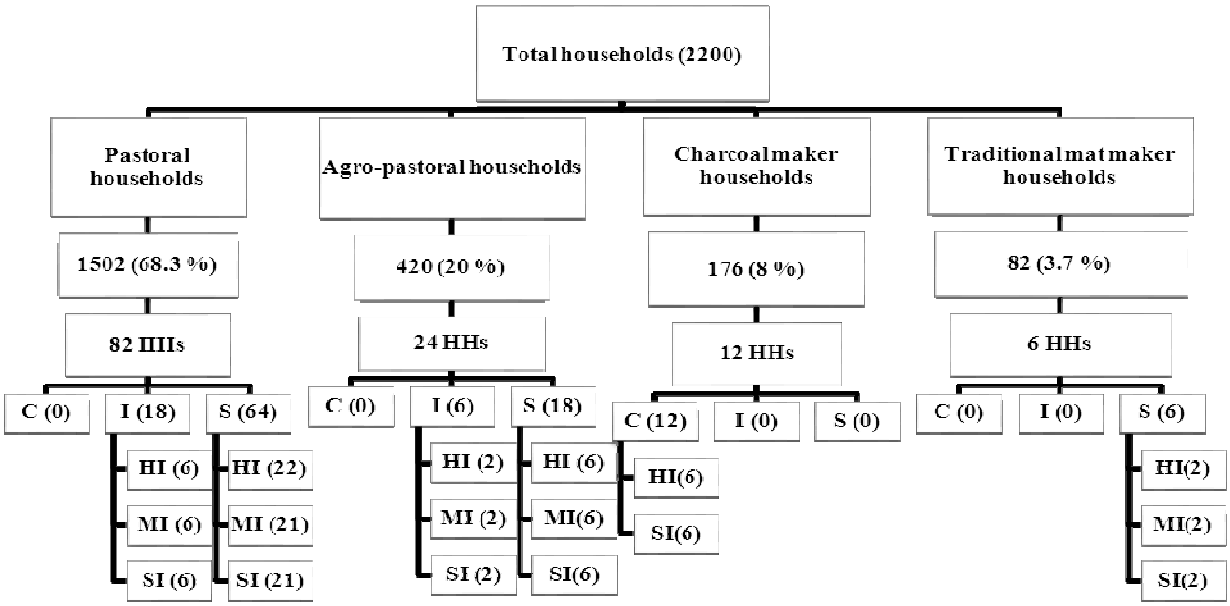

Figure 3: Flowchart of Sample Size and Sampling Technique

Note: HHs=households C=commercial I=intermediate S=subsistence HI=highly invaded MI=moderately invaded SI=sparsely invaded

2.4.3. Valuation of Components of Impacts in Annual Economic Cycle

2.4.3.1. Preliminary Phase for Components Valuation

Valuation of forest environmental resources and their respective impacts is important in most forest environmental decision-making processes (Kengen, 1997). An environmental market and non-market valuation should be combined with the use of economic analysis (CBA), which is the normal approach to the valuation of a full range of environmental impacts of investment alternatives (Hanley and Spash, 1998; Abeygunawardena *et al.,* 1999).

It is normally difficult to calculate the whole range of values needed in an economic analysis, and this

[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.*

may even be meaningless from the outcome point of view. A more realistic approach is to focus on the dominant impacts (Kengen 1997; Abeygunawardena *et al.,* 1999), i.e. impacts that were tangibly 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 (ETB)[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 negligible, a zero value was therefore included into the structured household economies.

2.5. Household Income Analysis

In order to standardize comparative analysis of *P. juliflora*-related household income, the monetized value *P. juliflora* and relative source of income were analysed. The proportional shares of the value and relative types of income sources were then included in measuring household economics.

The following standardized definitions are presented by Vedeld *et al.* (2004) cited in Laxén (2007) and used here to clarify the household economy results.

The first variable used in measuring of income is **AI** (absolute total income): which is the same as each household's total cash and subsistence income from all income sources. Another variable is **ACI (**absolute cash income): which is the cash income from all available sources. The pair to **ACI** is then **ASI** (absolute subsistence (or in-kind) income)

Where **AI = ACI + ASI**. ---------- (2)

Each of the variables above has its respective counterpart for the forest environmental income. The first is **AFI (**absolute forest environmental income): which is the total forest environmental income from all cash and subsistence income sources for a household. This can then be divided into **ACFI (**absolute cash forest environmental income); and **ASFI (**absolute subsistence (or in-kind) forest environmental income).

Further, a new variable for the (**ANI)** absolute non-environmental income is constructed; that is, the absolute income from all sources other than the forest environment, which would be then

ANI = AI – AFI ---------- (3)

It is, furthermore, equally important to measure the relative forest environmental income against that from all sources. First there is (**RFI**) relative forest environmental income

RFI = AFI / AI---------- (4) which measures the relative share of the AFI in relation to the absolute income. The equivalent for cash income is (**RCFI)** relative cash forest environmental income:

RCFI = ACFI / ACI---------- (5) which measures the share of the ACFI in relation to the overall absolute cash income of a household from all sources. The pair is **(RSFI)** relative subsistence forest environmental income

RSFI = ASFI / ASI---------- (6) measures the share of the ASFI in relation to the overall ASI of a household from all sources.

Input of household labor is also a component that needs to be factored into any economic valuation. Income from 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.

Moreover, income inequalities and distribution regarding the absolute forest environmental income (AFI) were analysed. There is no actual theory according to which one could explain the distribution of income, but there are some useful ways to measure and describe it (Laxén, 2007). One such description is the Lorenz curve, the Gini coefficient (or Gini ratio) ^{G} is a summary statistic of the Lorenz curve and a measure of inequality in a population. Thus, for perfect equality, the Gini coefficient is zero and for perfect inequality the Gini coefficient is 1 (Daly and Farley, 2004 cited in Laxén, 2007). According to Dixon *et al.*(1987); Dixon *et al.* 1988; Damgaard and Weiner (2000), the Gini coefficient is most easily calculated from unordered size data as the "relative mean difference," i.e., the mean of the difference between every possible pair of individuals, divided by the mean size μ,

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

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} |X_i - X_j|}{2n^2 \mu} \quad \text{---------- (7)}$$

Where **x** is **AFI** values of individuals, n is the sample size, *i* the sample household number, *j* another household sample number where $i \neq j$, and μ is the mean value.

2.4.3.4. Extent of Control through Income Generation

The impact exploitation of *P. juliflora* on controlling invasion was computed from the local people's point of view on the rate of exploitation of specific item verses the corresponding rate of controlling the expansion.

2.6. Statistical Data Analysis

The data were analyzed using SPSS version 15 software program along with MS-Excel 2007; and descriptive statistics were used for analysis of social-economic. All data were tested at 95 % of confidence interval. Moreover, land use/ land cover analyses were made using Arc GIS 9.2.

3. Result and Discussion

3.1. Detrimental Perceived Impacts of *P. juliflora* in the study area

It is now close to two decades since *P. juliflora* was 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. The use values showed that *P. juliflora* is largely employed for: charcoal production, fuelwood, construction wood, live fence, fodder, traditional medicine, local rope, lavatory enclosure, shade, scenery, wind break, and land rehabilitation. The consumption of its edible fruits by local children as a candy bar was also observed around. Conversely, it takes over pasture lands and irrigable areas; mechanical injuries by sharp and poisonous thorns; livestock lost in thicket missing their way out; destruction of indigenous trees and pasture species; blocking access roads; increasing challenges from predators; unrestricted livestock feeding on pods poses health problems; agro pastoralists spend huge amounts of money, time and energy to clear *P. juliflora*; affecting traditional way of life; puncturing vehicle tire; increasing malaria cases have identified bad **(Figure 4)**.

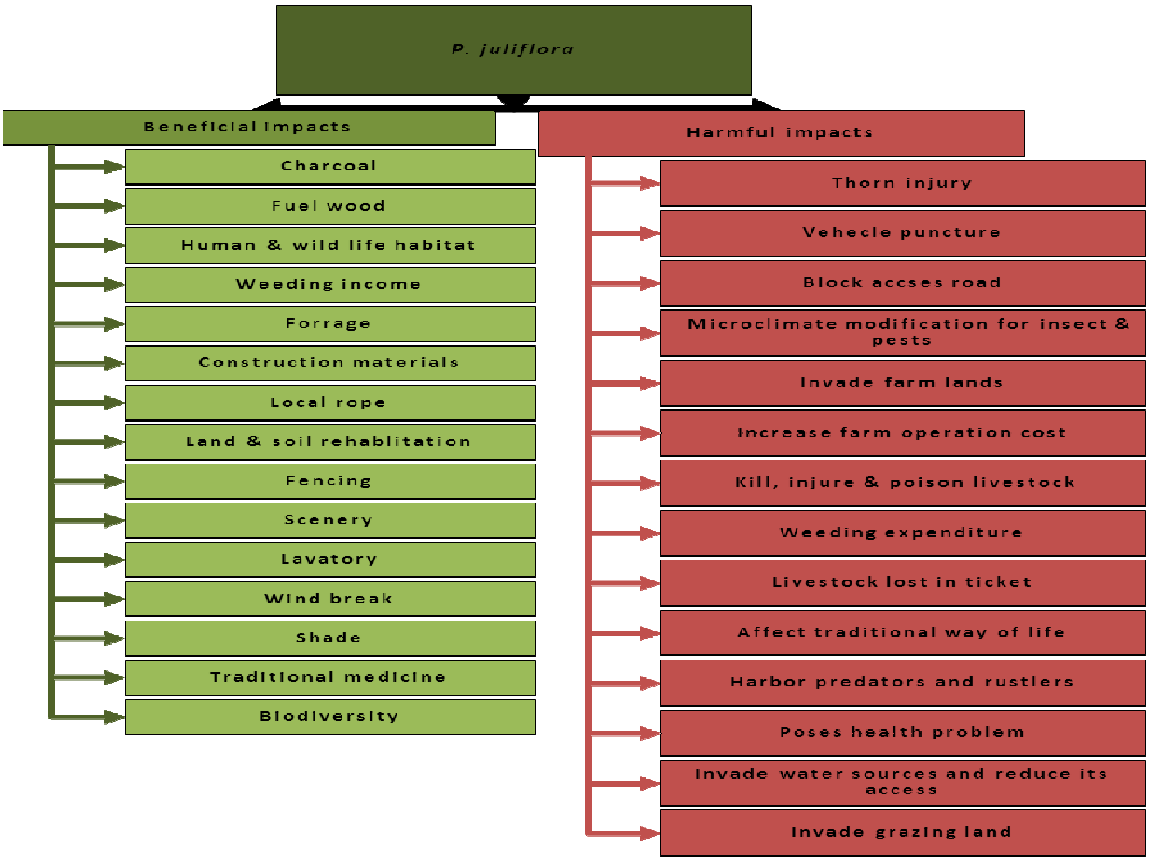

Figure 4: Community viewpoints of main impact of *P.juliflora* in the study area.

3.1.1. 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 "bad"; coded from 4 to -1, respectively. According to the respondent's fuelwood, forage, wind break and live fence were stated as top four ranking use values in the same order; while scenery, construction wood, traditional medicine, weeding income and biodiversity were the least four ranking, respectively (Figure 5). 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.

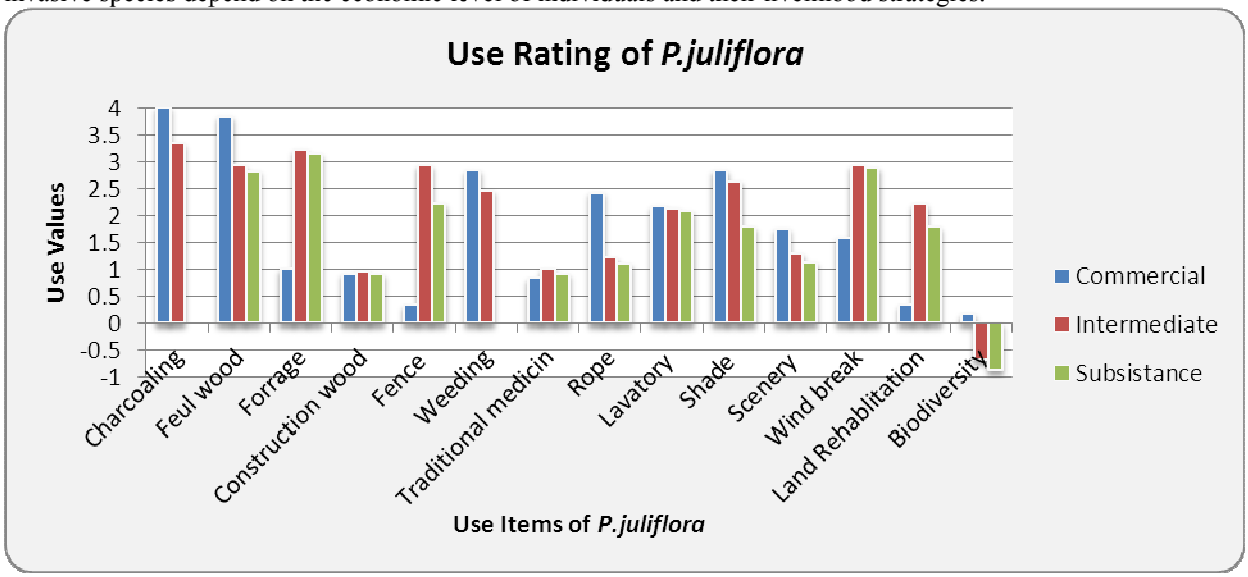

Figure 5: Opinion of respondents on the Usefulness of *P. juliflora*.

The overall result shows that fuelwood, windbreak, fodder and fence were mentioned as top ranked items (Table 1). 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 Ventashwarlu (1991) in India; Díaz Celis (1995) in Peru; Lea (1996) in Haiti; Varshney (1996) in Kenya; Shetie (2008) in Ethiopia, recorded high levels of uses for the stated items. Charcoal was the six frequent mentioned uses of *P. juliflora.* These is because the insignificant number of pastoralists and agro pastoralist were involved in charcoal making but rather the daily laborer who lead their livelihood by clearing bushes were reported use charcoal as their main source of income. While uses of *P.juliflora* for biodiversity (0 %), scenery (7.3 %), construction wood (12.1 %), land rehabilitation (20.2 %), medicine (24.2 %), were the least frequent mentioned use value. This is due to the unique adaptive traits with highly competitive and aggressive natural ability; lack of awareness and technical knowledge; crooked nature of the plant with less durability; and less satisfaction of peoples direct and immediate needs. However, in Ng'ambo, Kenya construction poles were mentioned most frequently used (Mwangi and Swallow, 2005).

Even though, all respondents admitted to some use of *P. juliflora* products. The use of *P. juliflora* for honey harvesting, human consumption, and extraction of exudates like gums, resins and other chemicals were lacking. Conversely, literatures like Duke (1983); Geesing *et al.* (2004) confirmed multiple uses of the species. The probable reasons may be: limited capacity with poor information and technological exchanges which is also confirmed by Farm Africa (2008) random introductions of poorly documented germ plasm into Africa, coupled with little transference of the technologies have led to under-utilization and poor appreciation of the genus.

Table 1: *P. juliflora* product and services in commercial, intermediate and subsistence exploiter group with evaluation of *P. juliflora* on fourteen use criteria (4=best; 3=very good; 2=good; 1=fair; 0=least bad = -1 also 4=greatly attractive 3= very attractive 2=attractive 1=fairly attractive 0=less attractive -1=ugly).

Usefulness of *P. juliflora*						
Use Items	**Use rating**[1]					
	Mean value			Overall mean	Rank	Remark
	CM	IT	ST			
Charcoal making (include protector)	4	3.33	0	1.03	10	Faire
Fuelwood	3.83	2.92	2.82	2.94	1	Very good
Produces pod for forage	1	3.21	3.14	2.94	1	Very good
Construction wood	0.92	0.96	0.91	0.92	11	Fair
Fence	0.33	2.92	2.22	2.17	4	Good
Weeding income	2.83	2.46	0	0.75	13	Fair
Traditional medicine	0.83	1	0.91	0.92	11	Fair
Local rope	2.42	1.21	1.10	1.50	8	Good
Lavatory	2.17	2.13	2.07	2.09	5	Good
Shade	2.83	2.63	1.78	2.05	6	Good
Scenery	1.75	1.29	1.13	1.22	9	Fair
Wind break	1.58	2.92	2.88	2.76	3	Very good
Land rehabilitation	0.33	2.21	1.78	1.73	7	Good
Biodiversity	0.17	-0.67	-0.86	-0.73	14	Bad

* The mean differences is significant at the 0.05 level

Source: Own survey, 2009

CM: refer commercial exploiters

IT: refer commercial exploiters

ST: refer subsistence exploiters

3.1.2. 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, injury, 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 (Figure 6).

1 Refers degree of usefulness (how useful is *P.juliflora*).

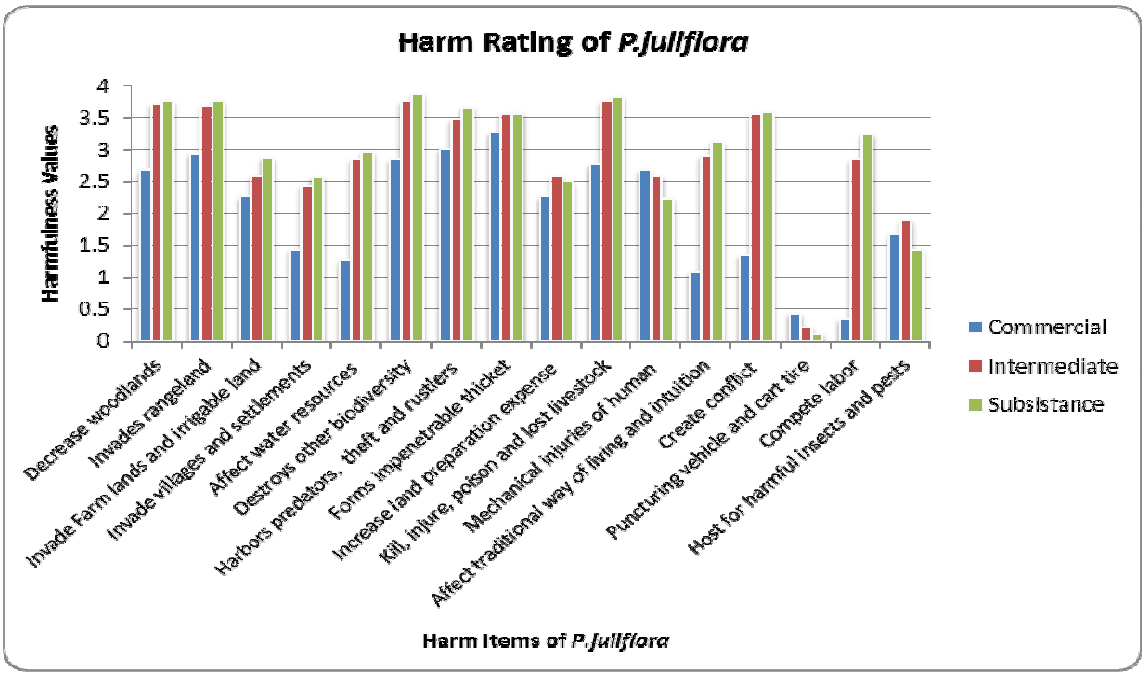

Figure 6: Opinion of respondents on the Harmfulness of *P. juliflora.*

When we look at the overall frequency of harm occurrence: mechanical injuries of human by sharp and poisonous thorns (100 %); formation of impenetrable thicket that blocked access roads and hinder easy movement (100 %); kill, injure, poison and lost livestock in thicket (91.9 %); create conflict (91.2); invades rangeland (90.3 %), decrease woodlands (90.3 %), and invade village and settlement area (90.3 %) were among most frequently occurred. Conversely, invasion of farm and potential irrigable land (27.4 %); increasing land preparation expense (19.4 %); host for harmful insects and pests (19.4 %); puncturing vehicle and cart tire (8.1 %) were mentioned the least frequent**.** Related problems were also faced elsewhere (e.g. Al-Humaid and Warrag, 1998; Gavali *et al*., 2003; Nakamo *et al.*, 2003; Esther and Brent, 2005; Zeraye, 2008)

Information from discussants also confirmed that more frequent drought was also one major feature for invasion of *P. juliflora*. It has been commonly perceived that the plant has many competitive ecological advantages over other plants; it is rapidly spreading as the native vegetation is suffering from overgrazing and climate change. The invasion has also caused migration of people to un-invaded locations; increased conflict on remaining limited resources. Moreover, *P. juliflora* encroachment and plant biodiversity were negatively correlated (Figure 6 and Table 2). *P. juliflora* invasion remarkably impeded seasonal movements of animals in search of pasture and denied access to available grass has eventually brought about the considerable decline in the number and type of livestock. Thus, slowly but persistently forcing pastoralists to change and look for other livelihood options and ways of life. They also quoted blaming *P. juliflora* as a hideout for predators and cattle rustlers. The wild life in the wereda is one of the areas that have been implicated by *P. juliflora* expansion. Although there is no significant introduction of types of animals that form the wilderness of the wereda, the number of prey animals has been considerably decreased since *P. juliflora* has created an infertile ground for their reproduction. Nowadays, predators live unusually near residences preying on the livestock and threatening human lives.

People further noted that *P. juliflora* invasion had negatively affect surface water resources. During rainy season, pastoralist use puddles of surface but due to invasion most are inaccessible and unsatisfactory. Similarly, elsewhere *P. juliflora* is accused of diminishing ground water with its long tap root system (Pasiecznik *et al*., 2001; Pasiecznik *et al.,* 2003).

In Afar culture there is high degree of reciprocity. If a household loses its livestock asset due to rustling, epidemics or other agents, the risk is shared among the whole clan thereby the household gets some stocks for rebuilding its stock asset. However, nowadays the possibility for risk division is very rare, as each household is under pressure of losing its livestock asset. The effect of the bush stated against traditional games and night walk. These kinds of activities are getting vanished due to its invasion of playing grounds and footpaths.

The local inhabitants are badly and frequently affected by thorns of *P. juliflora.* The thorn of *P. juliflora* penetrate the skin causes more inflammation than expected from physical injury. Although an injury from the thorn was mentioned the seventh harmful impact it does not heal easily despite intensive remedial treatments. Additionally, the presented reports on livestock toxicity vary. According to local people, the ingestion of the pod over long periods of time will result in death of livestock. This might be due to high sugar content of the pod that

depresses the rumen bacterial ability to digest cellulose. Similarly, Esther and Brent (2005) and Anonymous (2004) cited in Zeraye (2007) reported prolonged consumption of the pod causes constipation, jaw and tongue trouble (mouth disorientation), teeth fall off and swollen stomach. 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.

Table 2: *P. juliflora* negative impacts in commercial, intermediate and subsistence exploiter group with evaluation of *P. juliflora* on sixteen harm criteria (4=severe; 3=very bad; 2=bad; 1=fair; 0=least).

Harmfulness of *P. juliflora*						
Damages Items	**Harm rating[1]**					
	Mean value			Overall mean	Rank	Remark
	CM	IT	ST			
Decrease woodlands	2.67	3.71	3.75	3.64	4	Severe
Invades rangeland	2.92	3.67	3.75	3.65	3	Severe
Invade Farm lands and potential irrigable land	2.25	2.58	2.86	2.75	11	Very bad
Invade village and settlement area	1.42	2.42	2.56	2.42	13	Bad
Affect water resources availability and accessibility	1.25	2.83	2.95	2.77	10	Very bad
Destroys other biodiversity	2.83	3.75	3.85	3.73	1	Severe
Harbors predators, theft and rustlers	3.00	3.46	3.65	3.55	5	Severe
Forms impenetrable thicket, blocked access roads and hinders easy movement	3.25	3.54	3.55	3.52	6	Severe
Increase land preparation expense (weeding and plowing)	2.25	2.58	2.48	2.67	12	Very bad
Kill, injure, poison (Livestock feeding on pods poses health problems) and lost livestock in thicket.	2.75	3.75	3.81	3.69	2	Severe
Mechanical injuries of human by sharp and poisonous thorns	2.67	2.58	2.23	2.34	14	Bad
Affect traditional way of living and intuition	1.08	2.88	3.11	2.87	8	Very bad
Create conflict	1.33	3.54	3.56	3.34	7	Very bad
Puncturing vehicle and cart tire	0.42	0.21	0.09	0.15	16	Least
Compete labor and time	0.33	2.83	3.23	2.87	8	Very bad
Host for harmful insects and pests including malaria Incidence	1.66	1.88	1.42	1.53	15	Bad

* The mean difference is significant at the 0.05 level Source: Own survey, 2009

3.2. Impact of *P. juliflora* on income share drive

Table 3 summarizes the share of *P. juliflora* and other environmental income out of the absolute total income of the study households. For the commercial households almost all income is related to the forest environmental income and this income share is then steadily regressive towards the subsistence exploiters.

The household economy shows that, the share of forest environmental income ranges from an average of 96 % among the commercial households to an average of -240 % among the subsistence ones. *P. juliflora* constituted about -25 % of the absolute total income for the intermediate households. The subsistence exploiter population group spent more than their absolute income as *P. juliflora*-related income, while for intermediate population group the *P. juliflora*-related income accounted for -25 % on average of all the income, which was only 10.4 % of what the subsistence exploiters lost. Therefore, exploitation of *P. juliflora* would give back expenditures and reduce burdens loaded in relation to *P. juliflora* impacts.

1 Refers the degree of harmfulness (how bad is its effect).

Table 3: Structure of household economies (in ETB).

Household budget item N= 124 households	Commercials N=12		Intermediate N=24		Subsistence N=88	
	Mean	S.Dev.	Mean	S.Dev.	Mean	S.Dev.
Crop net income	**0**	**0**	**1311.3**	**2851**	**1318.4**	**2614.7**
Net cash income from crops	0	0	596.6	1586.4	733.6	1454.9
Net subsistence income from crops	0	0	714.7	1264.6	584.8	1159.8
Livestock net income	**104.2**	**252.7**	**8499.6**	**2232**	**8240**	**8420.2**
Net cash income from livestock	41.7	97.3	3610.23	1027.4	3651.2	1189.8
Net subsistence income from livestock	62.5	155.4	4889.43	1204.6	4589	1411.2
Swampy grass net income	**0**	**0**	**0**	**0**	**368.2**	**1369.02**
Net cash income from Swampy grasses	0	0	0	0	246.6	916.9
Net subsistence income from Swampy grasses	0	0	0	0	121.6	452.12
Net income of labor work	**536.4**	**244.3**	**1112**	**1108.4**	**1125.5**	**918.7**
Net income of unskilled labor (excluding *prosopis* related labor)	536.4	244.3	723	653.6	888.8	443.8
Net income from skilled labor work (excluding *prosopis* related labor)	0	0	389	454.8	236.7	474.9
Net income merchant/transportation	**141.7**	**490.7**	**0**	**0**	**0**	**0**
Net remittances (private & pension) and Aid	**0**	**0**	**569.4**	**297.6**	**611.6**	**234.9**
Land rent	**0**	**0**	**481.3**	**499.9**	**459.6**	**388.6**
Absolute non-environmental cash income	**719.8**	**832.3**	**6364.53**	**4519.7**	**6828.1**	**5103.8**
Absolute non-environmental subsistence income	**62.5**	**155.4**	**5604.13**	**2469.2**	**5295.4**	**3023.12**
Environmental (*Prosopis*) net income	**19003.5**	**9934.2**	**-2402.2**	**3627.4**	**-8559.1**	**5085.1**
***Prosopis* net cash income**	21312.5	9215.9	2868.7	1002.8	-248.3	207.33
***Prosopis* net subsistence income**	-2309	718.3	-5270.9	2624.6	-8310.8	4877.8
Absolute cash income	**22032.3**	**10048.2**	**9233.2**	**5407.5**	**6579.8**	**5155.3**
Absolute subsistence income	**-2246.5**	**592.7**	**333.2**	**3793.8**	**-3015.4**	**5900.92**
Absolute net cash income	6132.6	2044	2223.1	1255.2	286.4	632.8

Absolute cash forest environmental income was resulted positive value for commerial and intermediate exploiters category while absolute subsistence forest environmental income (ASFI) resulted negative for the whole category (Table 4). This shown that commercializing *P. juliflora* to generate cash income is better strategy to reduce its undesirable impacts.

Table 4: Relative share of *P. juliflora* and other environmental incomes from the households' absolute total income (AI) (mean AI in ETB and other figures as decimal ratios).

Total Income	**Population exploiter group**			
Mean Absolute incomes	Commercials	Intermediate	Subsistence	**Mean for** all HHs
AI	**19785.8**	**9566.4**	**3564.4**	**10972.2**
ACI	22032.3	9233.2	6579.8	12615.1
ASI	-2246.5	333.2	-3015.4	-1642.9
ANI	**782.3**	**11968.66**	**12123.5**	**8291.49**
ACNI	719.8	6364.53	6828.1	4637.48
ASNI	62.5	5604.13	5295.4	3654.01
AFI	**19003.5**	**-2402.2**	**-8559.1**	**2680.7**
ACFI	21312.5	2868.7	-248.3	7977.6
ASFI	-2309	-5270.9	-8310.8	-5296.9
Mean Relative incomes	Commercials	Intermediate	Subsistence	**Mean for** all HHs
RCI	1.11	0.97	1.85	1.15
RSI	-0.11	0.03	-0.85	-0.15
RFI	0.96	-0.25	-2.40	0.24
RCFI	1.08	0.30	-0.07	0.73
RSFI	-0.12	-0.55	-2.33	-0.48

For the study area the **Gini coefficient** for the absolute forest environmental income was found 0.66 which is greater than twice the national average. This suggests that the income distribution in the study area was fairly uneven, as some households had better been able to increase their income via utilizing *P. juliflora*. The environmental income did still substantial impact on the absolute total income level (Table 3 and 4), but it was not redistributed among the households, as almost all households utilize *P. juliflora*. Laxén (2007) in Sudan also found the substantially impact of the environmental income on absolute total income but imbalanced redistributed among the households.

3.3. Impact of Utilization versus controlling *P. juliflora*

Various attempts had been made to eradicate and control *P. juliflora* in the study area but proven unsuccessful and ineffective. Hence, changing the view and aiming on harvesting and utilization of the deliberate introduction of *P. juliflora* as a valuable resource to support rural livelihoods in the dry lands is become possible controlling strategy to minimize the spread of *P. juliflora*. Respondents requested about their opinion on the current correlation between utilization rate and invasion rate. Accordingly, all exploiter groups agreed that the current invasive rate was greater than exploitation rate at different extent (Table 5).

Table 5: Current relationship between utilization vs invasion rate.

Exploiter category	N	Mean	Std.D	Std.Error	95% Confidence Interval for Mean		Min.	Max.
					Lower boundary	Upper boundary		
Commercials	12	3.2500	.86603	.25000	2.6998	3.8002	2	5
Intermediate	24	3.9583	1.08264	.22099	3.5012	4.4155	2	5
Subsistence	88	4.2159	.66866	.07128	4.0742	4.3576	3	5
Total	124	4.0726	.82810	.07437	3.9254	4.2198	2	5

The fallowing evaluation criteria shows the current exploitation rate of *P. juliflora* verses their relative invasion rate on twelve judgment criteria; 5=invasion rate is extremely higher than exploitation rate, 4=invasion rate is very higher than exploitation rate, 3=invasion rate is higher than exploitation rate, 2=invasion rate is fairly higher than exploitation rate,1= invasion rate is slightly higher than exploitation rate, 0=invasion rate is comparable to exploitation rate -5=invasion rate is extremely lower than exploitation rate, -4=invasion rate is very lower than exploitation rate, -3=invasion rate is lower than exploitation rate, -2=invasion rate is fairly lower than exploitation rate,-1= invasion rate is slightly lower than exploitation rate.

The overall result from the local people revealed that 85.9 % (Table 5) 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 nature of resprout and their awareness at least one method of avoiding regrowth, however, only 27.4 % of the respondents have experienced on removing the plant without allowing resprout, most whom were agro pastoralists. 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*.

4. Conclusion

The study confirmed an overall assumption that *P. juliflora* has different value for different community group in Gewane. *P. juliflora* is still promoted by some group of the community because of its positive contribution to their livelihood. However, the aggregate loss due to *P. juliflora* far outweighs its positive values. 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 household economy shows that, almost all income for the commercial household generated from forest environmental income and this income share is then steadily degenerating towards the intermediate and subsistence exploiters. The share of forest environmental income ranges from an average of 96 % among the commercial households to an average of -240 % among the subsistence ones. *P. juliflora* constituted about -25% of the absolute total income for the intermediate households. The subsistence exploiter population group spent more than their absolute income as *P. juliflora*-related income, while for intermediate population group the *P. juliflora*-related income accounted for -25 % on average of all the income, which was only 10.4 % of what the subsistence exploiters lost. Therefore, utilization of *P. juliflora* would give back expenditures related to *P. juliflora* impacts.

Absolute cash forest environmental income was resulted positive value for commercial and intermediate exploiters category while absolute subsistence forest environmental income (ASFI) resulted negative for the whole category. This shown that commercializing *P. juliflora* to generate cash income is better strategy to reduce its undesirable impacts. The distribution of income among actors suggest there is specific

burden or advantage to some specific individual or group of individuals as they pursue their dominant livelihood strategies. Consequently, subsistence exploiter category experiences the greatest cost burden and need priority for any intervention. Thus, sole dependency on pastoralism was not feasible. Local people have to take different measures to secure their livelihoods through diversification of income through economic exploitation of *P. juliflora* as a coping mechanism.

The overall implication of utilizing *P. juliflora* to drive income verses controlling the current spread rate of the species in the study area was found least. The attempted controlling mechanisms practiced by the majority of the local people did aggravate rather than mitigate the invasion of *P. juliflora*.

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Appendices

Appendix I: *Socio-economic and demographic characteristics of the study households*

Demographic information		**Respondents frequency (n = 124)**	**Mean**	**SD**
Sex	Male	108	-	-
	Female	16	-	-
Age	14-24	11	19.8	1.81
	25-34	36	29.3	1.90
	35- 44	41	38.5	2.38
	>45	36	53.9	7.64
Marital status	Married	110	-	-
	Single	14	-	-
Polygamy status	Yes	16	-	-
House hold size			6	3.2
Education status	Illiterate	78	-	-
	Religious	16	-	-
	Read and write	10		
	Primary	15	-	-
	More	5	-	-
Main livelihood/occupation	Pastoralist	82	-	-
	Agro pastoralist	24	-	-
	Charcoal makers	12	-	-
	Traditional mate makers	6	-	-
Number of camels own	None	59	-	-
	1-10	15	5.4	3.03
	10-20	43	14.6	4.73
	>20	7	27.2	9.93
Number of cattle own	None	18	-	-
	1-10	91	6.4	3.2
	10-20	18	17.8	2.91
	>20	15	37.7	16.45
Small stocks own				
Number of Goat own(mean=4.22)	None	19	-	-
	1-10	48	7.6	2.98
	10-20	40	18.8	2.02
	>20	35	40.9	17.23
Number of sheep own(mean=2.7)	None	19	-	-
	1-10	48	7.6	2.98
	10-20	40	18.8	2.02
	>20	35	40.9	17.23
Number of equines own (mean= 0.02)	None	37	-	-
	1-10	87	1.53	0.93
	10-20	-	-	
	>20	-	-	

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