FARM Africa

Making a lasting difference to Africa's families

Experiences on *Prosopis* Management
Case of Afar Region




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ACRYNOMS

ANRS	Afar National Regional State
CBA	Cost Benefit Analysis
CP	Crude Protein
EIAR	Ethiopian Institute of Agriculture Research
ETB	Ethiopian Birr
FARM-Africa	Food and Agriculture Research Management
FGD	Focus Group Discussion
FRS	Forest Resource Strategy
GL-CRSP PARIMA	Global Livestock- Collaborative Research Support Program
	Pastoral Risk Management
HDRA	Henry Doubleday Research Association
HP	Horse Power
IAS	Invasive Alien Species
ILRI	International Livestock Research Institute
NAP	National Action Plan
NPV	Net Present Value
PARDB	Pastoral, Agriculture and Rural Development Bureau
PLI	Pastoral Livelihood Initiative
USAID	United State Agency for International Development
USD	United States Dollar

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The unreserved assistance, particularly from Ato Dubale Admasu and Ato Solomon Zewdu FARM-Africa Staff, is highly acknowledged.

Last but not least, I would like to express my sincere thanks to FARM-Africa for providing me the opportunity to contributing towards the fruitful efforts in identifying innovative approach in controlling *Prosopis;* and also in forging partnership amongst various actors towards the creation of a sustainable natural resource management-with *Prosopis* control in the central theme. I hope that the experiences documented; ideas generated, and the way forward will lay ground for scaling up of efforts in controlling *Prosopis*, and in forging partnership amongst actors in government, non-government and the Private sector.

Getachew Gebru Tegegn
October 2008

INTRODUCTION

Exotic plant species have been purposely and/or accidentally introduced through out 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). Encroachment of rangelands by invasive species, reduction of crop yield, genetic erosion of biodiversity, disruption of water flow, poisoning of livestock, formation of impenetrable thickets, etc are some of the impacts of invasive species across a wide range of agro-ecologies.

In the late 1970s and early 1980s, concern about deforestation, desertification and fuel wood shortages prompted a wave of projects that introduced *Prosopis* and other hardy tree species to new environments across the world (Mwangi & Swallow, 2005) that it did not take *Prosopis* a long time to be registered as one of the first 100 top invaders. During its introduction from its natives, South America, Central America and the Caribbean (Pasiecznik *et al* 2004), the indigenous knowledge of its management rarely followed and *Prosopis* remained under-utilized and unmanaged (HDRA, 2002).

This and other peculiar features of this species such as; tolerance of arid conditions and saline soils, fast growing, nitrogen-fixing (Anonymous, 2003, Pasiecznik *et al*., 2004), rooting abilities, coppicing abilities, ability to stay dormant for longer time in a media (eg soil) and germinate during favorable conditions, number of seeds/pod, sweetness of pods, etc made it grow tremendously, covering large areas within a short period of time than any woody species within its niche. The main source of dissemination are animals- *Prosopis* seeds once passed through the digestive tract of both domestic and wild animals their germination is further enhanced and are spread over wide range of areas, given the mobility pattern of the browsers and grazers.

The goal of this compilation report is to present the experiences around *Prosopis* management by FARM-Africa, and recently that of USAID supported Pastoral Livelihoods Initiative (PLI/ENABLE) under CARE Ethiopia consortium. Given that the successes registered in eradicating *Prosopis* are limited, coupled with the fact that the application of control methods are not within the reach of the pastoral communities', innovative approach towards the control through management were direly needed. Consequently efforts were put to control the spread of *Prosopis* through management which included clearing the *Prosopis* and making charcoal out of it, reclaiming the cleared land for crop and pasture production; and use of the crushed pods for animal feed. These approaches will in the long term significantly contribute towards the control of the spread of *Prosopis*. This documentation is part of the on-going effort to develop cost-effective and ecologically sustainable control of the spread of *Prosopis* through management. Not all the answers are in yet, but here are some trends of the efforts so far that those organizations working in Afar region are finding.

Prosopis Management in Native Areas

Prosopis (hereafter referred to as *Prosopis*) is a multipurpose dry land tree or shrub native to South America, Central America and the Caribbean (Pasiecznik *et al*., 2001). It is resistant to drought and poor soils, tolerant to repeated cutting, provide high biomass, grows in poor soils and improves the fertility status (due to the fact that it is a legume), and provides different products and services (Pasiecznik *et al*., 2001). Plantations and natural forests of *Prosopis* provide regional marketable outputs, such as timber and charcoal in the USA, honey in Mexico, animal feed in Brazil, gums, fodder and firewood in north-eastern India, timber, charcoal and human foods in South America, and firewood in West Africa. *Prosopis* species are unusual in their importance, both as a vital fuel resource for some of the poorest and most disadvantaged rural and peri-urban inhabitants in India, and as economically important sources of timber and animal feeds in South America.

Despite the positive characteristics of *Prosopis* in its native areas, there are concerns on its invasiveness. *Prosopis* species are known to be invasive even in the natural range in south and Central America and Argentina. *Prosopis* eradication programmes attempted, in its native areas, especially the mechanical and chemical ones are highly expensive and mostly ineffective (HDRA, 2005a). Insects were also utilized in the control of the invasion of *prosopis*. In the natural range *Prosopis* has many insect herbivores, which feed on, usually, seeds and pods of the tree that reduces the invasion. In North America, where *Prosopis* is native, more than 657 species of phytophagous insects have been recorded from *Prosopis* trees (Ward *et al*., 1977). Biological control measures such as using beetles, which damage the seed, were also tried in Australia and South Africa with varied level of success. It stands therefore that *Prosopis* control using conventional approaches remains a challenge.

Prosopis Management in Introduced Areas

Prosopis tree species form a major component in dry forests and savannahs in the Americas and introductions into Africa and Asia have now made *Prosopis* species, principally *Prosopis*, one of the most widespread trees in the arid and semi-arid zones of the world.

Based on its merits *Prosopis* has been introduced and naturalized in different parts of the world (Africa, Asia, and Australia) during the last 100-150 years (Pasiecznik *et al*., 2001). However, exotic species such as *Prosopis* that are known for their merits in the natural range can become serious invading weeds when introduced into areas without proper management (Shiferaw *et al*., 2004). Plant species usually become invasive in introduced areas as they miss the natural enemies and their management practices do not follow the introduction. Cronk and Fuller (2001,) defined an invasive plant as: 'an alien plant spreading naturally (without direct assistance of people) in natural or semi-natural habitats, to produce a significant change in terms of composition, structure or

ecosystem processes'. Invasive species are usually associated with economic, environmental and social losses in introduced areas (Anderson, 2005). The common problems are reduction of pasturelands, decline in crop yield, loss of biodiversity, changing water flow, injuries and poisons to livestock and humans and the formation of impenetrable thickets (Anderson, 2005).

Random introductions of poorly documented germplasm into Africa and Asia, coupled with little transference of the technologies whereby it is utilized commercially in its native range, have led to the under-utilization of this forest resource. A thorny *Prosopis* shrub, widespread in Africa and India, came from the introduction of inferior germplasm, and has led to a poor appreciation of the genus. Research trials from several continents have identified superior material in terms of growth, pod production, erectness and absence of thorns, in a range of rainfall and salinity regimes. There is a need for the dissemination of information concerning this material. In some regions, *Prosopis* has spread from the low rainfall zones in which it was planted, invading water courses, irrigated agricultural land, and adjacent higher rainfall areas. The need for information concerning the relative invasiveness of species, reproductive biology and methods for controlling the spread, or eradication has been strongly demanded by many organizations.

Prosopis is known to establish well and to provide socioeconomic and ecological benefits in introduced arid lands where other trees fail to survive (Mwangi and Swallow, 2005). In countries such as Cape Verdi and parts of Mauritania or Niger, *Prosopis* was reported to be the only effective vegetation cover and thus is an important source of fuel wood and fodder (Greesing *et al*., 2004). However, in South Africa and Australia it invaded the high potential rangelands and became the main cause for production loss in livestock, and high clearance cost (Greesing *et al*., 2004). In the Ethiopian case, it was wrongly introduced into high potential pasturelands and irrigable areas. Local people were not made aware of the invasive nature of the tree and also were not advised on the management practices to minimize further spread. As a result the shrub rapidly invaded vast areas of agro- and silvo-pastoral lands and affected the biodiversity and socio-economic environment. Over 700,000 hectares of land is either invaded or is at risk of invasion from *Prosopis* in the Afar Region alone (USFS 2006).

Control or eradication methods for invasive species could be categorized into three broad types: Physical; invader plants are removed by machine or people mechanically; Chemical; where herbicides are used to kill invader plants; and Biological; where predators or pathogens are used to control the invading plant's reproduction (Geesing *et al* 2004). However, experiences from America, Asia and Australia have shown that eradication of *Prosopis*, by the different methods, especially the mechanical and chemical ones are highly expensive and mostly ineffective (HDRA, 2005a). Hence, management strategies were recommended to minimize the ecological and socioeconomic impacts of the invasion and to make use of *Prosopis* as a valuable resource to support rural livelihoods in the dry lands (HDRA, 2005; Mwangi and Swallow, 2005). At the same time there is a dire need to control the spread of *Prosopis* to new areas.

PROSOPIS MANAGEMENT IN ETHIOPIA

Although the exact date and source of *Prosopis* introduction to Ethiopia had not been documented, it was believed to be introduced from India in 1970s by the ministry of Agriculture for conservation purposes (HDRA, 2005a). Since then, the tree has rapidly invaded vast areas of agro-and silvo-pastoral lands in ANRS and eastern Harargae (Shiferaw *et al*., 2004; Worku, *et al*., 2004; Mwangi and Swallow, 2005). The invasion is threatening livelihood of pastoralists and agro-pastoralists due to loss of pasture and indigenous trees and destruction of croplands (Shiferaw *et al*., 2004). The invasion also formed impenetrable thickets, which blocked human and herd mobility, and the strong thorns cause mechanical injuries to both humans and animals (Shiferaw *et al*., 2004). The government of Ethiopia identified *Prosopis* as one of the three major invasive plant species in the country and declared it as a noxious weed for eradication (Mwangi and Swallow, 2005), however, there has been no intervention to control the invasion.

***Prosopis* is a controversial plant that has many uses and bad characters**[1].

Uses	**Harmfulness**
Creates micro environment	Invades rangeland
Produces pod that is consumed by wildlife and domestic animals.	Destroys other plant biodiversity
Conserves soil	Harbors predators
Reclaims land which is affected by salinity.	Forms thicket and hinders easy movement of pastoralists
Supports wildlife by providing shade and pods.	Thorns make people blind and lame
The trunk is used in construction, timber production, firewood and charcoal making.	Doesn't allow underneath growth there by depriving livestock from their grazing resources.
Flowers are good for honey production	
Leaves contribute to nutrient recycling	Leaves are not browsed by livestock due to high tannin content

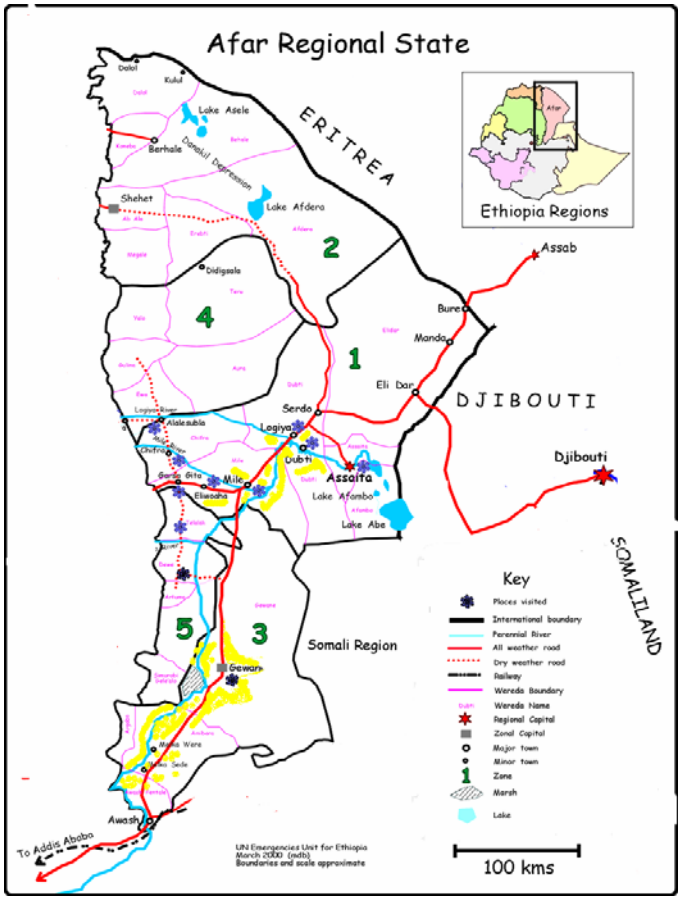
[1] Tafesse Mesfin. Overview of Prosopis Control and FARM-Africa's experience In Afar Region, In Proceeding of the Workshop on Afar Pastoralist Prosopis Project and Emerging Issues, April 7, 2006, Awash 7 kilo, Afar.

Benefits and losses to introduced areas in Afar Regional State

The effect of *Prosopis* to the biodiversity depends on the ecosystem to which it spread, and the economic damage and benefit depends on the socio-economic environment of the invaded land and its potential alternative uses' (Greesing *et al*., 2004).

Prosopis is affecting the biodiversity and socio-economic environment of invaded areas in Afar region. It takes over pasture lands and irrigable areas; people and livestock suffer from mechanical injuries by sharp and poisonous *Prosopis* thorns; indigenous trees and pasture species are lost due to the invasion; access roads are blocked; challenge from predators increases; unrestricted livestock feeding on pods poses health problems; agro-pastoralists spend large amounts of money to clear *Prosopis* from their farmlands; and malaria cases increased due to the favorable microclimate created due to the invasion.

The local people are aware about the ecological benefits from *Prosopis* such as - improvement in soil fertility, preventing erosion, improvement of saline lands, creating cooler microclimate, and reduction of wind damage. However, the aggregate loss due to *Prosopis* far outweighs these ecological benefits, and the local community members are bitter about
Introduction of *Prosopis*. Therefore community members, and strongly pushed the idea of its eradication. Eradication has not been that easy, however. A significant number of local people that have no alternative wood or pasture source depend on *Prosopis* for different purposes- which includes fuel wood, pods for animal feed, fencing, house construction and charcoal.



***Prosopis* invaded areas in Afar region**

Policies and strategies on Invasive Alien Species (IAS) management in Ethiopia

At the national level there is no clear policy or strategy about control and management of Invasive Alien Species in general and *Prosopis* in particular (Anage *et al*., 2004; Fisehaye, 2006). Nevertheless, *Prosopis* invasion has been recognized as an emerging threat to plant biodiversity by a few of the strategies and action plans such as the Forest Resource Strategy (FRS) and draft Ethiopian National Biodiversity Strategy and Action Plan (NBSAP) (Anage *et al*., 2004). Contrary to this, *Prosopis* is one of the trees recommended in the National Action Plan (NAP) to combat desertification (Anage *et al*, 2004). This reflects the contradiction of policy directions due to the knowledge gap about the invasive properties of *Prosopis*, which requires attention in the future. Moreover, the review of policy and stakeholders' analysis for invasive plant management in Ethiopia (Anage *et al*, 2004) showed that the institutional mandate is unclear and fragmented and the interventions so far made were not proactive and successful.

A general ban on charcoal production including invasive trees such as *Prosopis* appeared to be common elsewhere and in Ethiopia (Mwangi and Swallow, 2005; HDRA, 2005b). This remains a barrier for utilization of *Prosopis* products**.** In the Afar region, although there was pilot initiative where cooperatives were provided with license to produce and market *Prosopis* charcoal, due to the lack of extension and regulatory service by government offices and due to failure to respect requirements by users, the activity became unmanageable and was banned by the region government until the problems were rectified.

The draft regulation on Prosopis management, in Amharic

Based on the lessons learned so far from piloted interventions and sharing experiences from other countries, Afar National Regional State Pastoral, Agriculture, and Rural Development Bureau (PARDB) drafted a regulation in consultation with stakeholders which will guide *Prosopis* management in the region. The process was facilitated by FARM-Africa. The regulation outlined possible strategies to prevent further spread of *Prosopis* invasion and how to rehabilitate invaded areas.

The regulation also identified institutions responsible to lead *Prosopis* management at different levels, their roles and responsibilities as well. The regulation is awaiting approval from the regional council to be enacted. Once the regulation is endorsed, there is a

need to prepare a detailed implementation guideline, mobilize the stakeholders for its implementation.

Pod utilization for livestock feed

Animals, both domestic and wild, feed on *Prosopis* pods. These animals and flood water are the major dispersal agents of *Prosopis*. Moreover, birds, bats, reptiles and ants that feed on *Prosopis* pods are also expected to contribute for dispersal of the seeds (Pasiecznik et al., 2001). The principal cause for the dissemination of the *Prosopis* is the consumption of the sugary pods by domestic livestock and the passage of the seeds through the animal's digestive tract which results in the germination of the seeds in the moist feces. Thus the collection and utilization of the pods (after destroying the seeds through crushing) would greatly reduce the spread of *Prosopis.*

Prosopis is one of the non-native species in Afar whose pods are currently used as a source of feed. Elsewhere in the world, collected pods of *Prosopis* are fed to stalled livestock, 'raw' or 'processed', alone or as a part of a ration 'fresh' or after 'storage'. Successive studies were conducted to explore the potential availability and demand of the pods by feed processing plants (GL-CRSP PARIMA), followed by a feasibility study on the cost of collection, transportation (GL-CRSP PARIMA). These studies were followed by an action research, at a pastoral setting, on feeding the crushed pods to goats (FARM-Africa).

GL-CRSP PARIMA exploratory study showed that there exists demand for *Prosopis* pods by feed processing industries and small scale agro-industries located close to *Prosopis* growing areas. Survey activities were concentrated in towns that possess the majority of agro-industries for animal feed. These were Adama, Mojo, Bushoftu, and Qaliti (Addis Ababa) that form a belt along the international trade route. The potential of *Prosopis* availability and use as feed was also assessed in *Prosopis* dense areas- Gawane and Amibara.

Prosopis pods offer high nutritional value, high digestibility and excellent palatability for bovines, caprines, ovines, equines, pigs, fowls and other animals. The pulp is sweet, with a high content of suaccharose, calcium, phosphorus, iron, vitamin B1 and vitamin B6. *Prosopis* pods are not only rich in energy, but also have a relatively high protein value, with approximately 13% crude protein content. Seed protein content ranges from 34 to 39%. The pods may be fed ground or whole to the animals. Ground pods, in the form of flour, make it possible for the animals to use the seeds' protein.

A study conducted in Kenya shows that the crude protein (CP), and mineral concentration of *Prosopis* are satisfactorily high and warrant consideration of its use as supplement to low quality feed. It was reported that the CP of the *Prosopis* pods is 163g/kgDM. Recent study conducted by ILRI on nutritional value of *Prosopis* pods (green

on the tree, ripe on the tree and ripe on the ground) in four districts of Kenya also shows that the pods have nutritional worth for feeding animals.

Table 1: Composition of P juliflora pods in Kenya (Joe, 2007)

Dry matter (%)	Crude protein (%)	Cude fiber (%)	Ether extract (%)	Ca (%)	P (%)	NDF (%)	ADL (%)	ADF (%)	N free extract (%)	ASH (%)
87.81	11.68	29.81	2.36	0.30	0.36	42.01	7.70	29.85	50.89	5.28

Gewane and Amibara are the two extremely invaded woredas where the crushing of the *Prosopis* pods could help contribute further spread and ultimately reclaim the lost land. Six kebeles in Gewane and fourteen kebeles in Amibara have lost prime land to *Prosopis* (Gebru et al, 2007). Biomass assessment shows that the *Prosopis* stock density at the study locations is 3000 stems/ha that is beyond the critical density; it is in the state of invasion. It sets pod twice a year, from mid February to May and from mid September to January. Even though the productivity varies by site, moisture availability and other external factors (cutting, charcoaling, etc), this study reveals that a *Prosopis* tree yields 40-60 kg of dry pod per year. Sidafage co-operative members, Amibara woreda, mentioned that only within two months a mature *Prosopis* tree can set seeds that can fill up four sacs (approx. 120 kg) especially in homesteads and Awash River banks. Over 31 tons of pods were collected in one collection season by the Sidafage co-operative (Admasu, 2008). Given the prevailing rate of invasion in several woredas the amount of pods that can be collected is significant, and this can drastically lower the spread of the trees via animal vectors, if pods are collected and crushed.

Processors also showed willingness and interest in buying *Prosopis* pods to fulfill the current escalating demand by urban producers for processed feed. However, they needed to establish linkages and also visit the potential sites. An effort made to link the pod crushing cooperatives to feed processing enterprises (Addisalem Agricultural Development P.L.C. at Mojo, Alema Farms Private Limited Company at Debre Zeit and Kaliti Feed Processing Enterprise –Addis Ababa) was found to be good initiative to create outlet market for the cooperative. Visits were organized for cooperative leaders and government partner staff to the enterprises. With facilitation from GL-CRSP/PARIMA (which has done supply and demand study on *Prosopis* pod for livestock feed in the area), the feed enterprises also visited the cooperatives areas and started negotiations to enter into contractual agreement for pod purchase. To assist feed enterprises determine percentage inclusion of *Prosopis* pod into feed production, nutritive analysis of pod was done in collaboration with Holleta EIAR. The findings were similar with reports from Kenya which showed the crushed pod is rich in protein, energy and fiber which are the basic ingredients in livestock feed (Table 2).

Table 2: Prosopis pod nutritional analysis from Holeta EIAR

Sample description	Analysis result						
	DM	Ash	CP	NDF	ADF	Lignin	DOMD
Prosopis pod from Amibara woreda	94	3.53	19.15	30.93	16.99	5.21	87.85

POD Crushing

The following section also briefly explains on the pod crushing process, which is a joint venture between FARM-Africa and members of the pastoral community in order to promote *Prospois* pod utilization by the Afar Community with primary objective of controlling further spread.

Pod crushing with local mills

Plate 1: Small hammer mill used for pod crushing

Locally produced diesel operated small hammer mills were introduced through the four pilot cooperatives to run *Prosopis* pod based feed production as a business enterprise. The mills were able to crush the dried *Prosopis* pods, and it was demonstrated that there is substantial demand for the crushed pod by livestock keepers locally. However, the small mills were not able to handle the volume needed as the crushing capacity was small, only about 10kgs/hr.

Plate 2: Normal flour mill used for Prosopis pod crushing

To improve crushing capacity, normal grain mills, with higher efficiency (25HP, crushing 400Kg/hr) were installed with a support from FARM-Africa at the Sedhafagae cooperative.

The cooperative purchases pods from its members and non members at rate of ETB 0.5/kg and sells crushed pods at a rate of 2.50birr/kg to livestock keepers in the woreda. Research institutes are also buying crushed pods from the cooperative for research and demonstration purposes. In about one year period, Sedhafagae cooperative collected over 310 quintals of *Prosopis* pod; crushed and sold over 100 quintals and obtained a profit of 17,000 birr. Other cooperatives were also established (Bedulale and Halidege) and mobilised to collect pods from their respective areas and supply it to Sedhafage to utilize the capacity of the planted mill.

This cursory look at the potential and demand of *Prosopis* pod as animal feed appears to show there are opportunities to be exploited. Further study is required to shade light on marketing and sustainable availability of the prosospis pods. The question remains however-"Is *Prosopis* pods collection, transportation and crushing a feasible venture?" The following section will shade light on that. These results are from a GL-CRSP PARIMA study conducted in 2008.

Pre-feasibility Study on processing of Prosopis pods as feed

The Cost-Benefit cash flows of *Prosopis* pods collection, transport and processing

An evaluation was carried out, by GL-CRSP PARIMA on the financial feasibility of *Prosopis* pod collection, transport and crushing based on the costs incurred and benefits gained by the pastoral community in adopting it within a specified period of time. The scope of this study is limited to the analysis of financial feasibility of the proposed program normally by focusing on privately incurred costs and benefits gained by cooperatives, all evaluated at market prices. The cooperatives fix the buying cost of raw *Prosopis* and the selling price of crushed *Prosopis* pods at 0.4ETB/kg and 1.75ETB/kg, respectively. The focus of this study is on crushed *Prosopis* pods, and thus other potential benefits of the plant, such as charcoal, firewood and construction material, are not considered in the financial analysis. The pods were valued at current local market prices. The cooperatives also incur costs, which include the costs of labor, raw pod purchases, crushing and fuel. The basic data sources for this exercise are cooperative records and yield estimates of *Prosopis* trees. All future cost and benefits are discounted to get the present value (see Table 3 for projected cash flows). The final year figures are projected based on actual survey of the productivity of sampled trees. The value of the final year pod output is projected from estimated production of one ha of *Prosopis* tree in the study area.

Sedahafage cooperative is used as a sampled unit for financial analysis based on actual data for the period of 1998-2001 EC. The basic cost indicators include raw pod purchase (0.4 ETB/kg), hiring of an operator (0.4 ETB/kg) for milling and drying the pods and fuel cost of 0.17 ETB per kg of *Prosopis* (i.e., 30kg/ lit x 5.35 ETB). The initial investment, which includes machine cost the opportunity cost of land devoted to

Prosopis pods production, projected running costs and accrued benefits of *Prosopis* pod processing in years 0-3 are shown in Table 3.

Table 3: Projected cash flows for financial analysis

Cost	Year			
	0	1	2	3
Machine purchase	20,000	-	-	-
Pods purchases		454	1063.20	30,000
Operating cost		454	1063.20	30,000
Fuel cost		192.60	451.86	12,750
Total cost		1100.60	2578.26	72,750
Benefit		1982.75	3987	131,250

A project is infeasible if its CBR is less than 1 and the NPV is negative. The financial analysis of this study shows that the CBR is 1.43 while the NPV is Eth B 31.2 thousand at 10% discount rate. The financial analysis of this study shows that the proposed idea of *Prosopis* pods collection, transport and crushing for supplementary animal feed production in the Afar region is a promising investment option which in the long run can help control the further spread of *prosopis*.

Three things happened here:

- Controlling further expansion of *Prosopis* into farmlands and rangelands, by crushing the seeds which otherwise would intensify the invasion.
- Animals fed on crushed pods shoed positive response in growth rate. Crushed pod marketing provided alternative feed supply for livestock keepers. Herders buy crushed pod to supplement sheep and goats kept for selling to add value and for rental animals such as donkeys for loading. Crushing also improves feed value of the pods by availing protein rich seed to the animals.
- Earning money at house hold level by supplying pods to the pod crushing locations; organizing the community into cooperatives to process and sale pods to the local community. Households and cooperatives involved in collection and marketing of pod in Sedhafagae and Bedulale Kebeles raised income to complement household cash need. They obtained ETB 0.5 for each kg of pod they supplied to the cooperative.

Crushed *Prosopis* Pod feeding trial/demonstration

The action research was conducted by FARM-Africa in collaboration Amibara woreda agricultural office, and Werer EIAR to help control the spread of *prosopis* by crsusing the pods. The normal practice is that members of the local community would collect *Prosopis* pods and feed these 'as-is' to livestock at home. Out in the grazing fields livestock also munch and crunch the pods from the tree and whenever it falls on the ground during peak dry seasons. These practices promote the further spread of *Prosopis*, because the principal cause for the dissemination of *Prosopis* is the consumption of the sugary pods by domestic livestock and the passage of the seeds through the animal's digestive tract which results in the germination of the seeds in the moist feces. Thus the collection and crushing of the pods (after destroying the seeds through grinding) would greatly reduce the spread of *Prosopis*.

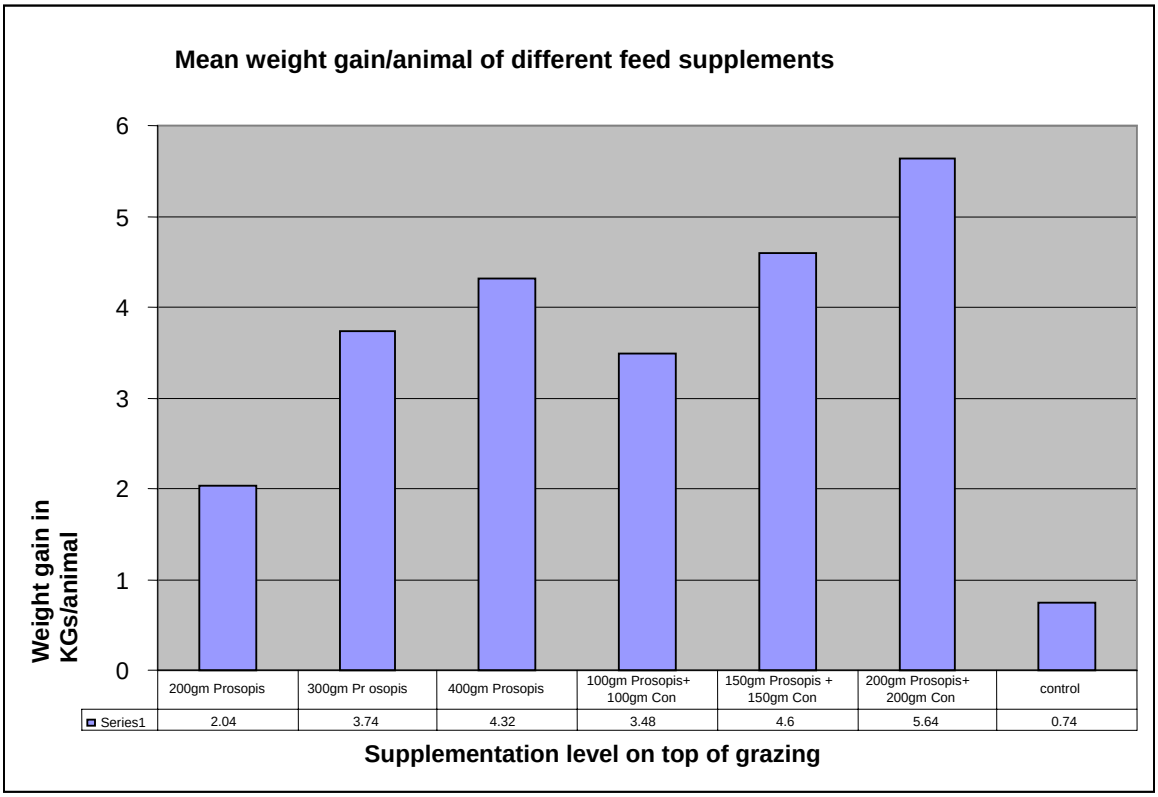
Plate 3 : Goats under the feeding trial

A demonstration site was established and was run for a period of three month time in the Sedhafage cooperative. The purpose was to create awareness among the local communities:

- On the advantage of providing crushed pod to their animals
- On the need to define an appropriate level of supplementation

A total of 35 goats were included in the trial, and these were divided into seven groups (six treatment groups and one control). The goats were allowed to freely graze during the day time under a traditional herding practice. In the evening the treatment groups were supplemented with different level of crushed *Prosopis* pod. The first three groups received 200, 300 and 400gm crushed *Prosopis*/day /animal, respectively. The rest three treatment groups were fed 50% mixture of crushed *Prosopis* pod and concentrate amounting 200, 300 and 400gm/day /animal, respectively. The feeding trial was

conducted for 12 weeks (18th May 2008 to 16th August 2008) - woreda agricultures office and Werer EIAR staff participated in the design and implementation of the demonstration trial.



Goats supplemented with mixture of 200gm crushed *Prosopis* pod and 200gm concentrate /head/day obtained highest mean body weight gain (5.64kg/head) followed by the group supplemented with 150gm crushed *Prosopis* plus 150gms concentrate feed (4.65Kgs/head). The group fed with 400gms of crushed *Prosopis*/animal/day was the third best performing group with mean total weight gain (over the three month) of 4.32Kgs/head. The result from the control group showed a total gain of only 0.74Kgs/animal over the three months period. Although this data needs proper analysis and comparison with similar researches done elsewhere, the overall performance appears very low. This could be due to the fact that the feeding was done during drought period. Although rain was expected in mid July, it was delayed until August and the pasture did not recover. The absence of the short rain (*Sugum*) early in the year (Feb-April, 2008) had also worsened the pasture availability in the area.

The observations from the action research indicate that:

- Supplementation of crushed pod increases the live weight gain
- Mixing crushed pod with other locally available supplements such as concentrate improves live weight gain as compared to sole *Prosopis* feeding

Prosopis Charcoal production and Marketing

FARM-Africa has been supporting local communities through provision of hand tools and organizing mass campaigns to clear *Prosopis* from pasturelands and cultivable areas. The approach couldn't get wider acceptance as there was no immediate benefit to the people. In the regional consultation workshop organized by FARM-Africa in 2004 on *Prosopis* control, the idea of control through utilization was raised with the principle of providing incentive for local people to be engaged on the control initiatives. Charcoal production and pod crushing for livestock feeding were two options endorsed by the stakeholders. Utilization of *Prosopis* tree for charcoal by clearing the stumps is assumed to restore the land, and the collection and crushing of the pods will also prevent further spread of the invasion to new locations.

Charcoal production was a banned activity in Afar region with a view to conserving indigenous tree species. Considering this, an agreement was reached for the regional government to issue a one-year license to four pilot cooperatives (Serkamo and Sedhafagae from Amibara woreda and Gelaladura and Beida from Gewane) to carry out the following:

- Clear *Prosopis* from invaded land;
- Use the wood for charcoal and fuel wood production; and
- Restore cleared land.

All the cooperatives were assisted in preparing a by-law which governs their activities. These included:

- Cutting the tree at least 10 centimeters below the ground to control coppicing (Shiferaw *et al*, 2004),
- Marking the boundaries of the areas of operation for each cooperative,
- Protecting indigenous trees species;
- Giving priority to pasture and crop lands; and
- Restoring cleared land.

Agriculture and cooperative offices were responsible to provide technical support to the cooperatives, to ensure the cooperatives abide by the by-laws, and to issue pass permits for *Prosopis* charcoal transportation. FARM-Africa played a facilitation role in the process. FARM-Africa also participated in building the technical and administrative capacity of the cooperatives and government offices to better manage the initiatives. These includes training on improved charcoal production techniques, introducing improved metal kilns, carrying out market study for charcoal and fuel wood, training on business management and leadership, and provision of start up capital.

Benefits to local communities

Cooperatives buy charcoal both from members as well as non members. The local people lack the experience in charcoal production, therefore it is mainly the migrant

laborers, who come to the area looking for daily labor at the state and private farms, which produce and sell the charcoal to the cooperatives. The cooperatives transport and sell the charcoal in major towns, commonly Addis Ababa. The arrangements of production, marketing and benefit distribution vary from cooperative to cooperative (Table 4). Average selling price for charcoal at Addis Ababa to whole sellers was 36.32 ETB/bag although it can drop up to 29 ETB/bag when the market is saturated. This was observed especially after establishment of many cooperatives in the area and (three in Amibara and seven in Gewane) and when individuals and investors started to be involved in charcoal production and marketing. The wholesalers sell a bag of charcoal on average at ETB50 rate to the retailers while the retailers sell on average ETB66/bag. This shows that on average the cooperatives, the wholesalers and the retailers get profit margins of ETB6.9, 13.68 and 16/bag of charcoal sold respectively (Table 5).

Plate 4 : *Prosopis* charcoal ready for sell

Table 4: Costs and benefits of charcoal marketing for cooperatives and traders (Oct 2004-Sep 2005)

Description of costs and income	Cooperatives			Average
	Serkamo	Sidehafagae	Gelaladura	
Production cost				
Charcoal purchasing cost/bag	12	18	13	14.33
Expense for a bag	2	2	2	2.00
Clearance of brushes	6	0	0	
Subtotal	20	20	15	18.33
Marketing cost				
Income tax to finance office	0.4	0.4	0.4	0.40
Charcoal transportation	7.15	7.34	10.72	8.16
Allowance and transport for sellers	1.79	1.5	4.29	2.53
Subtotal	9.34	9.24	15.41	11.09
Total expense	29.34	29.24	30.41	29.42
Cooperatives selling price to wholesalers	37.95	36.01	35	36.32
Profit to the cooperative	8.61	6.77	4.59	6.90
Wholesalers selling price	50	50	50	50.00
Whole sellers gross margin	12.05	13.99	15	13.68
Retailers price	66	66	66	66.00
Retailers gross margin	16	16	16	16.00

Source: MSc thesis, Dubale Admasu (2006) and partly from Tefera (unpublished)

In one year operation period (Oct 2004-Sep 2005) three sampled cooperatives bought and sold 188,246 bags of charcoal, earned a net profit of ETB 1,131,758 or $US 131,600 and cleared about 396 hectares of invaded lad (Table 2).

Considering 100 bags charcoal production per charcoal maker per month, the 188,246 bags produced and sold to the three cooperatives created job opportunities of 56,474 person-days to daily laborers. Considering the current daily labor payment ETB10, this is worth of ETB 560,474 or USD56, 047.

Table 5: Cooperatives charcoal purchase and marketing profile

Name of cooperative	MEM No.	Bags of Charcoal sold	Income (ETB)	Expense (ETB)	Profit (ETB)	Area harvested (hectares)	Working period
Serkamo	63	151,334	3,965,902	2,930,471	1,035,431	250	Oct2004-Sep 2005
Sedehafagae	87	24,291	706,069	630,460	75,607	100	Oct 2004-Sep 2005
Gelaladura	29	12,621	441,735	421,015	20,720	46	Oct2004-Sep 2005
Total	179	188,246	5,113,706	3,981,946	1,131,758	396	

Source: MSc thesis, Dubale Admasu (2006)

As result of the charcoal production and marketing interventions, cooperative members obtained substantial monthly incomes (e.g. up to 750birr in Serkamo), received annual dividend payments (1,500 ETB/member in Serkamo and 1257ETB in Sedhafage), and obtained good harvest from land cleared and cultivated in Gelaladura (Plate 5).

Plate 5: Maize farm in Gelaladura on land cleared from *Prosopis*

Some superior performing cooperatives such as Serkamo purchased assets such as ISUZU truck and tractor for charcoal transportation and cultivation of the cleared land, respectively. Other benefits from the intervention include; cooperatives that provide credit facilities and social support to community members and income to the government through taxation. When the cooperatives were operational it was known that illegal charcoal production was reduced as the illegal charcoal producers started working under the cooperatives. Moreover, the cooperatives themselves monitor the illegal charcoal production in their respective areas and report cases to the agriculture offices as they become resource competitors.

Workshops and meetings organised by FARM-Africa created critical awareness about the impacts of the invasion and opportunities for controlling the invasion through utilization. Provision of licenses for the cooperatives by the government authorities also motivated local people to be engaged on charcoal marketing. Within a year, several cooperatives emerged seeking the benefits of charcoal marketing, with the long term view of controlling *Prosopis* and reclaiming land.

Contributions of charcoal making to the control of Prosopis invasion

The pilot intervention evidenced that cutting the tree 10cm below the ground level for young trees; and up to 40 cm for the matured *Prosopis* trees was effective to prevent coppicing. However, sustainable restoration of the land depends on the potential of the land and follow up activities done after clearance of the stumps. Total of 616 hectares of land covered by *Prosopis* were cleared ending during in October 2004 by the initial 4 cooperatives. In areas where *Prosopis* trees were cleared, the stumps removed and cultivated due to availability of irrigation water, the land was reclaimed (e.g. Gelaladura and Urafita kebeles). However, the land needs to be cultivated continuously to disallow germination of *Prosopis* seedlings emerging from the soil seed bank, or from the additional seed load coming from animal manure/droppings, or brought by flood. In pasture lands, despite cooperatives' effort to remove the stumps after failing the tree for charcoal production, it was re-invaded from the seeds in the soil or new seed load from animals or flood. Pasture land users were not mobilized to clear emerging *Prosopis* seedlings to restore the land to its original use. Of 616 hectares of cleared land, only 71 hectares were cultivated with food and cash crops such as, maize, onion, sesame, etc. Apparently, respondents witnessed that the invasion was worst in pasture lands after the removal of the mature trees for charcoal production.

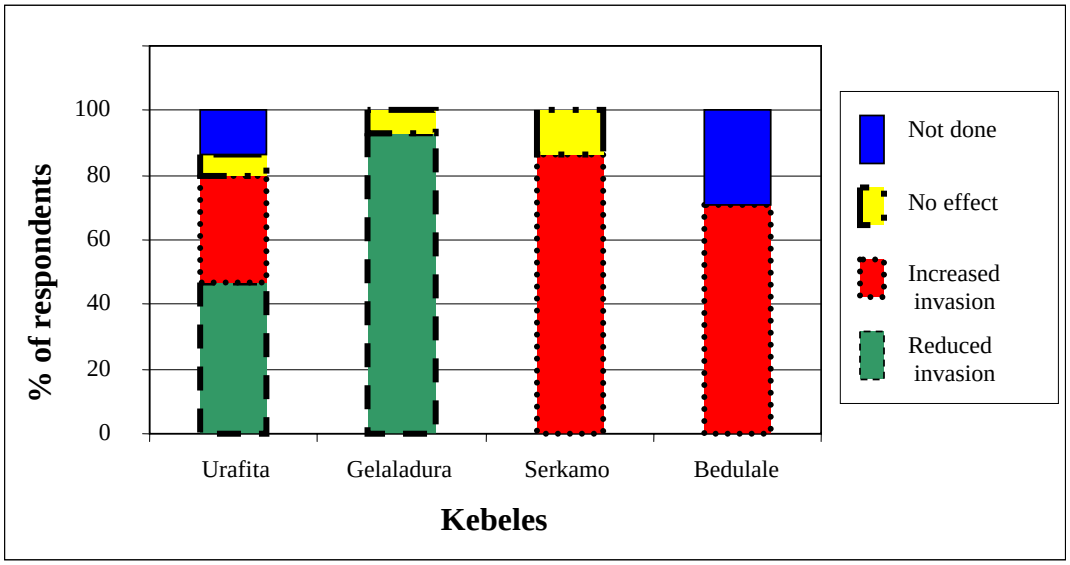


Figure 1: Opinion of respondents on the contribution of charcoal production to reduce Prosopis invasion

Source: MSc thesis Dubale Admasu (2006)

Seedlings emerged and coppices from unattended stumps formed impenetrable thickets, which challenged people and livestock mobility, caused mechanical injuries to people and livestock, reduce the use of pod for livestock feed (as matured trees were failed),

worsened the feed shortage, and harbored more predators (hyenas, foxes, lions, leopard and snakes) which attacked animals and even children.

In some, areas although the stumps were cleared and seedlings uprooted to rehabilitate the land-due to lack of land use right- cooperative members were not allowed to manage and use the land and it was re-invaded (e.g. case of Sedhafagae Kebele).

Except for Sedhafagae, where there has been a concerted effort put in place, other cooperatives (Serkamo, Gelaladura, Beida) were loose in the strict follow up of the guidelines of the *Prosopis* clearing-the charcoal makers usually left the stumps during cutting. To ensure stump clearing the Serkamo cooperatives tried to enforce the guidelines by withholding 2 ETB/bag of charcoal, if stumps were not cleared. However, the producers preferred to leave the 2 ETB/bag and sell the charcoal at 10 ETB/bag.

Plate 6: Stumps not removed

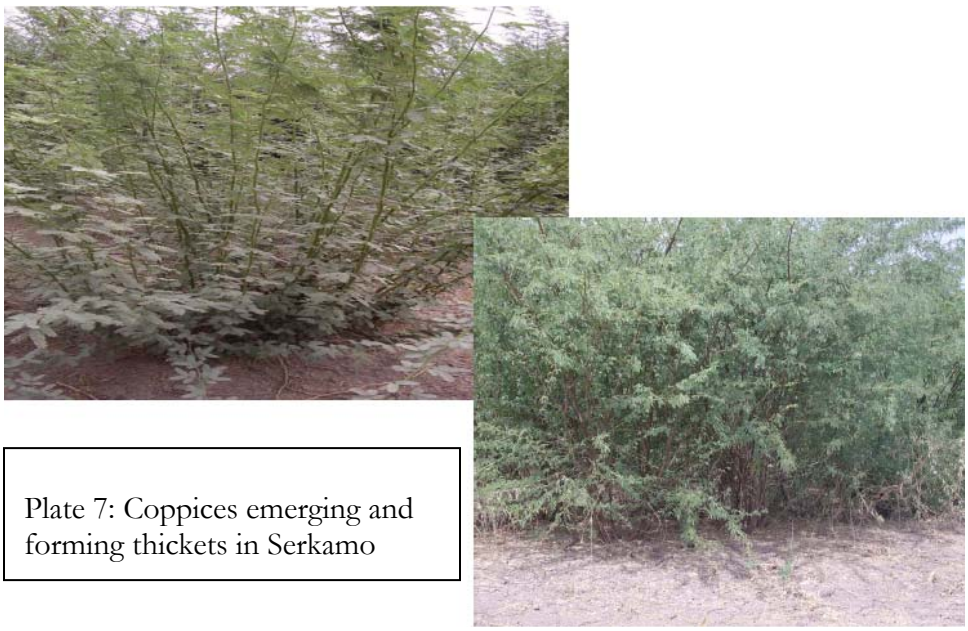


Plate 7: Coppices emerging and forming thickets in Serkamo

Limitations

Community level

Some cooperatives failed to respect their working territory, and even moved outside their Woreda breaking the agreement in their by-laws. Although their operation created more job opportunities outside their location, it has opened loopholes for the charcoal makers to cut indigenous trees for charcoal production because they could not be supervised by the government office or by the cooperatives. Moreover, it causes conflict between the cooperatives and residents of the expansion areas.

The government staff also felt that the traditional natural resource management system which protects indigenous trees has been weakened since the charcoal production was introduced. This is because some of the leaders who were responsible to lead the protection, locally called '*Feima tabas*', and the other local leaders were involved in charcoal marketing. However, local people do not agree with this idea. They associate the loss of the indigenous trees totally with the *Prosopis* invasion. There were evidences that the indigenous tress were being used for charcoal from the stumps left on the cleared land. The bottom line is therefore the inability to enforce the by-laws in clearing the land. The forest guards, based at community level, who are paid by the government, do not work closely with the traditional leaders or with the cooperatives so they are underutilized and their contribution was not reported. There was also no communication and coordination among the cooperatives engaged in charcoal marketing. The prices offered to the cooperatives are very low as compared to proportional increases of price at the terminal markets in Addis. The charcoal production techniques are traditional, and all of the charcoal makers use Earth mound kilns. Introduced metal kilns were not adopted as the production per cycle from these

was low. Only less than 10 bags were obtained from one metal kiln, while an Earth kiln provided 150 bags.

The participation level of members in the cooperatives was low, and there is some level of mistrust. The mistrust and splits between the members and the management committees emanated from the fact that major decisions were made by a few management committee members-usually by the chairperson. Also the cooperative's marketing and accounting systems are not well organized, and transparent enough. Charcoal was sold without formal receipt, and vouchers are not issued properly for expenses. Transactions were recorded in files, which lacked proof, and this makes auditing unmanageable.

Because the cooperatives were not organized under one umbrella system, there was unnecessary competition between them in markets, which usually lowered the price of charcoal to the advantage of wholesalers. The charcoal marketing business looks profitable but it's sustainability is questionable. This is because the resource can be depleted in a short time, as what had happened to the Serkamo cooperative, and that the operation is very dependent on external laborers'. Local people need to be involved in the intervention by introducing technologies which will be attractive to them. If the size of the metal kiln introduced is improved to produce larger quantity of charcoal, it would encourage local people to engage in the charcoal production and diversify their livelihood and better cope with chronic food insecurity. Metal kilns require less labor and less time which will attract local communities some of which are not much used to physical work.

Government level

Regional PARDB issued licenses to many cooperatives in the same year before the performance of pilot cooperatives was assessed; before required extension and regulatory support were provided, and without making sufficient planning and community mobilization at the ground level. Charcoal production permits were also given to private investors who cleared indigenous trees, such as *Acacia nilotica* and *Tamarix aphylla,* to produce and market charcoal, but also to free land for cultivation. All this created resource competition among users. Field level monitoring became almost impossible, and this further led to an out of control operation in most places.

There was no special bag or identification system to differentiate charcoal produced from *Prosopis*, and other sources. Pass permits were obtained without any countercheck at the field level. Based on this lesson, sample bags were produced with labeling and serial number, and these bags were to be used for *Prosopis* charcoal only. Pass permit printing was not centrally controlled by the zone or the region, but was handled by the cooperatives in the beginning and latter on by individual officers in the agriculture office. Woredas, even where there was no invasions, started to print and issue the pass permits for charcoal produced from any source. In the latter days of the operation, the pass permits were sold to individuals for ETB300-500 to transport 150 bags of charcoal.

This has contributed to the uncontrolled charcoal production and marketing- a move that totally lost its objective.

The regional government banned all the cooperatives and individuals, and abruptly closed all gates of passage. Some cooperatives lost a substantial amount of money, as they were not able to sell the charcoal they had in stock. Gelaladura cooperative lost an estimate of over ETB 35,000. Closure of the checkpoints, however, increased the illegal charcoal production and marketing in the area. Charcoal makers are still making and selling charcoal on the roadside, and a sizable portion of these is also trucked to Addis Ababa.

Lessons learned on charcoal production

- *Prosopis* control has come to the attention of ANRS government and draft regulation is produced to strengthen the extension and regulatory support on *Prosopis* management in Afar region. Local communities attained better capacity and awareness on *Prosopis* control.

- Indigenous trees, shrubs and grass which were lost due to *Prosopis* invasion from the pasture land were recovered when *Prosopis* was removed and emerging seedlings were uprooted to allow the indigenous plants space to grow.

- Despite the reduced labour demand and time for charcoal burning, introduced metal kilns could not get acceptance. This is due to low volume of charcoal produced per cycle as compared to the traditional system. The metal kilns need to be modified to improve the amount of charcoal produced for better acceptance.

- There was almost no involvement of women in the charcoal production and marketing cooperatives. There were amendments made in the process where some cooperatives included women as members as well as in the management committees. A good example is the Sedhafagae Cooperative where the vice chair person is now a woman, Ms Gello Umer.

- The new *Prosopis* management project needs to refine the regulation and lobby for its approval by the ANRS council and assist preparation of detailed implementation plan. If the regulation is endorsed and capacity of the Woreda agriculture offices is strengthened to implement it and is supported with detailed implementation guideline, limitations will be minimized and create enabling environment for the communities to be engaged in the management of *Prosopis*.

- There is a potential to control the spread of *Prosopis* to farmlands and key pasturelands by promoting utilization, which provides economic incentive to local people to be involved in the management if planned and regulated carefully. The pilot initiative was not supported with realistic land use plans especially for cleared pasture lands. Before starting the management intervention, invaded areas need to be properly mapped, intensity of invasion defined, the potential of

invaded land needs to be well studied with full participation of local communities. Based on the plan appropriate control measures and follow up management activities need to be done to restore and utilize invaded areas. Although the local people need to be in the front line in the management of the invasion, as the invasion covers huge area and the intensity is sever, external support in terms of community mobilization, technology transfer, private sector participation, and supply of resources is inevitable.

Rehabilitation of Prosopis invaded areas

Under the Pastoral livelihood Initiative (PLI) Project (2005-2008) community members were supported to clear and restore *Prosopis* invaded areas. Because of the ban on charcoal marketing, interested community members in Amibara and Gewane Woredas were organized in to cooperatives (Bedulale, Omerfagae and Adbaro Kebeles) to clear *Prosopis* and cultivate the land with forage, food crops and cash crops to improve their livelihoods. In a one year operation period, the three cooperatives cleared and cultivated 25, 11 and 4 hectares of land, respectively. Two cooperatives (Bedluale and Omerfagae) which started the interventions earlier were able to obtain income of ETB 12,700 and 6,750 from sell of cash crops such as vegetables and sesame from one cropping season.

Being attracted by the cooperatives performance, government institutions and other projects are supporting the cooperatives to intensify the restoration of invaded areas. EIAR- Removing Barriers to Invasive-plants Management Program selected the Bedulale cooperative to demonstrate restoring invaded areas with multipurpose endogenous fodder trees. The regional PARDB cooperative office approved credit of 150,000birr for the same cooperative for one year to expand their *Prosopis* management activity. Detailed flood protection and flood water harvesting design work was done for the Bedulale site in collaboration with EIAR-Werer station staff and Awash Irrigation Authority. Regional PARDB promised to finance the water harvesting structure construction.

Plate 8: Areas cleared from *Prosopis* and cultivated with different crops

Pasture development

Vegetables

Sesame

Improved variety of maize

WAY FORWARD

The *Prosopis* dilemma is only one example of the many problems brought about by the introduction of new species without proper scientific study concerning their long-term effects on the people's livelihoods, environment, preferred management, and optimal forms of utilization. Unfortunately, practical experiences from many parts of the world have now shown that complete eradication of established *Prosopis* is virtually impossible. There is a need to find ways of better utilizing and managing *Prosopis*, with an eye towards controlling its spread. Successful interventions would require extensive collaboration among government, non-government and private sector groups. These efforts require a multi-pronged approach involving policy and technical aspects.

The development of regional legislation and policy concerning *Prosopis* management and utilization could provide a framework for communities interested in using it as a resource and preventing future invasions. Because *Prosopis* affects pastoral, agro-pastoral, and agricultural communities in very different ways there may not be a one size fits all solution to the problem. At the local community level *Prosopis* issues should be evaluated and appropriate land use practices should be agreed upon by the stakeholders. The effect of the current non land-tenure system on the management of invaded lands differs by locality. Land use rights including grazing, pod harvesting, and wood extraction may be used most efficiently if several groups can agree to cooperatively use the resource in complementary ways. This may or may not require permanent land tenure rights.

Controlling the spread of new *Prosopis* infestations will be more cost effective than trying to eradicate existing stands. A general policy guiding regional control measures should be informed by a quality survey of the existing *Prosopis* invasion. Policy guidelines could include a quarantine period for animals being fattened on unprocessed pods as well as funding for education and awareness of animal seed dispersal problems. It is important that education efforts to control *Prosopis* spread are targeted to communities that exist on the periphery of the existing invasion.

Prosopis **management**

The scope for addressing *Prosopis* problems via government policies and legislation is vast. Local enforcement of regulations is also vital. The legality of introducing of alien species should be addressed. The process of land adjudication and promotion of appropriate land use needs urgent attention. Improved management and control of *Prosopis* requires organized efforts in terms of public education and public awareness-raising. This includes promotion of how *Prosopis* products could be best harvested and used. In other developing countries economic value has been added to some types of *Prosopis* products, and this involves comprehensive efforts incorporating product certification and marketing. Success stories revolving around wood prominently include firewood, charcoal, building materials, floor tiles, furniture, and handicrafts. Other opportunities involving non-wood products include processing for livestock feed, human food (toasted seeds), possible medicinal values, gum production, and tannin extraction.

Mobilizing people to better deal with *Prosopis* is a large problem. It would require full appreciation of constraints and opportunities imposed by socio-economic features of local societies. These include attitudes and values with respect to community participation in resource management issues, problems that poverty imposes on people's priorities, conflicts in land use, land tenure, the role of rural insecurity in resource use, and constraints in the availability of labor. Research is needed to assist this process- and it could include policy analysis and studies devoted to verifying attributes of *Prosopis.* There is also a need to carefully document success stories and constraints in the harvest, processing, and marketing of promising *Prosopis* products.

Coordination and net working

A workshop, on 2-3 April, 2008, organized by CARE PLI, FARM-Africa, and the Afar Regional state pulled together various local and international organizations that are directly and indirectly involved in works related to *Prosopis*, and this included EIAR, Institute of Biodiversity Conservation, Forestry Research Institute, Ethiopian environmental authority, the MoARD, GL-CRSP PARIMA, and SAVE the Children/USA.. The main objective of the workshop was to share ideas and experiences on management and utilization of *Prosopis*, and also to harmonize activities and to develop synergy between all stakeholders. The workshop identified research and development gaps, and suggested practical steps to move this concept forward and recommended the formation of a *Prosopis* forum. The workshop that led to the formation of the *prosopis* forum had also the following key outcomes:

- Experiences from different institutions were shared and interventions were identified for scaling up
- Representatives of the regional council promised to take the *Prosopis* management issues in general and the draft regulation case in particular to the regional president.
- Woreda and region participants were committed to include *Prosopis* control activities in the new budget year
- Regional PARDB promised to open a post and assign someone as well as plan required logistic for *Prosopis* management activities
- There were some overlaps observed in some activities carried out by few institutions, and this is understandable, given that there was no harmonization of activities thus far.
- The *Prosopis* forum will be led by ANRS PARDB, and will have the following functions:
    - To bring together actors on *Prosopis* management and control and lobby for appropriate policy
    - To disseminate information's that will assist *Prosopis* management
    - To search and mobilize inputs
    - To identify models and approaches that have shown promise in *prosopis* management
    - To actively participate in a national workshop to help bring together all efforts made so far in the country and document them. EIAR-Removing Barriers to Invasive Plants Management in Africa will host the workshop.

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