Invasive Plants and Food Security: the case of *Prosopis juliflora* in the Afar region of Ethiopia

prepared by Dubale Admasu (FARM-Africa) for IUCN
December 2008

1. Introduction

Invasive plant species, introduced deliberately or accidentally to different parts of the world (), can cause important economic, environmental and social losses (Anderson, 2005).

This case study reflects on the invasion of *Prosopis juliflora* in the Afar region of Ethiopia, revealing the serious potential impacts of invasive plant species on people's food security and livelihoods. It discusses the lessons learnt from subsequent management interventions by FARM-Africa in collaboration with local partners. These lessons may serve to alert other communities, practitioners and decision-makers in areas susceptible to the same problem of the high risks and costs of invasive species, and contribute evidence advocating for enabling policy environments to effectively manage invasives species.

2. Invasive plant species in Ethiopia

Ethiopia is one of the poorest and least developed countries in the world with 31 million people living below the national poverty line (on less than half a dollar a day) and over 80% of its 84 million people living below a poverty line of $2 a day. Every year six to 13 million people are at risk of starvation due to food shortage (MoFED 2006). The situation is worst in arid and semi-arid parts of the country which are economically and politically marginalized, where the rainfall is inadequate, recurrent droughts are experienced and infrastructure is undeveloped. These conditions make it particularly difficult for local people, dependent on their livestock as a source of food, income, and savings, to secure their livelihoods. The added impact of invasive species can further intensify food insecurity and increase vulnerability to hazards and risks.

Local studies have shown that invasive plant species can directly or indirectly affect the food security of local residents. In areas where they spread, invasives can destroy natural pasture, displace native trees, and reduce grazing potential of rangelands. They compete for and reduce productivity of croplands. Plants like the water hyacinth also block water ways for irrigation, navigation, electricity generation, fishing and livestock watering. They increase water loss. Some pose health risks to livestock and humans in the invaded areas by impairing mobility or causing injuries. The spread of invasive plant species in Ethiopia is a growing concern in national parks, lakes, rivers, power dams, and urban green spaces - causing huge economic and ecological losses (Hailu et al., 2004, Kassahun et al. 2004, Senayit et al., 2004, Taye et al., 2004c, Taye et al., 2004d.)

The Federal Government of Ethiopia has identified a number of major invasive plant species in the country and declared the need for their control and eradication (Taye et al., 2007). These include, parthenium weed (*Parthenium hysterophorus*), water hyacinth (*Eichhorniacrassipes*), mesquite (*Prosopis juliflora*), and Lantana camara and Acacia species, such as *A. drepanolobium*, *A. melifera*. The Environment Policy of Ethiopia, the Forest Resource Strategy and the National

Biodiversity Strategy and Action Plan, recognize invasive plant species to be growing threats to the biodiversity of the country and socio-economic welfare of the people (Anagae et al., 2004). At the national level, however, there is no clear policy or strategy for the control and management of invasive species (Anage et al., 2004; Fisehaye, 2006), and little attempt has been made in terms of their research and management. This case example of *Prosopis juliflora* in the Afar region, nonetheless shows the socio-economic and environmental risks that can arise if invasives species are left unmanaged, and advocates for a strong policy and strategy in Ethiopia to deal with them.

3. Impacts of prosopis on food security and livelihoods in Northeast Ethiopia

Prosopis juliflora is a multipurpose dry land tree or shrub native to South America, Central America and the Caribbean (Pasiecznik et al., 2001). It has been introduced and naturalized in many parts of the world (Africa, Asia, and Australia) during the last 100-150 years (Pasiecznik et al., 2001). However, despite its qualities and uses in its natural range, prosopis becomes a serious invading weed when introduced into non-native areas without proper management (Shiferaw et al., 2004).

In the Ethiopian context *Prosopis juliflora* was wrongly introduced in the 1970's by Ministry of Agriculture to high quality pasturelands and irrigable areas, including the Awash River basin in the Afar National Regional State (ANRS) of Northeast Ethiopia (figure 1) (HDRA, 2005a). Local people were not informed about the invasive nature of the tree at first and were not advised on management practices to minimize its spread (Dubale, 2006). As a result the plant rapidly invaded vast areas of agro- and silvo-pastoral lands, affecting both the biodiversity and socio-economic environment (plate1).

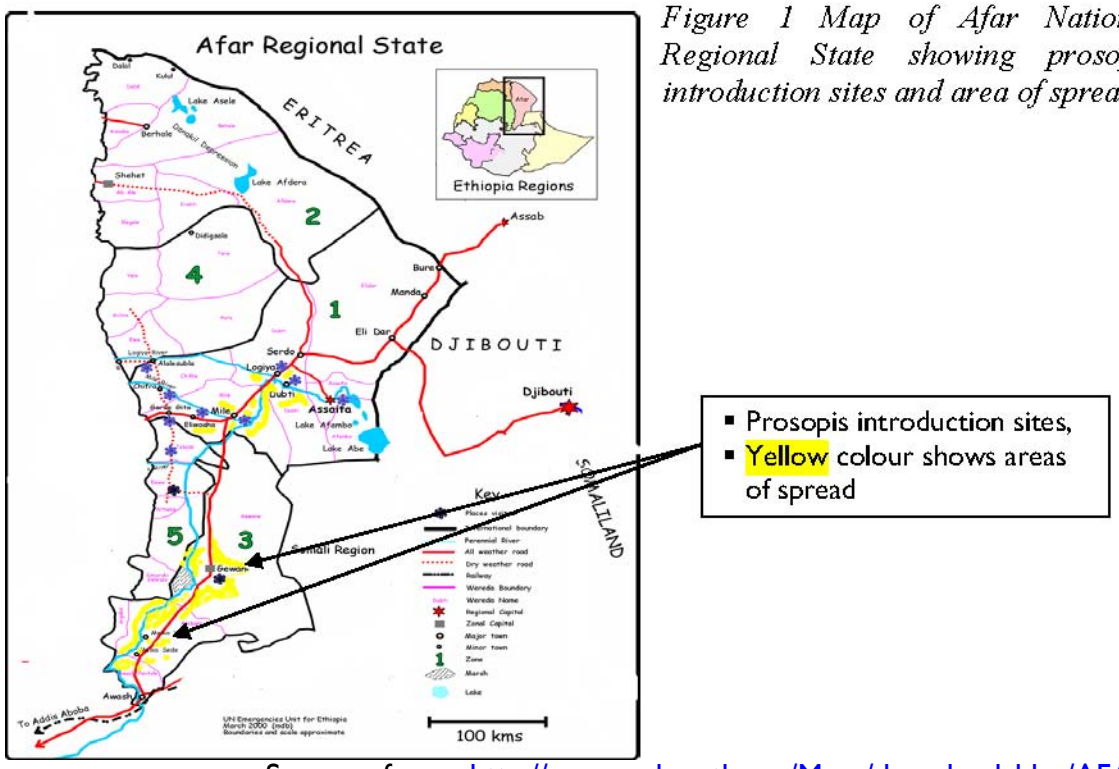

Figure 1 Map of Afar National Regional State showing prosopis introduction sites and area of spread

Source of map: http://www.ocha-eth.org/Maps/downloadables/AFAR.pdf

Over 700,000 hectares of prime grazing land and cultivable land following the Awash River is currently either invaded or at risk of invasion from prosopis in the Afar Region (US FS, 2006). This accounts for 15% of the region's productive land (4,670,316 hectares), excluding wetlands, water bodies, sandy and rocky areas (4,856,251 hectares). Refer table 1.

Table 1: Afar National Regional State land use cover

Land use type	Hectares	% coverage
Cultivated land	51,919	0.5
Grass land	1,409,426	14.8
Shrub land	3,005,719	31.6
Woodland	164,152	1.7
Natural forest	10,379	0.1
Reverine forest	28,721	0.3
Water	82,140	0.9
Wetland	48,860	0.5
Exposed soil, sand or rock	4,725,251	49.6
Total area	**9,526,567**	**100.0**

Source: Woody Biomass Inventory and Strategic Planning Project document (2003)

The prosopis invasion exists in four of the five zones and 11 of the 29 Woredas (administrative divisions) of the Afar Region (table 2).

Table 2: Zones and Woredas of Afar Region invaded by prosopis and status of spread in 2008

Zone	Woreda	Status of invasion
Zone 1	Dubti	Severely invaded
	Mile	Severely invaded
	Logya	Partly invaded
	Hadar	Partly invaded
Zone 3	Gewane	Severely invaded
	Buremoditu	Severely invaded
	Amibara	Severely invaded
	Dulecha	Partly invaded
	Awash 7 Kilo	Partly invaded
Zone 4	Yallo	Recently observed
Zone 5	Dalifagae	Recently Observed

Source: Pastoral Agriculture Rural Development Bureau (personal comm. 2008)

In the Afar Region people are predominantly pastoralists dependent on livestock rearing, or agro-pastoralism for their survival. However, the prosopis invasion, coupled with recurrent droughts that strike the area, has left the people unable to maintain these subsistence livelihoods.

According to local communities, the prosopis invasion has resulted in multiple negative effects on their food security, livelihoods and the region's environment (Dubale, 2006). The invasion of prosopis has caused considerable declines in livestock production and productivity due to the loss of dry season grazing areas to prosopis plants. Palatable indigenous pasture species such as *Chrysopogon plumulosus, Cenchrus ciliaris* and *Setaria acromelaena* have all reduced. Indigenous trees such as *Acacia tortilis, Acacia senegal* and *Acacia nilotica* have also declined in the rangelands due to the invasion. Pods and branches of these trees are the main dry season feed sources for livestock. Zelalem (2007) reported that camel ownership has reduced almost by one-third over the last five years alone while the mean number of calves and heifers was reduced by five fold. He also noted a higher rate of decrease in numbers of sheep and goats compared to camels, perhaps due to the relative advantage of camel to browse tall woody plants.

Box 1: Local opinion about Prosopis

An elder in Gelaladura Kebele of Gewane woreda, Afar region, commented that "we used to have only one traditional enemy, the Issa tribe, but now we have the worst one, Woyane hara" [the local name for prosopis]. He added that "some external people get confused about merits of Prosopis when they see local people using the tree for different purposes. Of course we use the tree for different purposes such as fuel wood, fencing, house construction, charcoal making, pods for livestock feed, because we do not have an alternative. We would prefer it though if we could eradicate prosopis and get back indigenous trees and the pasture land". *Source: Admasu (*2006)

Feeding livestock exclusively on prosopis pods for extended periods, due to lack of pasture in the invaded areas, has resulted in health problems to animals such as constipation, dental disfiguration and reduced overall productivity. Local people call the diseases in cattle Harmeko. According to their observations cattle manifesting Harmeko will die after prolonged loss of body condition.

People and livestock suffer from injuries from the sharp and poisonous prosopis thorns. Local people also say that predators (hyena, jackal, lion and leopard) attacks on livestock have increased since the prosopis invasion. In agro-pastoral areas, damage to the crop fields from wild herbivores such as warthog and bushpig has increased due to more hiding places in the prosopis thickets.

Box 2: Livestock mortality reported associated with prosopis invasion

Ato Genetu Mohamed is a pastoralist in Halidegae Kebele of Amibara woreda in Afar region. In an interview made by Ethiopian TV (2008) he indicated that he lost a total of 40 cattle since prosopis has severely invaded the area. 'Palatable indigenous grasses and tree fodder which were our traditional dry season livestock feed are lost and the livestock cannot withstand the recurrent drought striking the area. Some of my cattle also died due to injury from prosopis thorns. Once they are wounded they are not able to travel and feed themselves, they lose condition and finally die'. In the same interview W/o Hadi Mohamed, a pastoralist in Sedhafagae Kebele reported losing 30 cattle for the same reason.

Local people also perceived that malaria cases increased since invasion of prosopis. According to their observations, the moist microclimate in invaded areas provided a favourable environment for mosquito's multiplication. This observation was similar to reports from Kenya also experiencing the invasion of prosopis. (Mwangi and Swallow, 2005)

With the decline of grazing and cultivable land, coupled with recurrent droughts, people in the Afar region became highly food insecure and dependent on government food aid for their survival. In highly invaded areas people are now reliant on food aid on average for 5-6 months in good years and for up to 10 months in drought times (PCDP, 2005).

With these considerable impacts in local productivity, the majority of the pastoralists were forced to diversify their livelihoods to include crop farming, daily labour, charcoal production and trade or combinations of these. In a 2006 survey conducted in Gewane and Amibara districts (Dubale, 2006) it was recorded that 77% of the interviewed pastoralists diversified their means of living to selling labour for private and government state farms, involved themselves in charcoal production and trade and carried out shared cropping with emigrant labourers. Similarly, 87% of the interviewed agro-pastoralists engaged in other activities such as selling labour, charcoal production and trade (Table 3).

Table 3 Impact of *Prosopis* on local livelihoods

Occupation	None	Charcoal production	Selling labour	Crop farming	Selling labour & farming	Selling labour & charcoal	Farming & charcoal production	Total
Pastoralist	23%	5%	59%	5%	0%	9%	0%	100%
Agro-pastoralist	0%	0%	5%	14%	77%	0%	5%	100%
Total	**11%**	**2%**	**32%**	**9%**	**39%**	**5%**	**2%**	**100%**

Source: Admasu, 2006

4. Responding to the Invasion

4.1 What was done?

FARM-Africa, an international non-governmental organisation, organized several workshops bringing together community members, government officials and technical experts to discuss and create awareness of the effects of *Prosopis juliflora* as well as to introduce possible interventions to prevent further expansion of the invasion. Options for using the plant that would contribute to the control of the invasion and provide additional income to local people most affected by the invasion were given priority.

The control methods introduced included the following:

i) mobilizing communities to uproot seedlings from newly invaded areas, and restoring these area;

ii) cutting matured trees 10-30 cm below the ground level (depending on age of the tree to prevent coppicing) and using the wood for charcoal production; and

iii) reducing the dispersal of seeds by livestock and wild animals that feed on the pods of the prosopis and are unable to fully digest the seeds. To reduce this effect, pod collection, crushing (to kill the seeds) and sales for livestock feeding were demonstrated.

At the same time as seeking means to eradicate or control the invasion of prosopis, efforts were made to identify potential livelihood benefits from the plants, as incentives to better manage the invasion. Because prosopis tends to establish itself so well, including in arid lands where other tress fail to survive, it is known to provide various socioeconomic benefits (Mwangi and Swallow, 2005). These include wood products (firewood, fuelwood, charcoal, fence posts, poles, sawn timber, furniture, flooring and craft items), as well as non-wood products (flour for cakes, biscuit and bread, pod syrup, coffee substitutes, animal fee, honey, wax and exudates gum).

In the Afar region, charcoal production and pod crushing was introduced in areas where prosopis was established well and had mature trees that had started setting pods. To pilot the interventions four cooperatives were established in Gewane and Amibara districts and were granted official licences by the government to implement the identified activities.

Plate 2: Metal kiln on use Gewane

Cooperative members were trained and technically supported in how to manage their interventions which included: prosopis tree harvesting techniques to prevent coppicing; utilization of time and labour efficient charcoal production techniques using metal kilns (Plate2); pod collection, drying, and crushing using small hammer mills and normal flour mills (Plate 3) and cooperative leadership and financial management.

Plate 3: Prosopis pod ready for crushing, small hammer mill and normal flour mills were introduced

A market survey was carried out to better understand the charcoal trade in cities such as Adama (Nazareth) and Addis Ababa. The local cooperatives were then linked with the wholesale merchants in the surveyed areas. The cooperatives were given hand tools, sample metal kilns, sample pod crushing mills and "seed money" to initiate charcoal trade. The Ethiopian Rural Energy Promotion Centre (which has done research on improved charcoal production techniques) and private companies

with interests in the export of charcoal to the Middle East supported the introduction of improved charcoal production techniques.

Prosopis juliflora pods are highly nutritive and consumed by domestic and wild animals. Collecting and crushing the pods was assumed to contribute to the reduction of seed load to the soil and so minimize further spread of the invasion to new areas. In the beginning, four small hammer milLs (11kg of pod /hr crushing capacity) and later normal flour millS of higher capacity (25HP crushing 400kg/hr) were introduced to handle the large volumes of pods available. The cooperatives are also linked to feed processing factories in Adama and Mojo to sell prosopis pods, crushed or fresh.

In areas where there is better access to irrigation water, communities were supported with farm inputs and training to manage cleared land for pasture and crop production to prevent re-invasion. This activity was carried out in collaboration with the Ethiopian Institute for Agricultural Research Gewane Agricultural Technical Vocational College for technical support.

4.2 What major changes occurred?

a. Benefits from prosopis pod sales

Pod collection, drying, crushing and sales activities showed a substantial demand for the crushed pods by livestock keepers and feed processing factories. The activity benefited both local people and the cooperative that engaged in selling the crushed pods (Plate 4). The cooperatives bought pods at a rate of 0.50ETB[1]/kg and sold crushed pods to livestock keepers at 2.50ETB per kilogram. One of the active cooperatives engaged in pod crushing, Sedhafagae Cooperative, crushed and sold 10,000 kg to local people and government institutions. Local people who supplied pods to the cooperative obtained about 15,500ETB while the cooperative earned a profit of 17,000 birr from the activity after covering all expenses except electricity (electricity bill was not received when the profit was calculated).

Plate 4: Selling crushed pod, Sedhafagae

In addition to controlling the spread of prosopis to new areas, this intervention provided high quality feed to livestock rearers and helped local people raise additional income to better cope with the chronic food insecurity in the area caused by the prosopis in the first place (Plate 5).

Plate 5 : Feeding goats crushed pods

[1] ETB = Ethiopian Birr; one US$ = 10 Birr at the average 2007 rate

b. Prosopis pod feeding trial

A crushed prosopis pod feeding trial was conducted by FARM-Africa over a three month period (18 May - 16 August 2008). The objective of the trial was to raise awareness amongst local communities of the benefits of supplementing livestock pasture with crushed pod and to measure the productive benefits of supplementation. The local agriculture office and staff participated in the design and implementation of the demonstration.

The overall performance of goats supplemented only with prosopis in addition to normal pasture was low. This could be due to the fact that the feeding was done during unexpected drought period when there was severe pasture shortage. However, goats fed a mixture of 50% prosopis – 50% concentrate corn feed, showed considerably better performance as compared to the control groups on normal pasture grazing (see figure 2). The trial needs to be conducted throughout the year to avoid seasonal biases and better understand contribution of prosopis pod supplementation.

Plate 6: Goats under the feeding trial

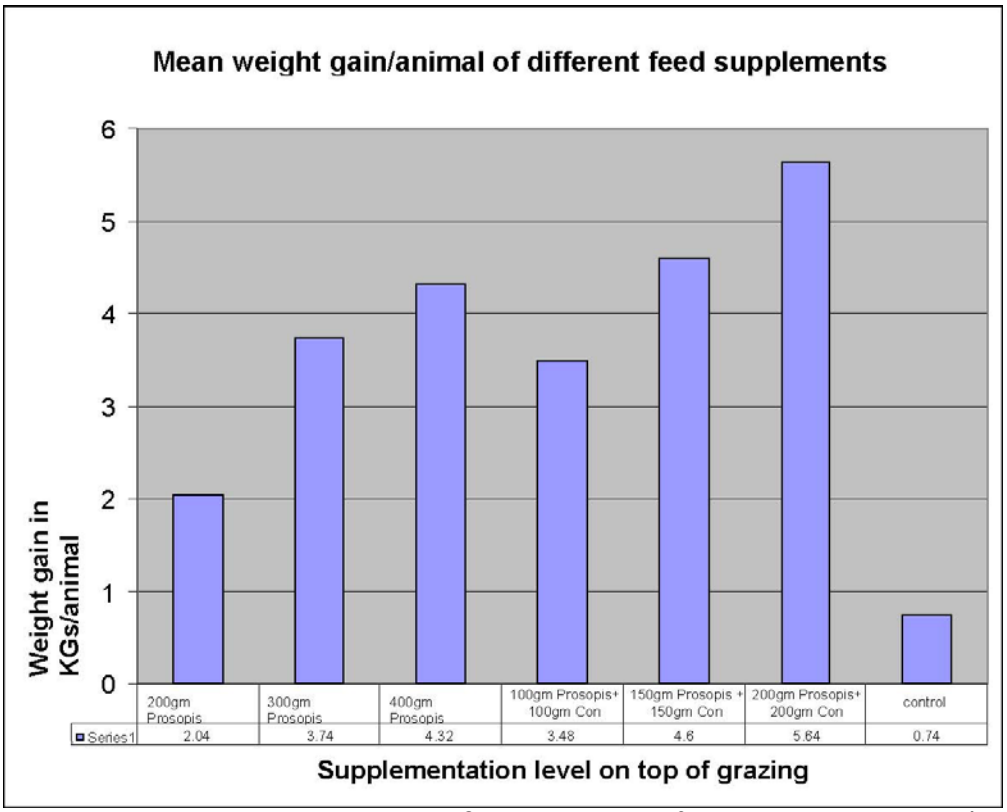

Figure 2: Prosopis pod feeding demonstration/trial results

c. Benefits from charcoal trade

Households involved in charcoal production and sales obtained good income and diversified their livelihood base to better cope with food insecurity. Within one year (Oct 2004-Sep 2005) three cooperatives (Serkamo, Sedhafagae and Gelaladura) with a total membership of 179, bought and sold 188,246 bags of charcoal and earned a net profit of 1,131,758 ETB or 113,176 USD. From the operation, cooperative members were getting up to 750 ETB every month. On top of the monthly income two of the cooperatives (Serkamo and Sedhafagae) were able to give annual dividend payments to their members' amounting 1,500 ETB and 1,257 ETB, respectively. With the income local people were able to cover their household expenses (clothes, medical services and food) and build their asset base by purchasing livestock (Dubale, 2006).

In a one year working period (Oct 2004-Sep 2005) three of the four pilot cooperatives (Serkamo, Sedhafage, and Gelaladura) were able to create over 233,509 man-days of labour opportunities for daily labourers. With 10 ETB or 1 USD minimum daily wages, the job created by the four cooperatives was equivalent to 2,335,090 ETB or 233,509 USD.

d. Benefits from managing cleared land

Cooperatives were able to clear prosopis thicket from over 396 hectares of land, in one year, and availed pasture as well as cultivable land to local communities depending on the potential of the land. In Gelaladura Kebele, where there is better access for irrigation water, local people cultivated all the cleared land (46 hectares) and obtained good harvests. They grew sesame, maize, fodder crops and vegetables (onion and tomatoes) both for household use and income from cash crops (Plate 7).

Plate 7. Maize crop cultivation and harvest from land cleared of prosopis

Crop by-products, weeds under the crop and fodder (Plate 8), provided additional feed sources during the dry season for sheep and goats, as well as lactating cows and calves which could not migrate to traditional dry season grazing areas. From the field observations it was shown that cultivation of land cleared of prosopis reduced the chance of re-invasion. People were able to improve food and income opportunities from the food and cash crops they cultivated in the cleared areas which helped them to better cope with recurrent drought.

Plate 8. Pasture cultivated on land cleared of prosopis

In addition, indigenous trees, shrubs and grass which were lost due to the prosopis invasion, gradually recovered when the prosopis trees and shrubs were removed and emerging seedlings were uprooted.

e. Change in policy

The control of *Prosopis juliflora* has come to the attention of Afar Regional and Federal governments. A draft regulation was produced by ANRS to strengthen the extension and regulatory service for control of prosopis invasion and to promote utilization of its products.

Illegal charcoal production and marketing, a chronic problem in the area, was reduced as the illegal charcoal burners started working under the supervision of licensed cooperatives.

4.3 Challenges and obstacles

Seeking to gain similar benefits as the cooperatives, unauthorized individuals engaged in the production and marketing of charcoal, including by (a) crossing local boundaries to harvest prosopis, becoming to a source of conflict in some areas, (b) leaving in some places uncleared stumps which formed thickets due to the high coppicing ability of prosopis, (c) buying and selling charcoal produced from unknown sources from other areas; (d) passing permits to unauthorised charcoal traders.

Without a legal framework in place to regulate the proper utilization of prosopis in a way that controls the invasion and protects indigenous trees, the operation became difficult to manage. As a result the region banned all charcoal production again, including by the cooperatives, until the appropriate legal framework is put in place. When the draft regulation is finally endorsed and enacted it will provide legal status to the community and district level authorities to correct such problems and enhance proper utilization of the prosopis resource, thereby contributing to its control.

Furthermore, there is need to help the regional government develop detailed implementation guidelines for prosopis management, to create critical awareness at all levels and to mobilize local communities for its action.

4.4 Lessons learnt

- Invasive species such as prosopis can have major negative impacts on food security and livelihoods if local communities are not mobilized and supported to adopt appropriate management practices to prevent further spread and restore invaded areas.

- There is a potential to control prosopis spread to farmlands and key pasturelands by promoting its utilization (charcoal, pods, etc) in planned and regulated ways that provide economic incentives to local people.

- The pilot initiatives lacked realistic land use plans based on detailed assessments of the potential of those lands to guide their management after clearance. Areas cultivated after the clearance were reclaimed through the ploughing and irrigation which checked re-growth of prosopis from seeds and stumps. In most cases, (non-irrigated) pasture lands

cleared from prosopis were reinvaded by seedlings emerged from seeds in the soil bank or re-infestation from animals grazing in the cleared areas coming from infested areas or from coppices. Community members were not mobilized and technically supported to sustainably manage such cleared pastureland. The problem is complicated due to free mobility of livestock. Rangeland users need to come together and agree on potential solutions.

- Appropriate forums should be established to regularly share experiences among the different institutions and community members involved in *Prosopis juliflora* management within the country. Opportunities should be also explored for networking and experience sharing with other countries facing similar problems.

Possible management options with technical supports from professionals to protect re-invasion of cleared pasturelands.

- Pod crushing by machine proved that it was possible to crush *Prosopis juliflora* seeds and so reduce the dispersal rate and provide high-value, protein-rich feed for livestock in invaded areas.
- Introduced metal kilns for charcoal production (despite the reduced labour demand and time for charcoal burning) could not get acceptance 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 is a need to develop awareness at the community level to develop ways for women to be involved in the cooperatives and contribute for the management of prosopis invasion.
- The sudden charcoal ban both for legal cooperatives as well as illegal producers pushed the cooperatives to bankruptcy as they were not able to sell the charcoal in stock. This led to further intensified illegal production.
- Future involvements of government and non-governmental institutions on prosopis management should be informed from the lessons learned and challenges observed from these pilot interventions of FARM-Africa in Gewane and Amibara Woredas.

4.5 A way forward?

Areas invaded by invasive species and areas at risk from further invasion need to be identified and mapped. Alternative uses of the invaded lands and restoration plans need to be developed based on the potential of those lands in specific locations. Local people in the invaded areas should be well advised and supported to carry out sustainable management of the cleared lands to prevent re-invasion.

Alternative control methods such as biological methods or combinations of biological and mechanical methods, as well as different utilization options should be researched, and

demonstrated to government partners and local people to prevent further invasion of new areas and to restore invaded areas in ways that benefit local communities. Technical and management capacities of communities as well as government institutions need to be enhanced to carry out research and facilitate management of invasive species.

An enabling policy environment, including appropriate legal framework, needs to be in place for the eradication, control and management of invasive species at sub-national and national levels.

5. References

Anagae, A., Reda, F., Tesfaye, G., Admasu, A. and Ayalew, Y. (2004). Policy and stakeholder analysis for invasive plants management in Ethiopia. Ethiopian Agricultural Research Organization, Report submitted to CAB International under the PDF-B Phase of the UNEP/GEF- Funded Project: Removing Barriers to Invasive plants Management in Africa, Ethiopia, p60.

Andersson, S. (2005). Spread of the introduced tree species Prosopis juliflora (Sw.) C in the Lake Baringo area, Kenya.

Dubale, A. (2006) Impacts of Prosopis juliflora invasion and control using charcoal production in Afar National Regional State, Ethiopia. MSc thesis (distinction), University of Wales, Bangor, UK.

Fisehaye, R. (2006). Personal communication

Frew, M., Solomon, K. and Mashilla, D. 1996. Prevalence and distribution of Parthenium hysterophorus L. in eastern Ethiopia. Arem, 1: 19-26.

Geesing, M., Khawlani and Abba, M.L. (2004) Management of introduced Prosopis species: Can economic exploitation control an invasive species? Unasylva, 217, Vol.55, 36-44.

Hailu, S., Demel, T., Sileshi, N. and Fassil, A. 2004. Some biological characteristics that foster the invasion of Prosopis juliflora (Sw.) DC. at Middle Awash Rift Valley Area, north-eastern Ethiopia. Journal of Arid Environments, 58 (2004) 135 -154.

Kassahun, Z., Yohannes, L. and Olani, N. 2004. Prosopis juliflora: Potentials and Problems. Arem 6: 1-10.

Ministry of Finance and Economic Development (MoFED) 2006, Ethiopia: Building on Progress. Plan for Accelerated and Sustained Development to End Poverty (PASDEP), p.191-194.

Mwangi, E. and Swallow, B. (2005). Invasion of Prosopis juliflora and local livelihoods: Case study from the lake Baringo area of Kenya. ICRAF Working Paper – no. 3, Nairobi, World Agroforestry Centre.

Pastoral Community Development Project (PCDP) Disaster Preparedness and Contingency Planning Manual, December 2006.

Pasiecznik, N.M., Felker, P., Harris, P.J.C., Harsh, L.N., Cruz, G., Tewari, J.C., Cadoret, K. and Maldonado, L.J. (2001). The Prosopis juliflora-Prosopis pallida Complex: A monograph. HDRA, Coventry, UK, p162. PCDP (2005) Final baseline survey report of Gewane Woreda, Afar Regional State, Pastoral Community Development Project, p. 56

Senayit, R., Agajie, T., Taye, T., Adefires, W. and Getu, E. 2004. Invasive Alien Plant Control and Prevention in Ethiopia. Pilot Surveys and Control Baseline Conditions. Report submitted to EARO, Ethiopia and CABI under the PDF B phase of the UNEP GEF Project - Removing Barriers to Invasive Plant Management in Africa. EARO, Addis Ababa.

Shiferaw, H., Teketay, D., Nemomissa, S. and Assefa, F. (2004). Some biological characteristics that foster the invasion of Prosopis juliflora (Sw.) DC at Middle Awash Rift Valley Area, Northeastern Ethiopia. Journal of Arid Environments, 58, 135–154.

Taye, T. 2002. Investigation of Pathogens for Biological Control of Parthenium (Parthenium hysterophorus L.) in Ethiopia. PhD Thesis. Humboldt–Universitat zu Berlin, Landwirtschaftlich-Gartnerischen Fakultat, Berlin. 152 pp.

Taye, T., Ameha, T., Adefiris, W. and Getu, E. 2004d. Biological Impact Assessment on Selected IAS Plants on Native Species Biodiversity. Report submitted to EARO, Ethiopia and CABI under the PDF-B phase of the UNEP GEF Project - Removing Barriers to Invasive Plant Management in Africa. EARO, Addis Ababa, Ethiopia.

Taye, T., Einhorn, G., Gossmann, M., Büttner, C. and Metz, R. 2004a. The Potential of Parthenium Rust as Biological Control of Parthenium weed in Ethiopia. Pest Management Journal of Ethiopia 8: 83-95.

Taye, T., Emana, G., Fasil, R., Senayit, R., Adefiris, W., and Agajie, T. 2004c. Identification and Planning of Control Project. Report submitted to EARO, Ethiopia and CABI under the PDF-B phase of the UNEP GEF Project - Removing Barriers to Invasive Plant Management in Africa. EARO, Addis Ababa, Ethiopia.

Taye, T., Fessehaie, R. and Firehun, Y., (2007) Invasive Alien Weed Species in Ethiopia: Biology, Distribution and Importance, and Available Control Measures

Taye, T., Obermeier, C., Einhorn, G., Seemüller, E., and Büttner, C. 2004b. Phyllody Disease of Parthenium Weed in Ethiopia. Pest Management Journal of Ethiopia 8: 39-50.

Tefera, M. (unpub). Proceeding of the workshop on Afar Pastoralist Prosopis Project and Emerging issues, April 2006, FARM Africa, Awash, Ethiopia. 47p.

USFS (2006).The United States Department of Agriculture (USDA) Forestry Service technical assistance trip report to the Federal Democratic Republic of Ethiopia (FDRE)

Zelalem, G. (200) Spatial variation in range dynamics in relation to prosopis juliflora invasion along river awash, Gewane district, north east Ethiopia, MSC thesis, Haramaya University, Ethiopia.