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agriculture and rural development




Final Report

Soil Conservation and Rehabilitation for Food Security, Afar Region Soil Rehabilitation

Analysis of Spread and Elaboration of Recommendations for the Management of Prosopis Juliflora

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Final Report

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Abbreviations

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a.o.	among others
APARI	Afar Pastoral and Agro-pastoral Research Institute
BOPAD	Bureau of Pastoral and Agricultural Development
°C	Degree Celsius
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organisation of the United Nations
GIZ	Deutsche Gesellschaft fuer Internationale Zusammenarbeit
ha	hectare
IAS	Invasive Alien Species
PADO	Pastoral Development Office
TA	Technical Assistance
ToR	Terms of Reference

1 Purpose of the Study

1.1 Background

Prosopis juliflora is a fast growing tree valuated for its tolerance against arid conditions and saline soils. The tree is native to South and Central America and has been introduced to Ethiopia in the 1970s and 1980s, similar to a series of other tropical countries, and in an attempt to respond to rising and/or urgent concern of deforestation / desertification and fuel wood shortages. Since its introduction to the Afar region in the 1970s, the area covered by *Prosopis juliflora* has been expanding, and the species is recognized today as an invasive species with considerable negative effects on the livelihood of the population in the invaded regions.

Although *Prosopis juliflora* is known as a multipurpose tree which could provide a series of benefits, incl. usage for firewood, charcoal, timber, livestock feed and human food but also environmental services such as nitrogen fixation, erosion control, soil improvement, live and dead fencing a.o., its negative effects are being predominantly perceived.

The Afar region is one of the least-developed and poorest regions in Ethiopia. Characterised by average temperatures between 25°C and 48°C and periodic rainfalls (of mostly less than 300mm per year), about half of the region is made up of marginal soils, the rest is largely covered by dry savannah. Livelihood of the population is mainly based upon semi-nomadic livestock farming (transhumance). Although the management of water, rangelands and arable soils is widely determined by the social structures of the Afar clan community, a system which proved to be well adapted to the marginal conditions of the region, it is noted that population growth, climate change (e.g. increase of drought events, reduced predictability of rainfall patterns), land use changes are increasingly bringing this system under pressure. Many of the Afar pastoralists had to give up livestock keeping as the principal pillar of their livelihood. Measures taken by the Ethiopian Government could so far not sustainably reverse the processes of degradation of the natural resources.

The underlying TA project "Afar Soil Rehabilitation" is part of a global programme on soil conservation and rehabilitation for food security aiming to preserve, rehabilitate and improve the productivity of pastures and arable land. It is expected that by the introduction of effective pasture management practices further erosion of soils can be avoided. Additionally, degraded rangeland and watersheds shall be rehabilitated. The resilience of pastoral and agro pastoral production systems shall be increased and positive impulses be given for the rural development.

The objective of the "Afar Soil Rehabilitation" project is to implement sustainable approaches to broad-scale support for soil conservation and rehabilitation of degraded soils is implemented in Ethiopia's Afar Region.

The effective management of *Prosopis juliflora* is one pillar of the TA project. This is in accordance with the strategy of the Ethiopian Government, which has dedicated considerable efforts to the development of a National Strategy for effective *Prosopis* management.

1.2 Objectives of the Consultancy

1.2.1 Overall Objectives for the Assignment

The purpose of this mission was to support the project in elaborating recommendations about the management of *Prosopis juliflora* in the project area: Based upon a comprehensive desktop research as well as a field survey in the project area and discussions with stakeholders, different management options for *Prosopis juliflora* should be analysed and good practices defined for upscaling and upskilling.

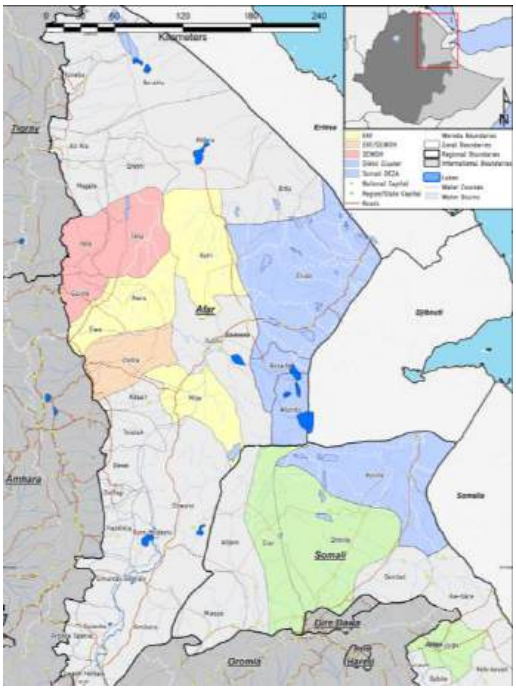


Figure 1: Map of the Project area

The project region did not comprise the whole Afar regional state, but rather the north-central part, incl. woredas from the administrative zones 1 (Chifra, Mile, Kurri) and 4 (Ewa, Gulina, Yalo, Teru, Aura).[1]

The landscape is characterized by a lowland area with isolated mountains, often of volcano origin.

One watershed area with a fine network of dry riverbeds often associated with gully erosion gives the overall structure to the landscape.

There is a mixture of geological formations, areas consisting of rocks on one side and on the other side unbelievable fine soils.

The lack of water is on those places the limiting factor to make the good soil productive, invasive plants are found scattered in the area, concentrated on uncultivated or badly cultivated areas and along river beds and road sides.

1.2.2 Specific Objectives for the Assignment

According to the ToR the specific objectives and tasks were the following:

- Literature review: analysing and documenting good practices of *Prosopis juliflora* management, using information provided by GIZ and own research;
- Field survey;
- Conduct interviews with approx. ten relevant institutes and organisations and other relevant national and international experts;
- Defining different management options for *Prosopis juliflora* in regard to the density of invasion and to different landscape requirements;
- Development of different options for pilot testing in the project area.

The present report is part of the defined deliverables, which also included:

- Presentation of concrete recommendations of management of *Prosopis juliflora*;
- Participation in a workshop for presentation and discussion of the findings.

This report presents the findings of the study:

- Documentation and analysis of relevant literature;
- Documentation of the findings on challenges and constraints for effective management of *Prosopis juliflora* from field visits;
- Recommendations for follow-up activities aiming at improved management of *Prosopis juliflora*.

[1]The results, especially from the field visits, are true for the Central part of Afar region. The situation might be different for the Southern (zone 3 and 5) and Northern (zone 2) part.

2 Concept and Methodology of the Study

The study was implemented following a two-step approach.

In the first step, acomprehensive review and analysis of literature related to the management and control of invasive species, and in particular *Prosopis juliflora*, has been performed.

Inthe second step, a field survey has been conducted and interviews with Ethiopian stakeholders have been carried out.

Based upon the results of both steps, recommendations for follow-up activities have been elaborated.

2.1 Desk Research / Literature Review

Quite a number of publications about *Prosopis juliflora* can be found on the internet. Some are dating back to the 90ies, but there is a concentration of reports during 2005-2010 and now dating from 2014 onwards.

The literature concerning Afar region comes nearly exclusively from the south Afar region (Gewane, Baadu), "one of the most heavily invaded areas in Afar, the Middle Awash Basin, the seasonally inundated floodplains of Gewane and of Amibara Woreda, where *Prosopis juliflora* has spread rapidly over the last decades" (RETTBERG & MÜLLERMAHN, 2012).

In comparison, not much information is available in the actual project area (see also section 1.2.1).

The following table provides an overview on a selection of most relevant publications on *Prosopis juliflora* management, published during the last 10 years (in order of publication date):

Title	Authors	Institution	Year
Management, Use and Control of *Prosopis* in Yemen	Dr. Mohamed Al Nassiri,		2003
Invasion of *Prosopis juliflora* and local livelihoods- Case study from the Lake Baringo area of Kenya	Esther Mwangi and Brent Swallow	World Agroforestry Centre	2005
Spread of the introduced tree species *Prosopis juliflora* (Sw.) DC in the Lake Baringo area, Kenya	Anders Granström Januari	SLU/SIDA	2005
The *Prosopis* Dilemma: Impacts on dry land biodiversity and some controlling methods	Abiyot Berhanu and Getachew Tesfaye	Ecosystem Conservation and Research Department, Institute of Biodiversity Conservation, Addis Ababa, Ethiopia	2006
Proliferation of honey mesquite (*Prosopis juliflora*) in Somaliland	Ahmed Ibrahim Awale, Ahmed Jama Sugule	Candlelight for Health, Education & Environment (CLHE)	2006
Invasive Plants and Food Security: The case of *Prosopis juliflora* in the Afar region of Ethiopia	Dubale Admasu	FARM-Africa for IUCN	2008
The Ecological and Socio-economic Role of *Prosopis juliflora* in Eritrea	Harnet Bokrezion	Johannes Gutenberg-Universität Mainz	2008
Experiences on *Prosopis*ManagementCase of Afar Region	Getachew Gebru Tegegn	FARM AFRICA	2008
Prosopis juliflora	Orwa et al.	Agroforestry Database 4.0	2009
Working Guide -for Integrated Man-	Faith Ryan	USDA Forest Service	2011

agement of Invasive Species in the Arid and Semi-Arid Zones of Ethiopia			
Prosopis, an Alien among the Sacred Trees of South India	Kurt Walter	TROPICAL FORESTRY REPORTS 38	2011
Mapping Current and Potential Distribution of Non- Native *Prosopis juliflora* in the Afar Region of Ethiopia	Tewodros T. Wakie, Paul H. Evangelista, Catherine S. Jarnevich, Melinda Laituri	PLOS ONE 10.1371/journal.pone.0112854	2014
The mesquite control toolbox	Rachele Osmond, Rieks van Klinken, Nathan March, Robert Cobon, Shane Campbell	CSIRO	2003
Controlling and/or Using *Prosopis juliflora* in Spate Irrigation Systems	Matthijs Kool, Frank van Steenbergen, Abraham Mehari Haile, Yasir A. Mohamed, Hamis Nzumira et al.	SPATE NETWORK	2014
Prosopis: A global assessment of the biogeography, benefits,- impacts and management of one of the world's worst woody invasive plant taxa	Ross T. Shackleton1*, David C. Le Maitre1,2, Nick M. Pasiecznik3 and David M. Richardson1	AoB PLANTS	2014
Managing *Prosopis juliflora* for better (agro-) pastoral Livelihoods in the Horn of Africa	Nadine Guenther and Elisabeth van den Akker	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
The spread of *Prosopis juliflora* in the wetlands of the Middle Awash Basin	Simone Rettberg	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Quantitative Assessment of Invasion of *Prosopis juliflora* in Baadu, Afar Regional State of Ethiopia	Yohannes Zergaw Ayanu,	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Ecological challenges and potential carbon storage benefits of *Prosopis juliflora* in Afar	Anna C. Treydte, Emiru Birhane, Abeje Eshete,	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
A social-economic assessment of the impact of *Prosopis juliflora* invasion and participative management approaches in the Afar Region, Ethiopia	John Ilukor, Regina Birner, Mesfin Tilahun, Shimelis Getu	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Households' demand for mitigation of *Prosopis juliflora* invasion in the Afar Region of Ethiopia: a contingent valuation	Mesfin Tilahun, Regina Birner, John Ilukor	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Gender aspects of *Prosopis juliflora* spread in Baadu area, Afar Regional State, Ethiopia - Perceptions, impacts and coping strategies	Helena Inkermann	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Impact assessment of *Prosopis juliflora* invasion in the Afar Region, Ethiopia - Synthesis and recommendations from an interdisciplinary perspective	John Ilukor, Simone Rettberg, Anna Treydte, Regina Birner,	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Controlling and/or using *Prosopis juliflora* in Spate Irrigation Systems	Matthijs Kool, Karim Nawaz, Yasir A. Mohamed, Hamis Nzumira	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Prosopis juliflora Management Stakeholders Analysis in Afar National Regional State, Ethiopia	Wondimagegne Chekol	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Experiences of managing *Prosopis*	Simon Choge, George Muthike	GIZ- Proceedings of the Re-	2014

juliflora invasions by communities in Kenya: Challenges and Opportunities		gional Conference, Addis Ababa, Ethiopia	
Socioeconomic and Ecological Impacts of *Prosopis juliflora* Invasion in Gewane and Buremudaytu Woredas of the Afar Region	Herrie Hamedu	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Socio-economic impacts of *Prosopis juliflora*-related charcoal trade in Gewane Woreda, Afar Region	Mohammed Datona	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Prosopis juliflora, Parthenium and beyond, challenges for an integrated strategy of IAS control in the Afar Region	Wondimagegne Chekol, Irmfried Neumann	GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia	2014
Capacity Development to Strengthen Drought Resilience of (Agro-) pastoralists in the Lowlands of Ethiopia"	(SDR-ASAL)	GIZ Project	2014
The Management and Utilization of *Prosopis juliflora*-Plocy Workshop	John Livingstone, Kaise Adbi and Amsale Shibsehi	Rep. of Somaliland, PENHA, IFAD	2014
Ecosystem engineer unleashed: *Prosopis juliflora* threatening ecosystem services?	Yohannes Ayanu, Anke Jentsch, Detlef Müller-Mahn, Simone Rietberg, Clemens Romankiewicz, Thomas Koellner	Regional Environmental Change	2015
How *Prosopis juliflora* can be economically rewarding to pastoral communities in Kenya's rangelands	Margret Syomiti	Kenya Research Institute	2015
Exploitation of *Prosopis juliflora* (SWARTZ) DC. and its Implication towards Controlling the Current Spread Rate at Gewane District, Afar Regional State, North-Eastern Ethiopia	Tegegn Argaw, Girmay Tesfay	Journal of Economics and Sustainable Development	2015

Figure 2: Analysis of publications about management of Prosopis juliflora

In the Annex to this report, a short summary is provided of the content of the most relevant publications.

2.2 Field Visits and Interviews with Stakeholders

Based on this first literature review and analysis a field survey was conducted. The survey took place October/November 2015 (1 week).

Apart from meetings with stakeholders active in the field of rangeland management, strengthening of (agro)pastoral production systems and management/control of invasive species on the national and regional level, interviews were carried out with Afari stakeholders, including local government authorities (BoPAD), agro pastoral research institutions (APARI) and local clan leaders.

The interviews and discussions revealed the different opinion, perceptions and experiences related to the most effective management approaches for *Prosopis juliflora* and served to elaborate a set of recommendations for further action.

The following table provides an overview of the sites visited as well as the interview and discussion partners:

Date	Day	Activity,	Location
25.10	Sun	Departure at Bonn 16.00	Flight to Addis Ababa
26.10	Mon	Morning: reading documents Afternoon: Meeting with Mr Wolf Berdel	Hotel GIZ office
27.10	Tue	Morning: Presentation of Prof Ato Renzene Afternoon: Discussion with Ms Elisabeth van den Akker, Mr Wolf Berdel, Mr SimonKamenisch (all GIZ)	GIZ office GIZ office
28.10	Wed	Morning: Discussion with Afternoon: analyzing Prosopis documentation Discussion: Tilahun Amede (ICRISAT)	GIZ office GIZ office
29.10	Thu	Morning: Flight to Semera Discussion: Mohammed Abdulkadir (BOPAD, Rangeland management expert) Afternoon: trip to Aysaita and Chifra, visit of Prosopis invested areas Discussion: Awal Seid Ebrahim (PADO, Agricultural extension core process owner)	Afar Region Aysaita and Chifera
30.10	Fri	Morning: Trip to Ewa, visit of Prosopis invested areas Afternoon: Trip to Dubti, visit of Prosopis invested areas	Afar Region Ewa and Dubti
31.10	Sat	Morning: Trip to Aura, visit of Prosopis invested areas Afternoon: Trip to Gulina, visit of Prosopis invested areas	Afar Region Auwura and Golina
1.11	Sun	Morning: Trip to Teru, visit of Prosopis invested areas Discussion: Ahmed Ali (Woreda Administrator), Shami Mahammed Goble (PADO, Animal, plant health and quality inspection and monitoring core process owner) Afternoon: Trip to Afdera-Kurri- Semera, visit of Prosopis invested areas	Afar Region Teru and Afdera
2.11	Mon	Morning: Trip to Kurri, visit of Prosopis invested areas Afternoon: Trip to Kurri, visit of Prosopis invested areas Discussion: Mahe Mohammed Wasii (Woreda administrator)	Afar Region Kurri
3.11	Tue	Morning: Trip to Asyaita, visit of Prosopis invested areas Afternoon: Trip to Afambo and Mille, visit of Prosopis invested areas Discussion: Fafi Yusuf Hassen (PADO, Disaster risk prevention and food security core process owner), Yashi Kebede Ali (PADO, Natural resource management core process owner)	Afar Region Mille
4.11	Wed	Morning: Flight to Addis Ababa Afternoon: Office discussions with Mr. Irmfried Neumann	Travelling GIZ office
5.11	Thu	Morning: Preparation of presentation Afternoon: Discussion with Mr Heinz Bender, Mr Irmfried Neuman Presentation of field findings to project team	GIZ office GIZ office
6.11	Fri	Morning: Report writing Afternoon: Presentation of results	GIZ office GIZ office
7.11	Sat	Morning: Report writing Afternoon: Departure from Addis 20.00	GIZ office GIZ office
8.11	Sun	Arrival in Frankfurt 5.10	Arrival in Bonn 9.00

Figure 3: Schedule for field visits and meetings

3 Results

3.1 Preliminary Results and Conclusions from Desk Study

The origin of *Prosopis juliflora* is in South/Latin-America. From these countries there is nearly nothing about negative or invading respective uncontrolled expansion aspects documented.

The literature of an invading species with negative aspects emerges mostly in African documents from 2005 onwards. Nearly all publications referring to *Prosopis*as as an invasive species are coming from relatively dry zones in Kenya, Ethiopia, and Yemen. In these regions, *Prosopis* was introduced as a highly draught tolerant plant also growing on poor soils.

Most of the studies acknowledge that *Prosopis* has ecological benefits, but they come to the conclusion that negative impacts outweigh the positive effects.

Some of the negative aspects seem to be reasonable, but some seem to exaggerative and disproportionate in the presentation of threats and negative impacts of *Prosopis* invasion. The Consultant observes that many publications treat the question of *Prosopis* invasion from a biased biological perspective.

As mentioned in Section 2.1 studies on Prosopis coverage, impacts of invasion and management approaches in Afar are mainly referring to the South Afar Region (Middle Awash Basin), and only little information was accessible for the actual project region. As it seems that agro-climatic conditions are different from the southern to the northern Afar region, additional research has to be done to elaborate well founded strategies for *Prosopis* management.

Some of the research papers give an impression of student work and/or work by non-professionals as basic factors of socio-economic realities in development countries are over emphasized and related to effects of *Prosopis*. Others give an impression of university oriented work with no or not much practical experience.

In general, it is perceived that publications about impacts of invasion and Prosopis management approaches tend to repeat the results of other studies, thus also repeating misinterpretations and overestimating the described effects. The general impression after reviewing of existing literature is that the positive effects of Prosopis are widely played down and the negative effects are overestimated.

3.2 Findings from Field Survey and Interviews

The following section presents the findings from the field visits in October 2015[2].

The field visit impressions are in contrast with what is written in the wide spread Prosopis related literature, which seem overestimating the negative effects.

No strong invasion of Prosopis was found in the project area, no alarming spread of Prosopis could be observed. Prosopis with vegetation cover < 10 % in the open area is not a threat for the development of other plants or an impenetrable area. Only along the river beds or on some isolated roadside parts, thick Prosopis growth was observed. The often stated arguments, getting a thorn in the eye or a tyre puncture seem to be overrated arguments; the real life challenges are more severe.

[2] The results presented here have to be understood describing the current situation at the time of the field survey. The situation might change in the course of the year. However, it is expected that the seasonal variations of Prosopis spread would not change the general picture.

The table below summarizes the observations of Prosopis invasion separately for each of the visited sites and presents the conclusions of discussions and interviews.

Project site	Field findings
Chifra, Ewa, Gulina, Yalo, Aura and Teru	Scattered Prosopis is found on: ▪ Overgrazed, under exploited areas (mostly small bushes) ▪ Roadsides (mostly small bushes) ▪ Riverbanks (sometimes big and dense bushes)
Kurri	No Prosopis was found in the interior Some Prosopis was found along the new main road Clan leader said there is also some *Prosopis* along an animal road, but is causing neither problems no harm
Aysaita	Scattered Prosopis is found on: ▪ Overgrazed, under exploited areas (mostly small bushes) ▪ Roadsides (mostly small bushes, but also some dense thickets could be found) ▪ Riverbanks (sometimes big and dense bushes)
Afambo	Heavy Prosopis infestation is found on: ▪ Former state farm area, but now it is heavily cleared by private farmer starting irrigated farming ▪ On cultivated land no Prosopis has be seen during the field survey, although interview partners commented on discrete appearance of Prosopis on some cultivated areas
Mile	Scattered Prosopis is found on: ▪ Roadsides (mostly small bushes) ▪ Riverbanks (mostly small areas)
All areas	**No big invested areas could be observed during the field visit!** ▪ *Prosopis* grows nearly all over the visited area where fertile conditions prevail, but its infestation is very different. Area wise *Prosopis* can be found widespread on areas with lower water availability and at a low density of around 25 plants per hectare. No other use of these areas seems feasible at this state of knowledge ▪ Strong *Prosopis* areas are found **along river banks**, about 4 to 5 meter high and 10 meter deep along the river ->protecting the river banks from erosion ▪ *Prosopis* is found at a varying extend **along roadsides**, between 0,5 and 5 meters high and about 2 to 3 meters deep ->stabilizes road sides, better growth as it gets the water from the road (Reason for infestation might be the water and the road bank which acts as a wind break) ▪ Scattered *Prosopis* is found on **marginal overgrazed and relatively dry land**, about 1 to 2 meter high, and about 25 plants (variation between > 5 plants per hectare < 200) ->Reduces wind speed, thus wind erosion; covers bare soil ▪ *Prosopis* is **following animal routes in the Afar region** at a (very) low intensity! Probably not because of intra-testinal distribution but to general better water conditions along the animal roads. Wind hose (vortex) seems to be a more reasonable distribution way than animal dung ▪ Some *Prosopis* is found in **urban areas** on places were litter is found as well -> Shows lack of care for home and communal places or places with low importance for the people, such as public building grounds ▪ *Prosopis* reacts strongly on water availability - ->There is probably a strong correlation between water availability and plant growth (density) - ->There is also probably a correlation between water availability and spread of Prosopis in the area

Figure 4: Findings from field survey

3.3 Conclusions from Desk Study and Field Visits, Analysis of Lessons Learnt

The following section presents a summary of conclusions.

3.3.1 Distribution and Impact of *Prosopis juliflora*

The literature about *Prosopis* shows a high degree of copying in many aspects. Attitudes and perceptions are continuously reiterated and rarely checked on their relevance. But in all documents a tacit common understanding seems to prevail: *Prosopis* is a bad weed and has to be, if possible, eradicated.

The results of the field visits, however, are quite in contrast to these positions.

Prosopis is a very undemanding plant, which grows on marginal areas. In none of the visited areas we found signs of *Prosopis* replacing other plant species in the area, but it growths when other plants species have disappeared, e.g. by draught, overgrazing, etc.

The preferred growing areas are good, well watered, non-utilized soils (non-used irrigation plots). Here *Prosopis* covers the soil without superseding other plants.

At the sites with a well established *Prosopis* coverage, positive effects could be observed: e.g. *Prosopis* is growing well along river banks, roadsides and road side ditches. At all these sites, *Prosopis* had a stabilizing effect. Growing within large river beds, *Prosopis* reduces water run-off.

Prosopis can be found on overgrazed land, but mostly at a very low density as this land is usually also quite dry. On these sites, which are characterised by a very low vegetation cover, *Prosopis* covers the soil and avoids strong wind and water erosion in the area.

Various publications refer to *Prosopis* distribution along animal roads, triggered by an uptake of *Prosopis* pods as feed for the animals and later leaving it at another site as animal dung.

Indeed, *Prosopis* is growing to a different extent (depending on the water availability) along animal roads. However, it is very unlikely to be distributed by dung containing *Prosopis* seeds, as animals as well as people eat the green, unripe pods. These are sweet in this growing stage, but not being able to germinate. The more likely reason for spreading is due to the availability of more moisture along the animal road. This conclusion is supported by preliminary analysis of aerial photographs, which make visible the courses of transhumance, and reveal the correlation between *Prosopis* distribution and water availability.

Some *Prosopis* can also be found in the villages, mostly at unused places and often associated with litter. Here it covers the neglected places.

In conclusion:

Prosopis juliflora could be observed in several sites of the project area. However, the extension and density of its distribution is far less than what was expected from analysis of literature. Water availability seems to be the principal factor for enabling the distribution of *Prosopis.*

In none of the visited field sites it could be observed that the invasion of *Prosopis juliflora* presents a threat for the livelihood of the Afar pastoralists and local population.

The contrast between the intensity of *Prosopis* invasion as presented in the multitude of publications analysed and the observations made during the field visits, is being continued in contrasting valuations of its impacts.

During the interviews with stakeholders both in Addis Ababa and in the project area, it became obvious that the understanding of *Prosopis* being a threat for the livelihood of the Afar people is being shared among representatives of Ethiopian authorities and administration. Especially the local administrative people put emphasize on *Prosopis* being **a threat for the livelihood** for people in the Afar region. In interviews local clan leaders, stated that *Prosopis* is **not a major problem.**

The following table illustrates the impacts of Prosopis on different aspects of the livelihood of the people in the project region. It summarises the observations of the Consultant and the results of discussions and interviews.

Sector / Aspect of Livelihood	Remarks	Impact
Agriculture	▪ *Prosopis* spreads nearly exclusively on: ○ degraded and underutilized areas ○ riverbanks and ○ roadsides ▪ *Prosopis* is not prevalent on intensely cultivated plots ▪ *Prosopis* is not suppressing other plants to an remarkable extent, it occupies empty spaces	Impact on agriculture is low (on the visited area)
Ecology	▪ Reduces wind erosion ▪ Reduces water erosion ▪ Stabilizes river banks ▪ Reduces soil temperature (evaporation rate) ▪ Creates positive micro-climate (shade cover) ▪ Creates biodiversity (small animals and insects) ▪ The Amibara weather station revealed that the *Prosopis juliflora* invasion has been useful in moderating climate variables and reducing expansion of desertification in Afar Region (see proceedings Ilukor et al.")[3]	Impact of ecology is high
Economy	▪ Land conservation ▪ Water retention ▪ Pod collection can become business in heavy growing areas ▪ Charcoal production can be a business in some areas ▪ Fencing material	Positive impact of economy is feasible
Health	▪ *Prosopis* thorns are not more dangerous than other thorns ▪ Not a major issue for health	Impact on health is neglectible

Figure 5: Impacts of Prosopis juliflora in the project region

The contrasting perceptions of the distribution and impacts of *Prosopis juliflora* might be related to different sources of information (incl. the effect of misinterpretation of information provided by scientific publications) and different attitudes.

[3]Impact assessment of *Prosopis juliflora*invasion in the Afar Region, Ethiopia- Synthesis and recommendationsfrom an interdisciplinary perspective, page 68

In conclusion:

Prosopis is **perceived as a significant problem by some authorities.**

Prosopis is **regarded as a minor problem for pastoralists.**

Prosopis is **no big problem for agriculturalists using the land intensively by irrigation** (despite the efforts of land clearing).

3.3.2 Analysis of Approaches and Experiences in Management and Control of *Prosopis juliflora*

There are several publications about different approaches to manage and control the spread of *Prosopis juliflora*. The table below provides a very good synthesis of the experiences and effectiveness of the proposed measures:

Control type	Advantages	Disadvantages
Biological control	• Relatively inexpensive once implemented • Works over large areas, including areas that are inaccessible for mechanical control • Minimal associated costs after biocontrol agent is released (monitoring is required)	• Biocontrol agents have not yet had substantial impacts on reducing stand density or extent of invasions and rates of spread in some areas such as South Africa but have been more successful in places like Australia • Initial research is expensive • Potential to spread across borders unintentionally • Inapplicable in areas where native *Prosopis* is weedy • Conflicts of interest around the use of biological control in areas where *Prosopis* invasion is seen as beneficial (e.g. South Africa, Kenya)
Mechanical control	• Efficient at removing *Prosopis* over large areas	• Labour and capital intensive
Chemical control	• Efficient at removing *Prosopis* over large areas	• Labour and capital intensive
Utilization	• Maximizes on benefits to be had from biological invasions • Promotes rural social–economical development • Reduces overexploitation of native spp. • Profits counteract management costs	• Encouraging utilization may create dependency on the species, thereby exacerbating conflicts of interest • Some areas have lower-value *Prosopis* spp. (more thorny, bitter pods, shrubby forms) making utilization more difficult • Many *Prosopis* invasions are in remote areas making large-scale utilization difficult
Cultural control/other control (e.g. fire, grazing and livestock transport management)	• Low costs • Can also prevent other types of degradation	• Requires people to change perceptions • Large-scale education programmers are needed • Does not always work for all *Prosopis* spp.—e.g. fire-tolerant hybrids • Not applicable in all areas, e.g. places with low biomass and fire-tolerant hybrids

Source: Prosopis: a global assessment of the biogeography, benefits, - impacts and management of one of the world's worst woody invasive plant taxa

In Ethiopia, past and ongoing experiences of management of *Prosopis* are either negligible or fruitless. The government spent some money to clear *Prosopis* infested areas completely by machinery and high costs, but left the area idle, so *Prosopis* took over again.

This kind of management is inefficient.

The collection of *Prosopis* pods to avoid the spread of *Prosopis* are also not very encouraging as the number of pods are big and the people may collect the pods at the outer side but do not go inside the bushes.

But the most important factor seems to be that there is some harmony of the local people with the *Prosopis*. They leave the *Prosopis* on areas they do not need for grazing, food or fodder production. But they cut *Prosopis* when they need the branches for fences or the land for cultivation. On cleared land under irrigation agriculture no *Prosopis* at all is found.

In the following an assessment is given on the different options for *Prosopis* management and control, which have been discussed during the field survey:

Management objective	Method	Observations and Comments
Eradication	By machinery	▪ very costly; ▪ might be done to clear the sugarcane fields in Aysaita when the factory starts sugar production on own fields
	Hand clearing	▪ done by machete when people think they have to remove the Prosopis
	Prosopis pod collection	▪ seems no efficient management method
	Chemical clearing	▪ was found only in the literature, ▪ mostly in Australia
Control of further spread		▪ No effective control exists to control the spread of the *Prosopis* when moisture land is lying idle. ▪ The described means of spreading seem not very convincing. The spread of Prosopis seed by the strong winds seem a much more likely distribution way than animal dung. ▪ Prosopis will not extend on too dry land, so natural limits exist for its spread.
Usage	Fencing material	▪ Very popular use of Prosopis both as living fences and as dry fences. ▪ Pastoralists use it to protect the animals (during nights); ▪ Agriculturalists use it to keep the animals out of the fields/protect their crops
	Charcoal	▪ Very good use of *Prosopis*, but not appreciated by the Government as the people also cut other trees (thus damaging other tree stocks). ▪ So the Government interdict the charcoal business; nevertheless cutting of other trees continues.
	Animal feed	▪ High potential use. ▪ Was supported by an FAO project, but due to complicated conception (comprehensive approach, based on Government and Cooperativemanagement) and short duration the activity came to an end.
	Human food use (pods)	▪ Has not been seen
	Flour	▪ Has not been observed during the visit
	Honey and Gum	▪ Was not observed during the visit
	Wood Chips	▪ Was not observed during the visit
	Timber	▪ Was not observed during the visit as in the project area, the *Prosopis* had no trees with trunks. ▪ Only bushes were observed, having no potential for timber.
	Biomass to Generate Power / Bio Fuel	▪ not observed
	Further usages	▪ Police batons are made according to a report

Figure 6: Overview of Prosopis management approaches in the project region

Integrated management approach of usage, control and eradication

The local people apply an integrated approach of usage and control of Prosopis. They remove Prosopis when it enters into their economic activities. They cut it, burn the root stump and remove it later. After this they plough the field with animal drawn equipment by themselves. There is some kind of balanced harmony in the field observable, nobody talks here about eradication.

In conclusion:

... and taking into account the above mentioned positive effects of *Prosopis*, it might be recommended to an integrated approach: making improved use of the positive effects of *Prosopis*, controlling and managing it in areas under cultivation, and leaving the *Prosopis* untouched as long as it does not hinder development.

4 Recommendations for Pilot Measures and Field Trials

Based upon the results of the desk study and field survey, no need is seen for immediate action combating the spread of *Prosopis juliflora* in the project region.

However, the observations during the field visits and interviews allow for some **general recommendations** aiming at the achievement of the projects objectives.

Clan leaders should be involved more effectively in the development, design and implementation of measures in order to sustainably improve the conditions of soil, water and other natural resources as principal means of (agro) pastoral production. This includes, but is not limited to:

- Include local clan leaders in the project planning activities;
- Elaborating a rangeland management plan with local clan leaders;
- Give local clan leaders leadership functions in the pasture management activities.

More in concrete, it is recommended to evaluate the possibility to establish:

- Improved feeding grounds if possible with local clan leaders (also approx. 0.2- 1.0 ha), and
- Wood lots together with local leaders for each clan (approx. 0.2- 1.0 ha).

In support of the rehabilitation measures it is strongly recommended to implement additional measures to reduce the risk of soil erosion, e.g. planting of elephant grass on water catchment structures (stone weirs) and on contour lines with ditches (also in cooperation with local clan leaders). In preparation for that, it is suggested to conduct field trials with suitable and indigenous grasses around water holding grounds (natural and artificial (weirs), possibly in cooperation of other NGOs working on this subject in Afar.

Furthermore, it is recommended to conduct human resource development, which facilitates for effective coordination and cooperation and efficient decision making at both local and national level.

It is not necessary to offer *Prosopis* specific trainings, but rather ensure that the decision makers have sufficient technical knowledge and a common understanding of the challenges and opportunities of approaches to sustainably preserve, rehabilitate and improve the productivity of pastures and arable land in the project region.

All staff, as well as selected promising locals (project and non project personnel), esp. women, should be invited to trainings on the spot (e.g. on planting and management of grasses around water holding areas, incl. evaluation of trial results), but also on national level or abroad. Local clan leader should be included in trainings both as participants but also as resource persons.

Further to these rather general comments, some more **specific recommendations** could be derived related to the management of *Prosopis juliflora* and other invasive species:

- Affected communities could be supported in *Prosopis* management by delivering a machete and a hoe for each household as well as a sharpening machine on communal level (to be maintained on a private basis) with the objective to provide them with the necessary means to control *Prosopis juliflora* on spots under agricultural use. The approach of facilitating the management of *Prosopis* through cash for work is not at all to be recommended, since it rewards for activities without taking into consideration the sustainability aspect.
- It is recommended to support usage and value generation based on *Prosopis*, such as the usage of *Prosopis* pods. This could include provision of support to establishing private purchase places for *Prosopis* pods as part of a more extensive *Prosopis* pod processing and marketing

structure. Taking into consideration the lessons learnt from the FAO project it is recommended to build up this measure upon a solid private sector interest rather than on cooperative structures. Technical assistance might also include initial marketing activities at local level and may be also more distant.

GIZ might assume a leading role in facilitating for an integrated approach of management of *Prosopis juliflora* and other invasive species in the project region. The following table lists suggestions for immediate action, which are recommended to implement.

	Recommendation for action	Remarks
1a	A half or one day sensitization and information meeting for policy makers and senior staff of institutions on the current situation of plant invaders in Afar (not only Prosopis)	▪ Leadership Dr Rezena in cooperation with project staff ▪ Objective: Propose a technical working group (not too big) on national and regional level (if not yet forseen in the not yet published national Strategie for invasive species), which will be responsible to accompany further measures in IAS-control. ▪ Create virtual working space for communication amongst members
1b	Create the technical working group on plant invaders including field implementation agencies (BoPAD, PADO, admin, research, training inst., and civil society persons)	▪ TA in establishing a working plan ▪ Organize and lead working group with new contents which should be studied ▪ Conduct studies on specific topics
2a	Prepare and carry out a survey on plant invader infestation and their ways of distribution (animal tracks)	▪ Whole of Afar – baseline ▪ in cooperation with research and higher education facilities
2b	Based on the results of survey, analyze propagation routes and define observation/monitoring plots accordingly Conducting a survey to collect information of pastoral and semi-pastoral land use and rigts to elaborate a rangeland management plan	▪ serves as basis for: ○ further pilot experience plots , ○ assessing and outlining of invader management and control strategy, ○ planning and implementing management and control measures
3a	In parallel, start with some basic pilot measures such as: on invader management and control in typical situations (infestations, socio-economic impacts together with communities)	▪ Areas with weir structures would be a suitable place to start some pilot activities
3b	Carry out and monitor control and management measures, pilot experiences	▪ Field trials with planting of different grasses ▪ Monitoring system for activities
3c	Invite research institutions to work on particular questions, that cannot be solved by pilot experiences	▪ Establishment of a knowledge exchange platform and cooperation
4	Develop and start income generation activities related to the use of Prosopis, esp. for women (collecting pods)	▪ Organize buying points for Prosopis pods, including processing and marketing with the private sector ▪ Work to the possibility to get the charcoal making legalized again
5	Organize the pastoral leaders in the project areas and get their development perspectives	▪ Implicate pastoral leaders in the elaboration of rangeland management plans and make them responsible for their implementation
6	Facilitate knowledge management on management of invasive species	▪ Document and disseminate results and recommendations

Figure 7: Recommendations for action

Possibilities for development of value chains based on *Prosopis*

For areas where *Prosopis juliflora* is well established, the potential for the development of Prosopis based value chains should be investigated more in detail. In accordance with the approach of an integrated management of *Prosopis juliflora*, this will not aim at eradicating Prosopis, but rather contribute to maximizing the positive effects of Prosopis on pilot level.

There are not many possibilities for viable value chains based upon*Prosopis* available.

Charcoal as fuel:

- Seems a very promising value chain
- Not requiring special tools or machinery, no new knowledge for the transformation process needed as charcoal making is well established in the region
- Marketing channels are well established. No training and supervision is necessary. All the activities are entirely on private basis already.
- This is a male centered activity

Seeds for animal feed:

- New value chain which needs also some specific equipment to process the seeds.
- Special knowledge for processing and marketing is needed, thus intensive training and supervision is necessary
- It is indispensible to organize the project support around private owned structures, just establishing collecting points for all interested suppliers
- This could be a women centered activity

New, **not yet tested** activities:

- Use of charcoal from Prosopis for improving soil conditions, e.g. as water storing material put in planting holes of trees
- Honey production.

Annex I: Analysed Literature

1) Prosopis juliflora

Agroforestry Database 4.0

LOCAL NAMES

Arabic (mesquite); Creole (bayawonn, bayawonn fran); English (ironwood,algarroba,honey mesquite, mesquite, mesquite bean); Filipino (aroma); French (bayahonda,chambron,bayarone,bayahonde francais); German (mesquitebaum); Hindi (vilayati khejra,vilayati babul,gandababul, vilayati kikar); Spanish (algarroba,bayahonda blanca,algarrobo cují,bayahon,algarrobo,bohahunda,cambrón,espino rucco,guatapaná,mesquite,plumo de oro,vallahonda,chachaca); Swahili (kikwajukwaju)

BOTANIC DESCRIPTION

Prosopis juliflora is an evergreen tree with a large crown and an open canopy, growing to a height of 5-10 m. Stem green-brown, sinuous and twisted, with axial thorns situated on both sides of the nodes and branches. Bark somewhat rough; dull red. The root system includes a deep taproot.

Leaves compound; leaflets in 13-25 pairs, oblong (3 x 1.7 mm) and dark green, bipinnate with 1 or sometimes 2 pairs of rachis, almost pendulous.

Flowers lateral to the axis with a tubular, light greenish-yellow, 1.5 mm wide calyx with hooded teeth; corolla light greenish-yellow, composed of 5 petals with 3 mm wide pubescent along its edges.

Fruit a non-dehiscent pod, straight, linear, falcate to annular, with a coraceous mesocarp in 1 segment or divided into several segments; seeds compressed, ovoid, hard, dark brown, with mucilaginous endosperm surrounding the embryo; cotyledons flat, rounded, epigenous when germinating.

ECOLOGY

P. juliflora is xerophytic and is adapted to many soil types under a wide range of moisture conditions. The value of the tree lies in its exceptional tolerance of drought and marginal soils. It tolerates strongly saline soils and seasonal water logging. P. juliflora has been planted successfully on soils with acid to alkaline reaction. It is sometimes said to dry out the soil and compete with grasses, particularly in dry areas; hence in some areas it is considered a weed.

BIOPHYSICAL LIMITS

Altitude: 0-1 500 m, Mean annual temperature: 14-34 deg. C, Mean annual rainfall: 50-1 200 mm

Soil type: It can grow on a variety of soils including rocky hills, saline flats, on shifting sand dunes and coastal sand, although it attains its best size in localities protected from wind and having the water table not far below the surface. It can grow in waterlogged conditions and is tolerant to high salinity.

PRODUCTS

Food: A rich, delicious flour can be made from pulverized pods from which seeds have been removed. Cotyledons and embryos when pulverized yield a flour rich in protein and sugar appropriate for diabetic people. There are reports that P. juliflora pods are used in preparing bread, sweets, syrup and coffee. The pods must be processed to improve the flavor. Sugars and sweeteners can be produced from the pods.

Fodder: For dairy cows, the flour may make up 40-60% of concentrate rations. In South Africa, it is fed unmixed to sheep. Ripe pods contain 12-14% crude protein. The short-fibred parts are also suitable for pigs and poultry.

Apiculture: This species is a major honey source in Bolivia, Jamaica, Pakistan, Western Australia and elsewhere. In Sri Lanka, it is one of the most important species for bee forage due to its very copious nectar flow.

Fuel: The generally crooked stems and branches make good firewood and provide excellent charcoal. Charcoal from P. juliflora wood is used extensively in the USA as barbecue fuel; about 30% of the charcoal sold for this purpose originates from P. juliflora from the Sonora Desert in northern Mexico.

Fibre: There is a large potential for P. juliflora as a source for fibre in the production of paper, paperboard and hardboard.

Timber: Seasoned wood is used for fence posts, furniture, crafts and corrals. It is rarely used in construction, as most tree trunks are not long or straight enough.

Gum or resin: P. juliflora heartwood contains significant amounts of extractable polyphenolic compounds from which can be isolated a unique flavinol compound used in the formation of new phenol-formaldehyde polymeric resins. A reddish-amber gum, similar in properties to the gum Arabic produced by Acacia Senegal, often exudes from the stem and older branches.

Tannin or dyestuff: Tannin or dyestuff can be extracted from P. juliflora but the yield is only about 10%. Tannin could also be extracted as a byproduct when P. juliflora wood is processed for other purposes, such as animal rations.

Alcohol: In Argentina, Chile and Peru the pods are an important item in making alcoholic drinks such as cocktails. **Medicine**: P. juliflora syrup prepared from ground pods has various medicinal values. It is given to children showing weight deficiency or retardation in motor development, the syrup is believed to increase lactation. It is also used for preparing various medicinal syrups, particularly for expectorants. Tea made from P. juliflora is thought to be good for digestive disturbances and skin lesions.

SERVICES

Erosion control: P. juliflora has been used to arrest wind erosion and stabilize sand dunes on coastal areas. It is listed as on the tree species used in sand-dune stabilization in India.

Shade or shelter: Planted in windbreaks and shelterbelts.

Reclamation: Widely planted for land reclamation because it is an aggressive colonizer, tolerant of very poor, degraded, saline and alkaline soils. In the USA, aerial seeding of a mixture of P. juliflora, Nicotania glauca and several Eucalyptus species is used to revegetate abandoned copper mines.

Nitrogen fixing: P. juliflora moderately enriches the soil with atmospheric nitrogen obtained through symbiosis with cowpea-type Rhizobium. The roots also form mycorrhizal associations with Glomus fungi. Plants with both Rhizobiumand mycorrhizal associations show significantly higher nitrogen fixation rates than those lacking the mycorrhiza.

Soil improver: Total nitrogen, sulphur and soluble salts, as well as organic matter, have been shown to increase 3-fold in the upper 4.5 m of soil under P. juliflora.

Intercropping: The best species to grow in association with P. juliflora are Cenchrus ciliaris, Opuntia spp. and Pancium maximum.

TREE MANAGEMENT

The tree normally grows to a height of about 10 m, but under favorable conditions it may reach 20 m. Spacing depends on the use intended for the trees. In South America when grown for fuel wood, a spacing of 2 x 2 m or wider is used. In rangeland in association with grasses and other crops, the spacing may be up to 10 x 10-15 m. When the emphasis is on pod production, the spacing used is usually 5 x 5-10 m. Young plants benefit from weeding around the stem and need protection from grazing animals. Thinning and pruning are needed to prevent P. juliflora from becoming a weed and to keep the plantation accessible. P. juliflora coppices readily, because of its aggressive nature, it is considered a noxious weed in more humid areas, e.g. the southern USA.

GERMPLASM MANAGEMENT

Seed storage behavior is orthodox; 60% germination following 50 years storage; viability can be maintained for several years in hermetic storage at 10 deg. C with 5-9% mc; no loss in viability following 24 hours of immersion in liquid nitrogen for seeds at 7% mc and 5% mc. There are 20 000-26 000 seeds/kg.

PESTS AND DISEASES

In South America, the wood sawyer insect Oncideres saga, which cuts off young branches, causes considerable damage. Other pests reported from South America are the lycainid butterfly Hemiargus ramon, which damages the flowers, and the lonchaeid fly, Silba pendula, and Bruchus beetles, which attack the pods.

Otinotus oneratus, is reported in India to cause damage.

2) Spread of the introduced tree species Prosopis juliflora (Sw.) DC in the Lake Baringo area, Kenya

Anders Granström Januari, SLU/SIDA, 2005

"The paper presents an assessment of the livelihood effects, costs of control, and local perceptions of the invasive tree, *Prosopis juliflora*, on rural residents in the Lake Baringo area of Kenya. Global concern about deforestation caused by fuel wood shortages, prompted introduction of *Prosopis juliflora* to the Lake Baringo area in the early 1980s. *Prosopis juliflora* is in IUCN's new list of 100world's worst invasive alien species. The *Prosopis juliflora* invasion in the study area has recently attracted national attention and contradictory responses from responsible agencies.

Unlike some other parts of the world where it has been introduced, *Prosopis juliflora* potential benefits have not been captured and few people in the Lake Baringo area realize net benefits from the widespread presence of the tree. Strong local support for eradication and replacement appears to be well justified.

Sustainable utilization may require considerable investment in the development of new commercial enterprises".[4]

Table 4: Economic value of *prosopis juliflora* products for individuals in the Ng'ambo and Loboi areas

	Ng'ambo (n=65)		Loboi (n=48)	
Product	Average value (Ksh)	Standard deviation of value (Ksh)	Average value (Ksh)	Standard deviation of value (Ksh)
Construction Poles	4,982	18,511	86	186
Fencing Poles	3,618	7,826	164	406
Fuelwood	5,140	4,215	9,263	26,522
Pods (for livestock fodder)	733	1,459	15	26
Ropes	22	58	0	0
Honey	1,297	3,761	31	216
Charcoal	228	1,688	53	242
Total for all 7 products	16,019	20,364	9,612	26,538

Source: authors' analysis of survey and market data

[4] Invasion of *prosopis juliflora* and local-livelihoods - Case study from the Lake Baringo area of Kenya, page 5

3) Invasion of *Prosopis juliflora* and local livelihoods-Case study from the Lake Baringo area of Kenya

Esther Mwangi and Brent Swallow, World Agroforestry Centre, 2005

"Invasive species cause ecological, economic and social impacts and are key drivers of global change. This is the case for the genus Prosopis (mesquite; Fabaceae) where several taxa are among the world's most damaging invasive species. Many contentious issues ('conflicts of interest') surround these taxa, and management interventions have not yet sustainably reduced the negative impacts. There is an urgent need to better understand the factors that drive invasions and shape management actions, and to compare the effectiveness of different management approaches."[5]

"The increased movement of humans around the world has facilitated transportation of many species to environments far from their native invasions that cause substantial ecological, social and economic impacts, and they are one of the key drivers of global change. However, many alien species have been embraced by humans and are crucial for local livelihoods and national economies through the goods and services they provide.

It is important to understand the dynamics of invasive species to reduce their negative impacts and maximize their benefits, but frameworks linking theory and management for biological invasions are lacking. Management is inefficient in many areas due to lack of knowledge on key aspects of the invasive species. It is crucial to understand the reasons for introductions, uses (benefits), costs, ecology and scales of invasions and to elucidate perceptions and potential contentious issues when creating sustainable management plans. This is true for invasive species in the genus Prosopis.

Taxa of Prosopis (mesquite; Fabaceae) occur in most of the world's hot arid and semi-arid regions as native or introduced species. The genus Prosopis described by Burkart (1976) consists of 44species. They have been introduced globally and have become naturalized or invasive in many places. Several Prosopis species are also 'weedy' in parts of their native ranges.

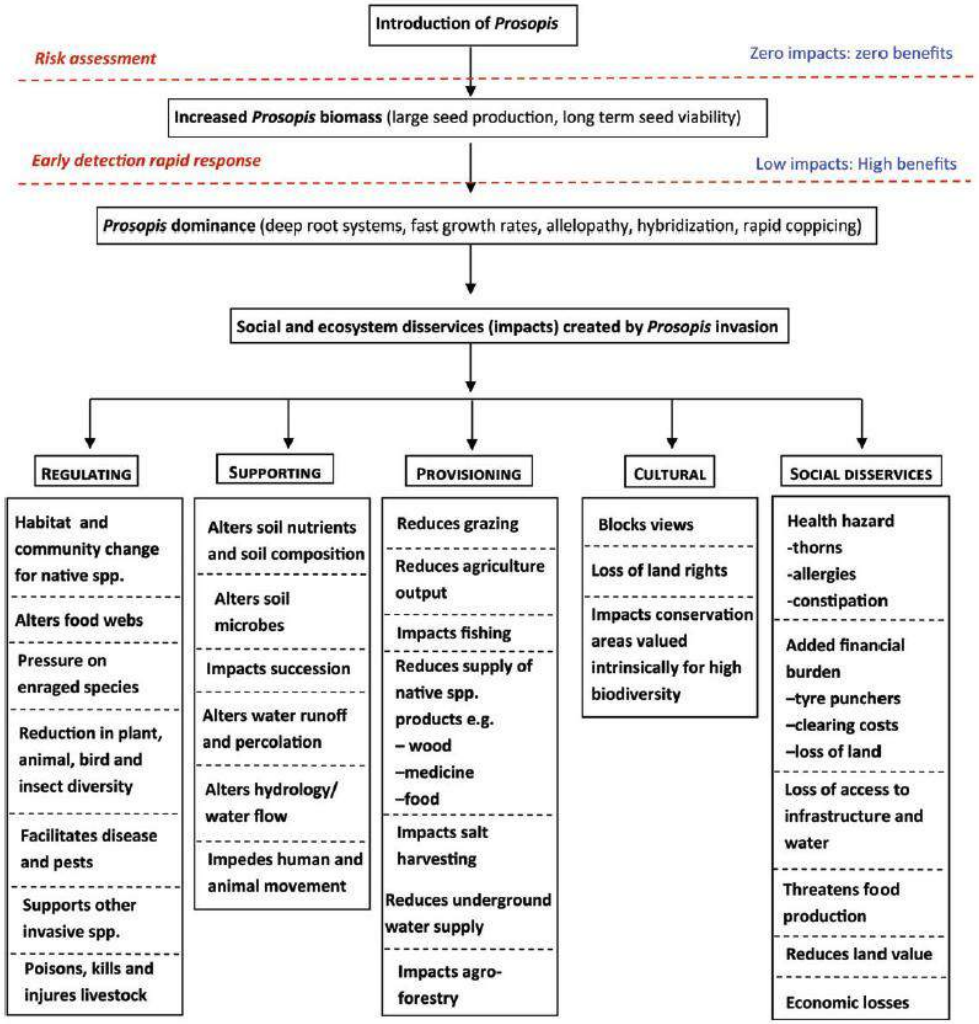
In this paper we define native species as those whose presence in an area is not attributable to introduction by humans (this includes species that have spread into areas without assistance from humans by overcomingbiogeographic barriers. Alien taxa are those whose presence in an area is attributable to introduction by humans. Naturalized taxa are alien taxa that are self-sustaining. Invasive taxa are naturalized taxa that have spread substantially from introduction sites (further details in Pyšek et al. 2004).

We define 'weedy' taxa as nativetaxa that have increased in abundance and/or geographic range in their native ranges. Numerous Prosopis taxa are recognized as major invaders across large parts of the world. 'Prosopis' is listed as one of the 20weeds of national significance in Australia and taxa in the genus are declared as major invasive species in Ethiopia, India, Kenya and South Africa, and Sudan is advocating for its eradication . Factors that make many Prosopis species successful invaders include the production of large numbers of seeds that remain viable for decades, rapid growth rates, ability to ranges. This has coppice after damage, root systems that allow them to efficiently utilize both surface and ground water (to depths of .50 m), and allelopathic and allelochemicaleffects on other plant species.

Many Prosopis species can alsowithstandclimatic extremes such as very high temperatures and low rainfall, and they are not limited by alkaline, saline or unfertile soils.Interspecific hybridization also enhances invasiveness in many introduced regions.

[5] Invasion of *prosopis juliflora* and local livelihoods-Case study from the Lake Baringo area of Kenya, Page 1

Prosopis invasions generate environmental, social and economic benefits as well as harm. This has led to contentious issues surrounding the genus. Some advocates promote it as a 'wonder plant' while others call for its eradication, or contrast its positive and negative aspects, e.g. 'Boon or bane' 'Pest or providence, weed or wonder tree?', 'Invasive weed or valuable forest resource?'. Contrasting views, contradictory perceptions and unclear policies are limiting options for constructive dialogue between different parties. This is exacerbated by problems in identifying and differentiating morphologically similar species, and by a general lack of knowledge on the distribution, scale of invasion, benefits, impacts and effective management approaches. Furthermore, many different approaches for managing Prosopishave been tried in different situations without a thorough evaluation of the relative effectiveness of the methods. The Food and Agricultural Organization has called for a sound, unbiased global overview of Prosopis act as a prerequisite for the holistic management of the genus. Such reviews have been useful for guiding and prioritizing management and improving knowledge in other groups of woody invasive plants. "[6]



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[6] Dito, page 2

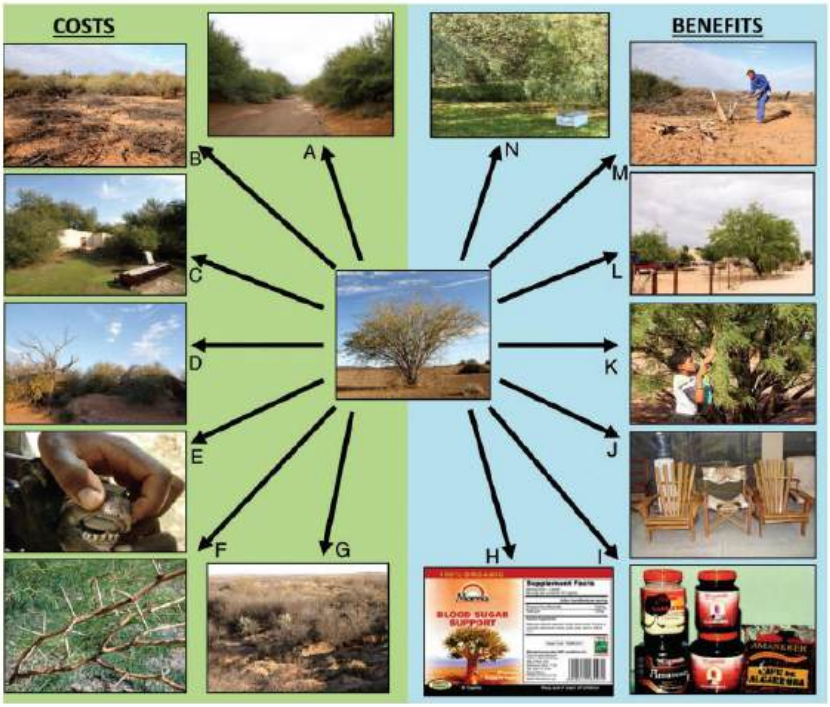

Figure 1. Costs and benefits of introduced *Prosopis* species: (A) invasive *Prosopis* stand altering hydrology in Loeriesfontein, South Africa; (B) cleared *Prosopis* in the foreground and uncleared in the background illustrating impenetrable thickets, loss of land, loss of grazing potential and the effort needed for its control in Kenhardt, South Africa; (C) loss of access to a barn and encroachment of fields in Calvinia, South Africa; (D) death of a native tree (*Searsia lancea*) due to competition from *Prosopis* in Kenhardt, South Africa; (E) effects of *Prosopis* pods on a goat's teeth in Kenya; (F) *Prosopis* thorns that cause tyre damage and injure humans and livestock; (G) *Prosopis* causing loss of topsoil and erosion in Prieska, South Africa; (H) 'manna'—a blood sugar medicine made from *Prosopis* in South Africa (www.mannaplus.co.za); (I) food products made from *Prosopis* in Peru; (J) timber from *Prosopis* used to make furniture in Kenya; (K) a young boy collecting *Prosopis* pods to feed livestock in Askham, South Africa; (L) *Prosopis* used for shade and ornamentation in Askham, South Africa; (M) *Prosopis* used as a fuel in Kenhardt, South Africa; (N) a bee hive placed in an invasive *Prosopis* stand Calvinia, South Africa. Photos: S. Choge (J), G. Cruz (I), P. Manudu (E, F), R. Shackleton (A–D, G, K–N).

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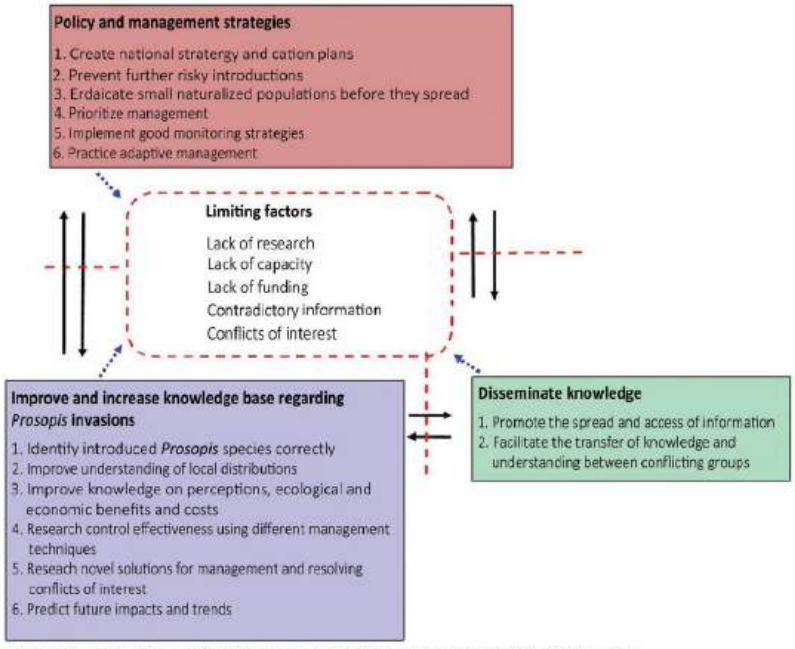

Figure 7. Requirements for research and management needs regarding *Prosopis* and factors limiting success.

4) THE PROSOPIS DILEMMA, IMPACTS ON DRYLAND BIODIVERSITY AND SOME CONTROLLING METHODS

Abiyot Berhanu and Getachew Tesfaye Ecosystem Conservation and Research Department, Institute of Biodiversity Conservation, Addis Ababa, Ethiopia, 2006

The desert and semi desert ecosystem covers a large proportion of the landmass in eastern and southeastern parts of the country. It includes most, if not all, parts of the Afar Region. It has vast ecological, cultural, economic and social values at national and continental level. Ecologically, this ecosystem consists of diverse habitat types that support a number of endemic flora and fauna and hosts Yangudi-Rasa National Park. Culturally and socially, it provides a living space for nomads and provides spiritual and medicinal values for the people and their livestock. With regard to economic value, it supports relatively high livestock population (earns foreign currency), provides agricultural lands (mechanized agriculture), salt mining, tourism (ecotourism) at Hadar and other parts of the region.

Areas in this ecosystem are being invaded by *Prosopis juliflora* (hereafter *Prosopis*) at an alarming rate. The species is forming monospecific thickets, and roads, watering areas, farms and grazing areas are being lost.

The species can grow in altitudes from sea level to 1500 m asl. In Ethiopia it occurs with altitudes of 450 m to ~1000 m asl currently invading areas in the Afar and Somali Regional States (Getachew 2002). *Prosopis* is reported to tolerate annual precipitation of 150 to 1670 mm, annual temperature of 20.3-28.5oC and a pH of around neutral (Duke 1983).

This study was conducted with the objective to 1) assess the impact of *Prosopis* on humans; domestic animals and dry land biodiversity in general, 2) evaluate the control options for *Prosopis* particularly mechanical control and prescribed burning, and 3) create awareness among the society in areas invaded by the species.

Conclusion and recommendations

Prosopis continues invading new areas and driving out pastoralists and farmers from their localities. Thus, proper management and control of *Prosopis* is urgent using the control methods suggested above in cooperation with experts and the local people. Otherwise, threats of the local biodiversity would be aggravated. Besides, tribal conflict for the remaining few grazing and farm areas free from *Prosopis* may turn into unexpected political crisis. Thus, the following points are recommended for better management and control of the species:

1. Identify those areas with potential uses as grazing, farms, and settlement and introduce prevention methods such as avoiding the usage of mature plants for fencing, otherwise by removing the ripe pods, and quarantine livestock for at least six days before moving them to new areas;

2. Organize the people (form task force) to control*Prosopis* mechanically (manually) in areas with potential uses for farming, settlement, grazing and other uses before the species becomes mature (bear fruits);

3. Remove *Prosopis* seedlings at the early stage (<1.5 yrs) and/or apply prescribed fire under controlled conditions;

4. Avoid cutting the plant randomly as it has strong coppicing ability if proper management such as repeated clearance is lacking;

5. Avoid taking the fruit to other/new areas and educate the people not to do so. *Acknowledgements*- The authors would like to acknowledge the Pastoralists, staff of the Agricultural Bureau and Natural Resources Management of Afar and Somali Regional States. The research was conducted as part of the usual activities of the Institute of Biodiversity Conservation.

The Impacts of *Prosopis juliflora* on Biodiversity in the Desert and Semidesert Ecosystem, Northeast Ethiopia

Biophysical Description

The altitudinal range of the desert and semidesert ecosystem varies from -120 m in the Danakil depression to roughly 900 m a.s.l in the Middle Awash (vertical rectangle is project site).

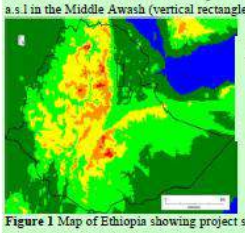

Figure 1 Map of Ethiopia showing project site

The peripheral low-lying region in the Danakil depression is an extended flatland, extremely hot, dry and harsh, and the slope goes gently undulating with an increase in altitude towards the central mountainous region of the country. The ecosystem is known for its poorly developed soil that varies depending on topography and climate. It is characterized by scant and unpredictable precipitation, cloudless days in most parts of the year, hot summer, and temperature.

Biodiversity and Social Values

This ecosystem consists of diverse habitat types that support a number of endemic & endangered flora and fauna and part of it has been designated as a National Park (Yangudi-Rasa NP). It supports relatively higher livestock population, provides agricultural lands, salt mining, tourism at Hadar and other parts of the region. The Afar, Somali and Oromo tribes inhabit this ecosystem with rich cultural diversity.

The Plant Material

Prosopis juliflora is a tree/shrub that belongs to the family Fabaceae and subfamily Mimosoideae. The species was intentionally introduced from central/south American to Ethiopia as multipurpose tree and escaped cultivation becoming the worst invasive in the desert and semidesert ecosystem. The most important reason for its fast invasion is attributed to the role of livestock, people and wildlife in dispersal of the seeds.

Figure 2 Cattle are the major dispersers of *Prosopis* seeds

Project Objectives

This study was conducted to 1) asses the impact of *Prosopis juliflora* on humans, domestic animals and biodiversity, 2) evaluate the control options particularly mechanical control and prescribed burning, 3) create awareness among the local community and 4) develop a management guideline.

Results

1. Impacts of *Prosopis juliflora*

* Locally used for fencing, windbreak, forage and fuel

Figure 3 A Camel feeding on *Prosopis* fruits

Figure 4 Goats feeding on Prosopis twigs and fruits

* Negative impacts
  - Prohibits grazing and farming
  - Has formed thick monospecific scrub
  - Has poisonous spines to livestock and people,
  - Impairs the growth of forage (grasses),
  - Pods form balls in the stomach and kill livestock
  - Has reduced the total biodiversity of the area by reducing their abundance, distribution and the ecosystem function

Figure 5 *Prosopis* has formed monospecific thicket near wetland

* Most members of the local community support eradication of the species
* Awareness was created and a guideline developed for the management of *Prosopis juliflora*

2. Control Methods

Mechanical control

Stem count revealed the number of stems from the coppiced stands was significantly higher than original stands. Manual clearance and using bulldozers followed by proper management system was found to be effective in state farms.

Figure 6 Discussion with stakeholders and local experts on the problem

Prescribed burning

The method was destructive for young stands where as mature stands were not burnt down

Figure 7 Trial of prescribed burning at a grazing land invaded by *Prosopis*

Lessons Learned

- Complete eradication of *Prosopis* is very expensive and impossible but minimizing the risk
- Using mechanical control and prescribed burning followed by proper management are effective
- Random cutting without any management intervention aggravates the invasion by *Prosopis* producing more branches and fruits/seeds
- Many areas of the desert and semidesert ecosystem are at risk of being invaded

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2. Abiyot Berhanu & Getachew Tesfaye (2004). Ecological management of *Prosopis juliflora* (A working manual)
3. Hailu Shiferaw (2002). Some biological characteristics that foster the invasion of *P. juliflora* in the Middle Awash Area, Northeast Ethiopia. MSc. Thesis

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5) PROLIFERATION OF HONEY MESQUITE (*Prosopis juliflora*) in Somaliland

Ahmed Ibrahim Awale, Ahmed Jama Sugule, Candlelight for Health, Education & Environment (CLHE), 2006

One major issue whereby Candlelight for Health, Education & Environment has been closely monitoring over the past few years is the proliferation of mesquite *(Prosopis juliflora)*; an invasive plant and vast spreading weed which establishes itself fast almost everywhere, even in low rainfall areas and in problematic soils. Interestingly, whilst the indigenous trees are dying fast in the wake of over-exploitation in Somaliland for fuel wood, charcoal, thorn enclosure fencing and for building materials, mesquite *(Prosopis juliflora)* has been aggressively establishing itself everywhere. The Somali name *'Garanwaa'*, literally meaning *the Unknown*, was coined by Somali returnees from refugee camps in eastern Ethiopia during early 1990s, thereby unexpectedly coming into contact, upon their return, with this 'unknown', quick-spreading plant which annexed large areas within the towns and farmlands only during span of time not more than three years (1988-1991).

The alarming rate of expansion of the weed, its encroachment into farmlands and rangelands, its prolific characteristic of annexing large areas which result in limiting the free movement of people and livestock and the resulting impact on their socio-economic conditions is a subject of heated discussions and debates.

Candlelight has done some experimentation on the possibility of preparing charcoal from mesquite. The results were very encouraging and the light-weighted charcoal can be graded second or third to *Galool* (*Acacia Bussei*), the best charcoal tree around in Somaliland.

Candlelight's interest in this plant lies within the argument: *'if you cannot win the war against mesquite, reconcile with it and make optimum use of it as resource'.*

On the basis of the predominant negative community perception about the weed, and the repeated calls for its eradication, Candlelight may be regarded as a devil's advocate. Coincidently, in many countries the plant is dubbed as the Devil's Tree.

This study will focus on the following aspects of the plant:

- General information of the plant and its origin
- Its history and introduction to Somaliland
- People's perception about the plant
- Current utilization of the plant
- Further opportunities for its utilization
- Conclusions and recommendations

The Case Study Team has relied on the following sources of information and methodology to complete this case study:

- Published information from the internet
- Group and individual interviews with local people
- Transect walks
- observations

This is probably the first study of its kind carried out in Somaliland (if not Somalia as whole), and it hoped that it will be a basis of similar works on the plant.

CONCLUSION

Due to the limited information and knowledge by the local people on *Prosopis juliflora* together with its fast spreading, coppicing and undesirable characteristics, the plant is largely ignored or considered a useless weed. It is still paradoxical that *Prosopis* is advantageous and disadvantageous

for the local people. Some groups are in need of it while others are looking for techniques to eradicate it from their surroundings.

*Prosopis julifloras*eems to be a good option for rehabilitation of seriously degraded dry sandy areas, where the spread will not get out of control. It is extremely important to limit the planting areas so that extensive spread cannot occur that has caused difficulties in some irrigated agricultural schemes.

There is a dire need for alternative source of wood and wood products other than the heavily pressured acacia species. With the increase in the use of mesquite, the threat on the native woodland resources could be minimized as the annual increment rate of growth of *Prosopis* juliflora is considerably high compared to the Acacia species. However, even in countries where its utilization is greater, restrictions are now in place on the plant for fear of its overuse!

RECOMMENDATIONS

- Maximum utilization of the plant should be encouraged rather than condemning it as a useless plant. This could be achieved through awareness raising and demonstrations on its multipurpose uses.
- Popularization of Prosopis charcoal, particularly in the areas where it has heavily annexed viz. Bioxidheenka, Agabar and Sabacad.
- Commercialization of the other potential uses of Prosopis such as timber, pod flour, gums.

6) Prosopis, an Alien among the Sacred Trees of South India

Kurt Walter, TROPICAL FORESTRY REPORTS 38, 2011

The problematic of invasive species in an alien environment has aroused the attention of scientists all over the world for quite some time. One of the exotic tree species that has provoked special attention in the tropical dry lands is *Prosopis juliflora*. Originating in South America, Prosopis (hereafter referred to as Prosopis) has been introduced in the hot and semi-arid zones of the world particularly to provide fuel wood, to stabilize sand dunes and to combat desertification. The tree has become an essential source for fuel wood and a provider of several other products and services in areas where it has become established.

However, despite the numerous benefits the tree provides to rural people, in several regions Prosopis has become a noxious weed with a negative impact on the environment and to the economy of farmers and landowners. In India, Prosopis was introduced in Andhra Pradesh in 1877.

The purpose of this study was to investigate the overall impact of Prosopis on local rural livelihoods in the dry lands of South India. Of particular interest was the examination of the different usages of the tree, especially as fuel wood, and people's perceptions of it. Furthermore, the study examined the negative impacts of the uncontrolled invasion of Prosopis on croplands, and its occupation of the banks of irrigation canals and other water sources.

The data were gathered during two fieldwork periods in the states of Andhra Pradesh and Tamil Nadu, in South India.

The results confirmed that Prosopis both provides benefits and causes hazards to different stakeholders. Farmers and agriculturalists suffer economic losses in areas where Prosopis has invaded crop fields and competes with other plants for water and nutrients. On the other hand, for a significant number of poor rural people, Prosopis has become an important source of livelihood benefits. This tree, which grows on government wastelands, is commonly a free resource for all and has thus become a major local source of fuel wood. It also provides several other goods and services and cash income that contributes to improve livelihoods in rural communities.

Prosopis ranked lowest in the tree classification in system of the Hindus of South India. Although it is appreciated for many benefits it provides for poor people, it has remained an "outsider" compared with the indigenous tree species. On the other hand, the most sacred trees, such as the bodhi or the banyan, are completely excluded from extraction and it is seen as a sacrilege to even cut branches from any of these trees. An unexpected finding was that, in a few cases, Prosopis had also been elevated to the status of a sacred tree.

Goods and services from Prosopis are not utilized in the most beneficial way. Silvicultural management practices are suggested that would provide additional income and employment opportunities. Interventions are recommended to control further invasion of the tree that might cause serious negative effects in the future. For Hindus, the sacred always ranks highest, even above economic gain. The conservation of sacred groves and sacred trees is a tradition that has its roots in ancient history. These socio-religious practices need to be respected and continued. Successful management of tree and forest resources depends on the willingness of the local people to manage their natural resources, and this willingness exists – and has always existed – in South India.

7) Controlling and/or Using Prosopis Juliflora in Spate Irrigation Systems

SPATE NETWORK, 2014

Prosopis juliflora invades land and even worse encroaches on river beds and canal beds –blocking them and causing drainage patterns to uncontrollably shift. Yet Prosopis juliflora is a blessing as well, albeit mixed. It is a source of biomass in some of the most marginal lands and provides fuel wood, charcoal and fodder.

This practical note takes stock of how to manage this 'mixed blessing' in spate irrigation systems, based on first-hand experience and grey literature. In the last thirty years the hardy well rooted shrub made its way from Latin America to all parts of the world, covering millions of hectares in for instance India, Pakistan, Yemen, Sudan, Somalia or Ethiopia. In many places it was first introduced in sand dune stabilization projects. However Prosopis juliflora has the habit to 'overstay its welcome' and expand rapidly and not go away. The area estimated conquered by the invasive species in the last ten years in India. Pakistan, Yemen, Kenya, Sudan and Ethiopia are way above 10 million hectares.

Particularly in areas where there is livestock grazingProsopis juliflora spreads rapidly: the seedpods cling to the animal skins and are distributed widely. Prosopis juliflora germinates easily and once it has settled in an area it is difficult to get rid of it. It takes over the natural vegetation, does not allow undergrowth and hence greatly reduces the grazing value of land.

It also tends to creep into waterways – including dry riverbeds – choking them in the process and causing Flood Rivers to run wild. The Prosopis juliflora thorns are poisonous and can even cause blindness. Livestock, particularly cattle, can become ill when they are almost exclusively fed with pods of Prosopis juliflora. Symptoms can bifacial contortions and constipation, sometimes resulting in death.

Prosopis juliflora was widely distributed in Ethiopia as a biological soil and water conservation agent during the late 70s. Now it is considered a major threat because of its invasive nature. Prosopis juliflora has an aggressive invasive character invading pastureland, irrigated cultivated lands and irrigation canals causing an irreversible displacement of natural pasture grassesas well as native tree species

In terms of coverage, the area's most adversely affected nationally include the Afar and Somali Regions in the east and southeast of the country and the area around Dire Dawa City. There are also moderately affected areas in Amhara, Oromia, Southern Nations Nationalities and Peoples (SNNP) and Tigray Regions – that is, in the mainly dry lands of Central, East and North Ethiopia (Steele 2009).Infestations typically originate from the many small villages, extending along the main routes and are now steadily advancing into the surrounding landscape. The invasion of Prosopis

Experience in Afar, Ethiopia

There is a potential to control the spread of Prosopis juliflora to farmlands and key pasturelands by promoting utilization which proved economic incentive to local people to be involved in the management if planned and regulated carefully. Farm-Africa had been supporting local communities through provision of hand tools and organizing mass campaigns to clear Prosopis juliflora from pasturelands and cultivable areas. However the approach couldn't get wider acceptance as there was no immediate benefit to the people. The idea of control through utilization such as charcoal production and pod crushing was raised with the principle of providing incentive for local people to be engaged on the control initiatives (Tegegn 2008). Cooperatives set up by Farm Africa were able to clear Prosopis juliflora 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 (Admasu2008). Be-

cause Prosopis juliflora expands in Afar its area faster than the area that is brought underproductive use, research from Farm Africa shows that not much can be done to eradicate Prosopis juliflora, if external support in terms of community mobilization, technology transfer, private sector participation and supply of resources is not taking place.

8) The mesquite control toolbox

CSIRO, 2014

Integrating control options

As mesquite species respond differently to control methods, the most effective method or combination of methods will vary depending on the size, density and species of mesquite present. For this reason, correct species identification should be made before any control work is started.

Rarely will one control option fix the problem. Usually a combination of methods (e.g. mechanical, chemical, biological and management) will be most effective. Assessment of the best option should be carried out on a paddock-by-paddock basis, and a plan made for each individual situation.

In general, the shrub forms of mesquites more difficult to control than the tree form. This should be taken into account when deciding on control methods.

The following should be considered:

- Size, density and species of the infestation
- Short-term and long-term objectives of the project
- Accessibility of the infestation and the type of land infested—for example, flat open plains, along major watercourses and flood plains availability of resources—for example, spray equipment, tractor, dozer, labor
- Management options
- Easiest and most cost-effective methods
- Complementary control options—for example, chain pulling, followed by burning, followed by application of herbicide
- Type and amount of native woody vegetation present. This will have implications on what options can be used without the need for a tree-clearing permit. When working out the control program, keep in mind that:
  - Widespread use of chemical and mechanical control can be expensive in rangeland situations
  - Seed banks can be large and long-term, so follow-up control is extremely important
  - Mechanical control can provide the opportunity to re-sow with suitable pasture species, which will provide competition for new mesquite seedlings as they emerge.

As mesquite has different survival characteristics control, therefore, requires a long-term program.

Table 4: Shrub form—mostly multi-stemmed (*P. velutina, P. glandulosa, P. juliflora* and hybrids)

Control option	Situation				
	Scattered	Low density	Medium density	High density	Regrowth/ seedlings<1.5 m
Physical control					
Blade ploughing		✓	✓✓	✓✓	✓
Chain pulling					
Dozer pushing					
Stick raking [3]		✓	✓✓	✓✓	✓✓✓
Fire			*	*	✓
Chemical control					
Basal bark spraying	✓✓✓	✓✓✓	✓✓	✓	✓✓
Cut stump technique	✓✓	✓✓			
Foliar spraying					✓✓✓

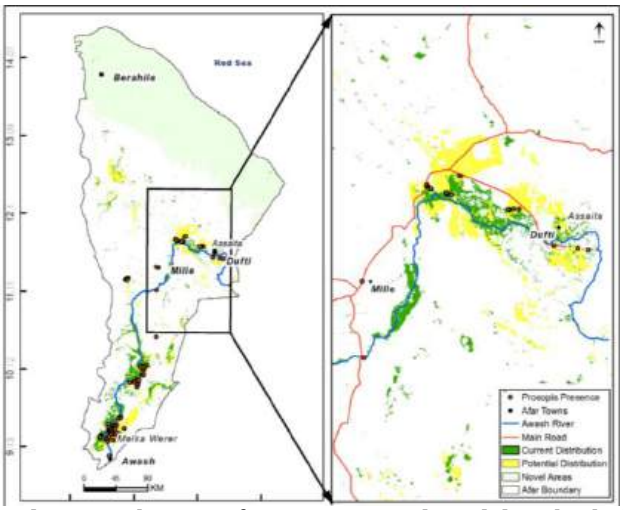
9) Mapping Current and Potential Distribution of Non- Native *Prosopis juliflora* in the Afar Region of Ethiopia

PLOS ONE, 2014

Early detection and mapping of invasive species are essential to formulating effective containment strategies. However, in Ethiopia, quantitative assessments of the area invaded by P. juliflora and its potential distribution have not been adequately conducted. Conventional ground surveys and mapping activities are time consuming, and costly, especially over large areas. New integrative spatial modeling approaches that employ advanced remote sensing, Geographic Information Systems (GIS) and modeling algorithms (e.g., correlative models) are increasingly being used to map both the current and the potential distributions of invasive species.

Vegetation mapping primarily involves understanding the behavior of the electromagnetic radiation and the reflectance properties of features and plants. Healthy vegetation has chlorophyll which reflects the green, and absorbs the blue and red, portion of the visible electromagnetic radiation. During different phonological stages and stress conditions, the amount of blue and red electromagnetic radiation reflected by plants changes. Likewise, healthy vegetation highly reflects the near infrared portion of the electromagnetic spectrum. Variation in internal leaf structure among plant species creates subtle differences in reflectance values. This unique spectral value, also called spectral signature, can be detected by remote sensing sensors, and can be used to discriminate plants at a species level. By manipulating reflectance values in the blue, red, and near infrared portion of the spectrum, it is possible to create different ratios and vegetation indices which permit discrimination of vegetated areas. Among the commonly used vegetation indices are the Normalized Difference Vegetation Index (NDVI) and the Enhanced Vegetation Index (EVI)

Prosopis juliflora and P. pallida trees have evergreen to semi evergreen leaves, shedding leaves completely only under stressful and drought conditions. Besides having evergreen leaves, P. juliflora forms dense thickets and dominates the canopy layer, all of which are useful traits for remote detection of tree species. Mapping current distributions of invasive plants is generally conducted by discriminating spectral reflectance from different remote sensing sensors and derived vegetation indices. Recent studies have provided evidence that inclusion of topographic predictors with remote sensing data can improve these mapping efforts (e.g.). In contrast to mapping current distributions, predicting potential distributions attempts to relate species occurrence to environmental conditions, such as climate or topography, and then uses these relationships to predict locations with similar environmental conditions to those where a species is found invasive P. juliflora trees has been quantified in Ethiopia. Here, we present correlative techniques for mapping and modeling both the current and potential distributions of P. juliflora trees in Afar (Ethiopia), using remote sensing and topo-climatic predictors, species occurrence points, and Maxent species distribution modeling software. Specifically, our objectives were to:



1) map the current distribution of P. juliflora in the Afar region of Ethiopia using a time-series of vegetation indices from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite; and

2) predict its potential distribution using climatic and topographic environmental variables.

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

Dubale Admasu, FARM-Africa for IUCN, 2008

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 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.

At the national level, however, there is no clear policy or strategy for the control and management of invasive species 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 invasive species are left unmanaged, and advocates for a strong policy and strategy in Ethiopia to deal with them.

According to local communities, the Prosopis invasion has resulted in multiple negative effects on their food security, livelihoods and the region's environment. 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.

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

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.

11) The Ecological and Socio-economic Role of *Prosopis juliflora* in Eritrea

Harnet Bokrezion Johannes Gutenberg-Universität Mainz, 2008

In 1999, during field research the author conducted within her Masters dissertation on desertification and land degradation in Eritrea, *Prosopis* was mentioned as an indicator for degraded land by the local communities in the Western Lowlands (Gash Barka region).

Moreover, within a continuous national effort to protect and regenerate the natural resources base and to boost afforestation, the cutting of live trees and shrubs for household or commercial consumption or for unauthorized agricultural land clearance in rural areas has-been strictly prohibited. *Prosopis* was the only species excluded from this policy and communities were allowed to continue cutting it. In the view of a widespread need for fuel wood - the main source of rural energy - one would have imagined that *Prosopis* was regarded a savior or at least a valuable tree among the rural population, particularly poorer households, but the opposite was the case: Eritrean farmers and pastoralists alike made it clear that the plant was a cause for serious concern to their livelihoods and they claimed it was killing their animals. They simply wanted it eradicated.

The decision of Kenya's Ilchamus community in the Rift Valley Province to take the Food and Agriculture Organization (FAO) of the United Nations to court over the introduction of *Prosopis* into their area is another illustration as to how damaging residents feel the impact of *Prosopis* invasion is on local livelihoods and the lengths to which communities are prepared to go in the fight against the species. Therefore, researchers, experts and policy makers alike should take the concerns of the rural communities seriously.

They need to be incorporated in any assessment and management planning even if certain research trials or surveys have demonstrated the potential benefit of *Prosopis*. On the other hand, this study and others have indeed demonstrated that *Prosopis* can be of benefit to communities. For example by providing fuel wood or a substitute to animal fodder particular during the dry season, resources which are both very high in demand in Eritrea and the wider region and which can be used for income generation. Therefore, these two stands - the threats and the benefits - need to be combined and more importantly acted upon in an integrated strategy that seeks to find the appropriate way forward.

Thus, the 'paradox *Prosopis*' that so many researchers refer to may not be so much of a mystery after all. If some refer to *P.juliflora* as the devil and others call it a savior, some think it is an aggressive weed and others believe it is a multipurpose wonder tree one needs to see the external factors that may lead to this divergence in views.

12) Capacity Development to Strengthen Drought Resilience of (Agro-) pastoralists in the Lowlands of Ethiopia" (SDR-ASAL), GIZ Project,

(SDR-ASAL), GIZ Project, 2014

Recently, it has become clear that some invasive alien plant species (IAPS) are having very negative impacts in the Afar National Regional State of Ethiopia, spreading at an alarming rate, and threatening rangelands, croplands, natural forests, waterways, lakes, rivers, roadsides and urban/village green spaces.

The invasive plants that are the targets of the GIZ SDR-ASAL Project include: the annual herb *Parthenium hysterophorus* and perennial invasive shrubs *Prosopis juliflora* and *Acacia nubica*. Other emerging / potential plant invaders will be also considered as long-term mitigation measures against IAPS in the project areas and neighboring localities.

As part of the GIZ SDR–ASAL Project technical support to design and implement pilot measures on participatory management of invasive alien plant species a field trip was conducted between 17 - 23 September 2014 in the four study *woredas* of the Afar region (Mille, Chifra, Ewa and Awra) together with the GIZ SDR ASAL project team: Prof. Irmfried Neumann, international consultant for technical back-up; Ato Mohammed Awol, SDR NRM expert and Ato Indris Siraje SDR PME expert. Throughout the field visit the mission was supported by experts and Focal Persons from the respective study *woredas'* PADOs. The Team's particular focuses were: *Acacia nubica*, *Prosopis juliflora* and *Parthenium hysterophorus*.

The objective of the mission were to conduct an assessment on encroachment with and management of IAPS and to support the design, implementation, evaluation and learning of participatory pilot measure for controlling and managing of IAPS in SDR ASAL project area which will be based on the community perception with a special focus on *Acacia nubica*, *Prosopis juliflora* and *Parthenium hysterophorus*.

General recommendations

- Questionnaire based survey on distribution and socio-economic impacts of major and emerging invasive plant species in the five woredas.
- Prepare and carry out full vegetation inventory: to be carried out by 2 - 4 M. Sc. Postgraduate students in collaboration with Addis Ababa and Haramaya Universities
- Awareness creation and trainings for the pilot communities as well as senior and field staff on different aspects IAPS on the problems and challenges as well as on practical solutions to the problems in collaboration with the extension service. This in turn will help to understand the pastoral system and to design appropriate interventions.
- Educational campaign on (animal and human) health issues of *Parthenium* and total control in settlement areas.

Recommendations for pilot measures

- Five to ten pilots are envisaged by the project, initially starting with 2 – 3 depending on consultations with the communities.
- Where possible, the pilots will be designed according to an integrated approach: communities running the pilot measures will work on cultivation of crops, improved rangeland management, soil- and water- conservation, income generating activities and business and organizational skills.
- All pilots shall target the establishment of productive land-use through a comprehensive approach, of which IAS control is one element (soil and water conservation, fertility management, improved cropping systems).
- The accent in agro-pastoral land-use (irrigation) on intensive small scale land-use to start with, for easy adoption and intensive learning (vegetable, fruit and cereal production, some forage.

Test also rainwater harvesting from roofs etc.).Later stepwise increase of cultivated area according to capacities.

- In intensified pastoral land-use, compare different options of rangeland rehabilitation (Intensive dung use with planting resistant forage species, natural re-growth over different time periods, compare different patterns of grazing after rehabilitation etc.)
- Development of adapted management measures: (Assessment of best options of land-use; Evaluation of best management practices for target IAPS; Determination of soil seed bank for all selected pilot sites; Area closure/stock exclusion of severely degraded land after IAPS clearance; fodder development focusing on native herbaceous legumes, grasses, fodder trees and shrubs after IAPS clearance. Grazing management of rehabilitated areas;
- Negotiate individual and community land use rights for irrigation and rangeland use before pilot start

Organizing the pilots

- Training of pilot communities as well as senior and field staff on different aspects likes IAS etc.
- Organize scientific support groups (IAS, NRM, S&WC) to prepare and accompany the pilot experiences (APARI, Samara University, Development actors …)
- Consult with pilot communities and their local partners (BoPAD, CDC etc.) and chose the first pilot sites.
- Organize pilot inception workshops with community and partners. Start diagnosing and planning.
- Have experience shared between the pilot communities
- Establish monitoring system to measure impact of measures (spread of IAS, productivity of the different land-use options etc.)
- Up-Scaling of pilot experiences

13) Experiences on Prosopis Management Case of Afar Region

Getachew Gebru Tegegn, FARM AFRICA 2008

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.

The development of regional legislation and policy concerning *Prosopis* management and utilization could provide a framework for communities interested in using it as are source 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.

14) Spread of the introduced tree species *Prosopis juliflora* (Sw.) DC in the Lake Baringo area, Kenya

Anders Granström Januari 2005, SLU/SIDA

Far from every exotic plant species become invasive weeds. Only a small amount of introduced plant species form viable stands/populations and even fewer naturalize to the new environment. It has been estimated that one or two percent of introduced exotic plants become invasive weeds (Groves 1986). However, it is difficult to predict whether a plant species has the ability to spread uncontrollably. A common phenomenon with introduced plant species is a so called 'time lag', where the plants only start to show invasive tendencies after a period of years to many decades (Hughes 1994, Mooney & Cleland 2001). There are three main strategies to control or eradicate invasive species: Physical, where plants are mechanically removed, chemical where herbicides are used against plants, and biological, where predators or pathogens are used to control the invading plant's reproduction

In the initial stage *P. juliflora* was appreciated due to its ability to grow where nothing else seemed to be able to grow. It was easy to plant, prevented soil erosion and sandstorms, provided shade and its pods served as a source of food for livestock (Lenachuru 2003). After about ten years problems with *P. juliflora* started to occur. It started to spread rapidly and its ability to survive cutting by coppicing made it uncontrollable. People are today complaining about the shrub forming impenetrable thickets that are preventing other plants from growing. Furthermore they claim that their goats get bad teeth (Figure 3) after eating the sugary pods from the trees, which leads to teeth loss and thus starving goats. However, that has not been documented. Other com-plaints about *P. juliflora* are that its thorns are causing injuries on people and livestock and punctures on vehicles

The spread of the introduced plant *Prosopis juliflora* (Sw.) DC was studied in the Lake Baringo area in Kenya. In addition, woody plant diversity and soil characters were studied. Major initial planting sites with *P. juliflora* were located and marked with GPS. The number of major plantations was 16 and obvious signs of spread were found from 9 of the plantations. Sites planted with *P. chilensis* were found as well, but no signs of spread were observed. Small scale plantations with *P. juliflora* and *P. chilensis* were also located. Observations of spread by *P. juliflora* were made both from major planting sites and from small scale plantations. *P. juliflora* showed the strongest signs of spread along roads and in areas where the soil had a fine texture and where there was seasonally or permanently good access to water.

The abundance of plant species was low in the area and 31 species were scored during the inventories. However, the sampling was not large enough to capture the whole species pool. Plant diversity was slightly higher where *P. juliflora* was absent. Soil samples showed a high pH and the highest was detected in Loruk in the northern part of the study area. Loruk also had the highest amount of exchangeable potassium and the coarsest soil.

The invasion of *P. juliflora* seemed higher in areas where no previous vegetation existed and in areas with high water accessibility. Some indications also showed that slopes and coarse soil texture was unfavorable for *P. juliflora*

15) Management, Use and Control of *Prosopis* in Yemen,

Dr. Mohamed Al Nassiri, 2003,

The opportunities for integrated control, utilization and economic development greatly increased with the arrival and utilization of the wood chippers to convert small spiny branches into easy-to-handle wood chips and the hammer mills that have been used to grind pods for livestock use. This latter process accomplishes 2 objectives, (1) it makes the protein in hard seeds available in the digestion process and (2) it destroys the seeds so unlike ingestion of ungrounded pods which results in large quantities of germinating seeds in the livestock feces, no seedlings emerge from the feces of animals that have eaten ground pods. The arrival of long handled pruning poles along with local purchase of gloves and safety glasses makes the harvest of the spiny stems safer and more convenient. Good progress was also achieved in eliminating re-sprouts from harvested *Prosopis* stumps by combinations of kerosene applications followed by burning.

Processing trials of the pods of a sweet local strain of *Prosopis* (1 out of 72 trees examined) into traditional bread at the Post Harvest Research Center in Aden gave excellent taste panel tests. In contrast, use of the local unimproved variety unfortunately provided negative taste panel tests. One log was processed into boards suitable for small craft projects and also a turned flower vase and illustrated the great potential of *Prosopis*for high value applications. Now that valuable products are being produced, i.e. chips, boards, turned articles; pod flour for livestock use, the priority should be placed on stimulating the market demand of these products to create revenue, employment and economic incentives to manage the weedy *Prosopis* stands. In Texas similar stands of small diameter trees contained from 30 to 60 tons of green biomass per hectare.

The research and development is being conducted in 5 major agricultural centers. The wood chipping and flour processing is being conducted; (1) on the west coast at theTihama Agriculture Development Authority in Al Hodedah, (2) along the south coast at the Abyan at El Kod Research Station, and (3) at the northeastern interior region at theHadramaut Governate at the Seiyun Research Station. Supporting research and development on the human use of the flours is being conducted at the Food Research &Post Harvest Technology Center in Aden. The development of the mist system propagation system for the superior local sweet clone is being done at the main agricultural research center in Dhamar

As it was necessary to adapt integrated *Prosopis* management and weed control to Yemeni ecological, cultural and economic conditions, the majority of the training activities including the development of the training manual have not yet been completed.

For example the costs for the only herbicides demonstrated in scientific journals to kill *Prosopis* stumps, i.e. clopyralid and triclopyr would cost about US 250/ha while if a combination of kerosene and burning can be proven effective, this cost for the same number of stumps per ha would only be only US 5/ha. Ongoing research at Hodedah and Abyan will verify if this treatment is successful by measuring lack of stump re-sprout in long term trials(3 and 6 months after treatment). Furthermore the economics of *Prosopis* management will radically improve if markets can be obtained for the chips resulting from the recently imported chippers. This improved market scenario will need to be included into the training manual. As information becomes available to the international consultant from the national coordinator and Director of Research, Dr. Mohamed Al Nassir, this will be included in the training manual.

16) Managing *Prosopis Juliflora* for better (agro-) pastoral Livelihoods in the Horn of Africa

Nadine Guenther and Elisabeth van den Akker GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia 2014

Encroachment of Invasive Alien Species is a globally common phenomenon and often has detrimental effects on rural households in developing countries. *Prosopis juliflora* is one of the world's worst invasive alien species causing severe environmental degradation to the arid and semi-arid lowlands of the Horn of Africa and threatening the livelihood and thus food security of pastoral and agro-pastoral communities.

Today, many countries such as Ethiopia, Sudan, Kenya, Eritrea, and Somalia are heavily affected. In Ethiopia the *Prosopis juliflora* invasion has been growing out of control for already more than a decade. In Ethiopia's Afar Region, with 90% of the Afar population being (agro-) pastoralists and their livelihood mainly depending on livestock production using rangeland, more than 700,000 ha has already been invaded as *Prosopis juliflora* rapidly spreads across both pastoral and agricultural lands. The ecological consequences have been devastating since rangeland areas are degraded due to severe losses in ecological functions and forage grass productivity has declined drastically. The major impact in economic terms has been a massive impoverishment, especially among cattle pastoralists whose animals depend on the rich floodplain grasses along the Awash River that have almost completely been replaced by *Prosopis juliflora.*

The spread of *Prosopis juliflora* also influences social and environmental aspects beyond invaded areas. Pastoralists who lost their grazing land have to search for new livelihood opportunities or move to new grazing areas, which raises the risk of land conflicts with other pastoralists and farmers. Furthermore, increasing livestock densities on the remaining pasture land trigger continuing land degradation. Under these conditions, the vulnerability of pastoralists has increased and drought induced acute food insecurity has been replaced by chronic food insecurity for large parts of the pastoral population.

The complex phenomenon of *Prosopis juliflora* invasion has not been addressed sufficiently yet, even though today it seriously challenges (agro-)pastoralism as well as irrigated agriculture implying a multitude of social, economic and environmental threats affecting the overall development in the Horn of Africa. Therefore, the GIZ Sectoral Project for Rural Development, on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), financed a comprehensive research study to assess the social, economic and ecological impacts of *Prosopis juliflora* invasion using the example of Ethiopia's Afar Region. The research was carried out between October 2013 and April 2014 by an international research team led by the University of Hohenheim (Prof. Dr. Regina Birner and Dr. Anna C. Treydte) and the University of Bonn.

The conference proceedings summarize the presentations held and the results of the fruitful discussions during the 2-day conference. The conference presentations as well as further information and material on *Prosopis juliflora* can be downloaded from http://agriwaterpedia.info/wiki/Prosopis

17) The spread of *Prosopis juliflora* in the wetlands of the Middle Awash Basin

Simone Rettberg, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia 2014

For many decades the problem of land degradation has dominated the public debate in Ethiopia, informing a variety of governmental and international development and policy initiatives that aimed at the conservation of natural resources through soil and water management (KEELEY & SCOONES 2003). In this regard one of the activities of the Derg military regime during the 1970s and early 1980s was the intentional introduction of *Prosopis juliflora* to the Ethiopian lowlands. This was part of its environmental rehabilitation campaign in which the planting of *Prosopis juliflora* was conceived as an afforestation measure to halt desertification processes in dry land areas (RETTBERG & MÜLLER-MAHN 2012). This development intervention had massive unforeseen socio-ecological consequences (as can be seen in most contributions in these conference proceedings) due to fact that *Prosopis juliflora* increasingly out-competed the native vegetation, taking over valuable grasses, shrubs and trees, leading to a substantial shift in the vegetation composition.

This invasion process affected mainly the best areas in terms of agro-ecological conditions, the wetlands, large floodplain areas (Afar: Kallo) along the Awash River, where seasonally flooded fertile soils provided abundant grazing opportunities for pastoralists as well as a good potential for irrigation agriculture.

Therefore, it was these areas where the imperial regime of Haile Selassie and later the Derg regime decided to establish irrigated cotton farms, ignoring the customary land rights of the local Afar clans who had been using this area as dry season grazing area and drought retreat for centuries. When local administrators were ordered to plant *Prosopis juliflora* seedlings around the state farms and in the few permanent settlements in the vicinity of these farms, it was mainly for the benefit of governmental agriculture and the settled population (mostly migrant workers from the highlands) who were supposed to benefit from an improved microclimate, e.g. less wind and more shade, and from improved soils that might raise future cotton yields. From the beginning, the transfer of the exotic *Prosopis juliflora* plant to the Afar lowlands was not intended to improve the livelihood of mobile Afar pastoralists, the main inhabitants of the area, whose mobile livelihood and assumed 'unsustainable land use practices' were considered by the government to be the main source of the problem of land degradation. The introduction of *Prosopis juliflora* in the Afar Region of Ethiopia exemplifies how an external intervention of natural resource management in dry land areas, although well-meant at least for part of the population during the time of its introduction, turned out to be one of the main drivers for a socio-ecological disaster that has been unfolding in the Afar Region over the last 30 years. Cynically though, it is the mobile pastoralists who were the ones most affected by this and whose vulnerability to drought increased tremendously.

Conclusion

Unfortunately the Ethiopian government did not value the importance of these wetlands so far either due to lack of knowledge or ignorance. There is no comprehensive policy or strategy neither for the management of *Prosopis juliflora* nor more generally for the management of wetlands. Studies and pilot projects were implemented; calls for a controlled management of invasive species were voiced but no institution was given the responsibility and necessary resources to deal with the ongoing critical changes in the wetlands of Baadu (proceedings Chekol). Dealing with the invasion of *Prosopis juliflora* should be embedded into an integrated plan for the management of wetlands that is based on clear rules and regulations and a strong institution enforcing these rules. Unless the invasion of *Prosopis juliflora* is understood as one among several problems in a wider scenario of risks which include ecological dynamics as well as social threats and unless the current ongoing economic developments are considered as one of the main pressures and risks for the ecosystem and its' inhabitants any external management intervention will lack sustainability.

It needs to be acknowledged that *Prosopis juliflora* is actually not the root cause for the destruction of the wetlands but a symptom of misguided environmental management, something which should be prevented in the future.

18) Quantitative Assessment of Invasion of*Prosopis juliflora* in Baadu, Afar Regional State of Ethiopia

Yohannes Zergaw Ayanu, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia 2014

The increasing human population has put pressure on natural resources and resulted in severe land degradation in Ethiopia. Moreover, drought and harsh environmental conditions in some parts of the country affected the livelihood of the people. The middle and lower parts of the Awash River Basin that are parts of the Afar Regional State of Ethiopia have been economic sources of Ethiopia where large-scale state farms are located. Irrigation capacity of the Awash River provides ample potential for large scale commercial farms. Besides, the area is home to Afar pastoralists whose livelihood is largely dependent on livestock production that basically relies on the rangelands along the Awash River and the seasonally flooded low lands.

Pressure on the natural resources in the area continues to increase due to increased population and expansion of large-scale state and private farms. In the past decades, there is a remarkable decrease in pasture lands in the area that threatened the livelihood of the Afar pastoralists. During the last three decades, the Afar pastoralists of Northeast Ethiopia have been faced with accelerated social and ecological change which was linked to processes of massive impoverishment and increasing vulnerability. Especially the loss of extensive grazing areas and nomadic mobility resulted in chronic food insecurity.

Besides the aforementioned problems, deforestation in the past resulted in degradation of the natural ecosystems in the area, challenging the sustainability of resource use and management in the region. In the past, attempts have been made by the government to regulate soil erosion problems in the floodplains of the Awash River. One of these attempts is introduction of fast growing species such as *Prosopis juliflora* to restore degraded lands and protect against soil erosion. *Prosopis juliflora* was introduced to the arid and semi-arid regions of Ethiopia in the 1970s and 1980s mainly for the purpose of soil and water conservation.

Although *Prosopis juliflora* was introduced on purpose for regulating wind speed and for regulating water induced soil erosion, it has developed unforeseen negative outcomes leading to loss of enormous ecosystem services. Recently, spreading of this invasive plant species has become a major problem threatening the livelihoods of people in the Awash Basin, particularly the middle and lower Awash Region such as Baadu, Amibara and Dubti. After being well-established in the introduction sites, the species turned to be invasive and spread to larger areas and it is continuously spreading at an alarming rate. Therefore, quantifying and mapping the spatial extent of the spread of *Prosopis juliflora* is essential to understand the extent of damage it causes and explore applicable management options.

In this study, the area of *Prosopis juliflora* invasion in Baadu, a source of dry season pasture for Afar pastoralists, was quantified and mapped using combination of satellite remote sensing data and field surveying.

Conclusions and outlook

In a nutshell, over the past two decades *Prosopis juliflora* continuously spread to new areas especially in the flood plains of Baadu. Thus, more efforts are needed in order to control its invasion and ensure sustainable resource use and management in the Awash River Basin in particular and the rest of Ethiopia in general. The seed dispersal mechanisms, soil preference, and water demand of the species needs to be further investigated. More emphasis needs to be given to finding effective management practices to control the damage caused by *Prosopis juliflora* invasion. Due to their high susceptibility, flood plains in the

Awash Basin should be continuously monitored with regard to invasion by *Prosopis juliflora*. Management of *Prosopis juliflora* requires an integrated approach where experts from various disciplines are involved. Different stakeholders such as the pastoralists, agro-pastoralists, large-scale investors on agriculture, government organizations and NGOs should work together to find an optimum solution to halt its drastic effect.

19) Ecological challenges and potential carbon storage benefits of *Prosopis juliflora* in Afar

Anna C. Treydte, Emiru Birhane, Abeje Eshete, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia, 2014

Invasive alien species are a global phenomenon and often have detrimental effects on the fauna and flora biodiversity. In Ethiopia, *Prosopis juliflora* invasion has been devastating; rangeland areas have been degraded and forage grass productivity has declined drastically as a result. Soil erosion and a loss in livestock productivity have been the consequences, leading to fewer and lower quality rangeland sites available to pastoralists. The spatial extension of *Prosopis juliflora* in Ethiopia is difficult to assess since it is expanding rapidly, up to 18% per year. One mill ha is already covered by *Prosopis juliflora* in entire Ethiopia, of which about 700,000 ha are located in the Afar Region. A further rapid spread is to be expected (Figure 1).

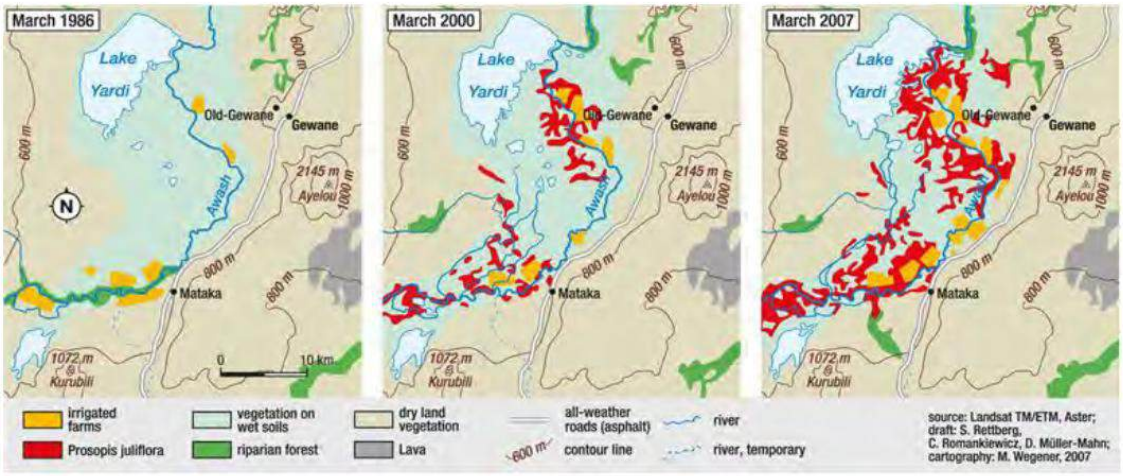


Figure 1: Expansion of *Prosopis juliflora* within Baadu Area, Afar, from 1986 – 2007 (RETTBERG & MUELLER-MAHN, 2012)

Attempts of controlling and managing *Prosopis juliflora* in the Afar Region have often lacked an overall long-term ecological perspective on consecutive shifts in ecosystem functioning. *Prosopis juliflora* outcompetes important forage species and, thus, reduces long-term forage availability and, hence, the sustainability and quality of livestock production. The remaining low quality rangelands might force pastoralists into shifting their livestock practices drastically or even adopting other income generating activities. Hence, the vulnerability of pastoralists has increased and drought-induced acute food insecurity has been replaced by chronic food insecurity for large parts of the pastoral population.

Prosopis juliflora does not establish at sites where native woody vegetation species are already present. It rather infests areas that have been overgrazed and lack both a healthy woody and herbaceous layer component. Thus, preventing the fresh growth of *Prosopis juliflora* in vulnerable sites (e.g. sites of low or no infestation) is crucial.

The high number of spores at highly invaded areas could be due to a low-level of soil disturbance/ tillage, high number of plants with interconnected roots, high vegetation cover and more active biological conditions compared to plots in open areas.

Overall, the study suggests that it is not too late for rehabilitation of *Prosopis juliflora* infested sites. These sites still contain a high regeneration potential of native species as shown in the soil seed bank. Current management, however, might not be sufficient and often rather encouraging additional *Prosopis juliflora* growth after coppicing. Aiming management at seedling spread prevention as well as slight but long-lasting thinning (but not eliminating) activities are the way forward.

20) A social-economic assessment of the impact of *Prosopis juliflora* invasion and participative management approaches in the Afar Region, Ethiopia

The Woody shrub or plant *Prosopis juliflora*, native to Mexico, South America and the Caribbean has become a devastating invasive shrub in the Afar Region in Ethiopia. Growing to a height of 12 meters and with trunk diameter of 1.2 meters, *Prosopis juliflora* forms impenetrable spiny thickets along riverbanks and floodplains, reducing biodiversity and pasture production, by denying native plants water and sunlight, and not providing food for native animals and cattle. The plant was first introduced to Afar Region in the late 1970s and early 1980s to combat desertification.

Non-governmental organization especially FARM-Africa and Care Ethiopia are looking for ways to commercialize the woody tree. Existing literature on *Prosopis juliflora* also show that the shrub offers significant opportunities for rural households such as income and livelihoods diversification as well as ecological benefits like microclimate regulation, improvement of the soil fertility and desalinization of the soils found that soils under the *Prosopis juliflora* had higher organic carbon and total nitrogen than the soils in the open areas. Even though the soils under the acacia trees had higher organic carbon and total nitrogen than soils under *Prosopis juliflora*, the acacia trees are not capable of sustainably surviving in Afar Region and continue to provide fuel wood, charcoal and regulate the micro climate compared to *Prosopis juliflora*. *Prosopis juliflora* high coppicing ability and the deep roots enable it to survive in desert areas and provide a number of benefits including alternative energy sources. The pods from *Prosopis juliflora* can also be a source of nutritious human food (CHOGE et al., 2007), and can be a source of nutritious, less costly feed ingredient for livestock In Afar a region, *Prosopis juliflora* is also attributed to have increased crop yields by 29%.

Nonetheless pastoralists who call it the "Devil Tree" and the “AIDS” to the animals insist that*Prosopis juliflora* should be eradicated. Effective control of *Prosopis juliflora* has been difficult because of the extent of infestations, the aggressive nature of the shrub and the type of terrain where it occurs. Worse still, policy makers and development partners are faced with the dilemma of whether to manage *Prosopis juliflora* invasion or to completely eradicate it. If they have to eradicate *Prosopis juliflora*, who are the beneficiaries, the losers and what are cost effective methods of controlling or eradicating *Prosopis juliflora*?

The results from the survey show that about 84% of households preferred complete eradication of *Prosopis juliflora* and mechanical techniques were perceived to be the most cost effective and thus the most preferred method over other methods such as commercialized use of *Prosopis juliflora* pods and charcoal burning by organizing pastoralists in to cooperatives. Moreover, the pastoralists have abandoned the cooperatives and some cooperatives have been completely closed or transformed to other activities such as cereal production. Analysis of cost-effectiveness reveals that:

A household incurs a loss of 41 USD per year in pod crashing. However, those that burn charcoal earned a net benefit of 420 USD per year.

Mechanical clearing without using wood was found to result to a net loss of 149 USD per hectare while using or selling wood results to a net benefit of 2 USD per hectare.

Mechanical clearing while using wood from the cleared land generates negative returns of 111 USD per hectare if households have to dig out the roots.

Digging out roots which seen as most effective approach is only profitable if the wood is used for charcoal burning or sold and the land is either used for crop production or fodder production.

Based on the results, we conclude that there is need to encourage and support pastoralists to clear the land, utilize the wood, and the land for crop or fodder production in order to sustain-ably control and manage *Prosopis juliflora*.

21) Households' demand for mitigation of *Prosopis juliflora* invasion in the Afar Region of Ethiopia: a contingent valuation

Mesfin Tilahun, Regina Birner, John Ilukor, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia, 2014

A number of *Prosopis juliflora* species including *Prosopis juliflora* are native to Latin America. However, they have been introduced to the arid and semi-arid regions of Africa in the past two centuries for their beneficial uses. *Prosopis juliflora* was introduced to Ethiopia in the late 1970s in very few agricultural research stations for the purpose of soil and water conservation. Currently, the species is considered as a major threat mainly for pastoral livelihood due to invasive nature. *Prosopis juliflora* in the Afar Region of Ethiopia has invaded over one million hectares of land. It is estimated that Pastoral and agro-pastoral communities in Ethiopia, Kenya and elsewhere are becoming increasingly concerned about the negative impacts of *Prosopis juliflora*. Its negative effects include the impact of this invasive tree on beneficial native species; encroachment onto paths, villages, homes, water sources, crop- and pastureland; and injuries due to thorns that impacted animal and human health apparently resulting in some human fatalities.

Management of invasive species can be undertaken with the application of mechanical, chemical, and biological control methods. However, the effectiveness of any management intervention requires the full participation and willingness of local communities for the fact that they are the immediate victims of the negative effects caused by invasive species. Thus, this study aimed at assessing the willingness of Afar's pastoral and ago-pastoral rural communities to contribute in either cash or labor for the mitigation of *Prosopis juliflora* invasion using mechanical clearing and biological control methods. It also assesses the socioeconomic factors affecting the households' willingness to pay and willingness to contribute labor for mitigation of *Prosopis juliflora* invasion.

Conclusion

Prosopis juliflora invasion creates a significant threat to pastoral and agro-pastoral livelihood system in the Afar Region of Ethiopia. Unless action is taken to mitigate the threat, the region as well as the country is unlikely to meet its development goals of improving pastoral and agro-pastoral livelihood and reducing poverty in the region. This study indicated that the pastoral and agro-pastoral communities in Afar are willing to make cash and labor contributions for well-organized actions that aim to mitigate the threat that *Prosopis juliflora* invasion is causing on their livelihood. Most households in the study area prefer the complete eradication of the invasive plant than the option of controlling the plant through productive use.

Moreover, the cash and labor contributions that the households are willing to make for the complete eradication option are higher than the contributions for the controlling of further expansion of the invasive plant. However, in any effort for mobilizing the cash and labor resources and attain a successful intervention, it is important to consider the following:

- The pastoral and agro pastoral communities should be provided with full information on the negative effects as well as beneficial uses of the species,
- The mobilization of the contributions should be on voluntary basis,
- There should be a strong and sustainable institution that can create the awareness, mobilize the communities, and design appropriate management plan,
- Before a mitigation intervention, a management on how to utilize the land that is cleared from *Prosopis juliflora* and the cleared biomass of *Prosopis juliflora* is important as an incentive for the communities.
- Training on different mitigation technologies as well as trainings on charcoal making to local communities is also important in empowering local communities to benefit from the beneficial uses of the invasive plant while controlling its expansion and mitigating the negative impacts.

22) Gender aspects of *Prosopis juliflora* spread in Baadu area, Afar Regional State, Ethiopia - Perceptions, impacts and coping strategies

Helena Inkermann, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia 2014

The Afar Regional State located in the north-eastern lowlands of Ethiopia is heavily invaded by *Prosopis juliflora*, an invasive species originally coming from South and Central America. Invasive plants can cause extensive environmental, economic and social harm which should be assessed in a gender sensitive way since men and women utilize resources differently. In a pastoral society strict gender roles can be found which influence the work load and work task of men and women, power relations, the role of women in decision making processes, as well as their access to resources. Against the background of these different gender roles this paper argues that there are gender-specific impacts related to the spread of *Prosopis juliflora*.

Often, women have less ownership rights then men do and also less access to resources. A gender perspective can improve our understanding of the socially differentiated impacts of invasive species as well as the effectiveness of future management interventions. Gender sensitive approaches in managing invasive species can contribute to more social equity, taking the importance of women as social actors into account.

In the past, research failed to include the gender dimension of *Prosopis juliflora* invasion. This paper deals with gender-sensitive questions. To what extent is the vulnerability of women changing due to the invasion of *Prosopis juliflora*? How do the perceptions, the impacts and the coping strategies of men and women differ? What kinds of differences exist among the group of women? To what extent does the invasion influence gender roles? The following paper presents the results of a case study located in Baadu area in the middle Awash Basin. The Baadu area has been heavily affected by the spread of *Prosopis juliflora*, leaving almost no grazing areas for the livestock of the pastoralists.

In the case study, which was part of a social impact assessment implemented by the University of Bonn in collaboration with GIZ and Bayreuth University, a qualitative approach was used to identify gender differentiated perceptions, impacts and coping strategies.

The paper outlined that the invasion of *Prosopis juliflora* has a high impact on gender aspects and that there are clear differences to be made between the perception, impacts and coping strategies of men and women. Looking into the gender differentiated perceptions of *Prosopis juliflora* a close connection to the religious believe and lifestyle of the people was observed. The main differences were seen in the raking of problems the Afar pastoralist society is facing. The focus on impacts of *Prosopis juliflora* invasion on men and women showed that there is no direct differentiation made by the locals. The observation of impacts from a research perspective illustrated that the impacts on women are generally higher than on men, because they are affected in their everyday life activities. Also, women are the ones who suffer under food insecurity at first hand. Pastoralists, especially female pastoralists were identified as the most vulnerable group in Baadu. The research on coping strategies showed that the existing coping strategies lead to positive developments as well as threats for women. The positive development is seen in an empowerment process of women. This positive development is supported on an administrative level. Threats occur in connection to the rapidly growing charcoal business, protection mechanisms do not function in the known way anymore creating new areas of fear. The paper also stressed that differences need to be made within the group of women who cannot be seen as a homogenous group. A clear differentiation needs to be made between women living in rural areas and those who live along the roadside. Women living along the roadside profit from the given access to the markets while those women living in the rural areas, still living a purely pastoralist live, do not have such options to cope with the problematic situation turning the negative into the positive. Therefore, afar women in rural areas can be identified as the most vulnerable group in Baadu.

In order to come up with measures to control or eradicate *Prosopis juliflora* in Baadu, there is a need for a clarification of administrative responsibilities. A first effort has been made by the regional government of Afar which came up with a guideline in 2011. Besides identifying responsibilities this guideline shows a clear motivation to include women in the process. Women should be identified as important social actor whose knowledge and experience is absolutely needed in order to be able to control the invasion.

The ongoing empowerment process which is changing the role of women and giving them a new stand in decision making process should be assisted. Advice can be taken from the Women's affairs office and NGOs like Rohi Wadu in Awash who can share from their long years of experience.

On a more general basis, experiences which have already been made on the control and eradication of *Prosopis juliflora* should be studied and taken advice from. A land use plan could help to clearly identify the use of specific sites for specific activities. The land use plan needs to be developed with the help of clan leaders, respecting the traditional boundaries of clan areas. Interests and options of women should be included in the process. Lastly, all measures planed should be analyzed concerning their effectiveness. There is no one fits all solution and the biggest group living in the Baadu area are still pastoralists who should not be forgotten. Talking about the pastoralists one should not forget women who might be in need of different assistance than men. Without their incorporation any measure is foreseen to fail.

23) Impact assessment of *Prosopis juliflora* invasion in the Afar Region, Ethiopia - Synthesis and recommendations from an interdisciplinary perspective

John Ilukor, Simone Rettberg, Anna Treydte, Regina Birner, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia2014

The spread of invasive plant species within the arid and semiarid lowlands of North-east Ethiopia is an increasing threat for pastoral livelihoods and ecosystems. One of the most invasive species is *Prosopis juliflora*, an evergreen, fast-growing mimosa tree or shrub. In 2006, approximately 700,000 ha of land had been taken over by *Prosopis juliflora*, out of which more than 70% is located in the Afar Region, mainly within the Middle and Lower Awash Valley of the Afar National Regional State. Recent studies have shown that the invasion rate is increasing rapidly, suppressing indigenous plants, while negatively affecting human health as well as livestock production. The invasion of *Prosopis juliflora* also offers positive impacts, for example, increased production of firewood, charcoal and wind breaking because it grows and coppices fast, has dense ground cover and is deeply rooted. In addition, *Prosopis juliflora* can play a significant role in rehabilitating degraded land and in restoration restoringsalinized soils However, the management measures that have been adopted in the Afar Region are not able to manage and control its rapid spread and it appears that the negative impacts exceed the positive impacts, especially for pastoralists, the main inhabitants of Afar Region in Ethiopia.

The quantitative assessment of *Prosopis juliflora* spread within the Baadu area (Gewane Woreda) based on a comparison of satellite images revealed that until end of 2013 almost 40 % of the wetland vegetation in Baadu had been taken over by *Prosopis juliflora* while the surrounding higher-lying dry land area has remained almost free of *Prosopis juliflora* so far (see proceedings Ayanu). Other highly invaded areas within Baadu included abandoned farms, roadsides and settlements.

The spread pattern of *Prosopis juliflora* implies that specific socio-ecological conditions favor its growth in areas of moist soil conditions that contain a large number of livestock, i.e., the floodplains along the Awash River This observation was supported by the results from ecological analysis which suggests that *Prosopis juliflora* infests areas that have been overgrazed and lack both a healthy woody and herbaceous layer component Due to the significant loss of the previously abundant grasslands in the floodplain areas, a key grazing resource for pastoralists during the dry season and drought times the pastoral vulnerability to drought has increased tremendously.

Most pastoralists within Baadu, previously known for their wealth due to large cattle herds, now live under conditions of chronic food insecurity. More and more pastoralists became sedentary within the last years, performing different kinds of income-generating activities (wage labor, petty trading, sale of charcoal, firewood, grass mats, etc.) and small-scale irrigation agriculture

Only few Afar people value *Prosopis juliflora* for its economic potential and consider it to be a ‘black gold ‘due to its monetary benefits through charcoal production and trade (see proceedings Datona).

With the invasion of *Prosopis juliflora* charcoal production has been booming within the flood plains of Baadu, linked to a massive influx of migrant workers from the highlands Few, mainly young and educated, Afar have been able to generate high profits through charcoal trade but with severe ecological consequences due to the illegal cutting of indigenous trees, which is against the traditional law of the Afar.

Results from economic analyses reveal that the benefits of the *Prosopis juliflora* invasion in the Afar Region are higher than the costs Moreover, the benefits and costs tend to vary with user groups such as mobile pastoralists, sedentary small scale agro pastoralists, and large-scale farmers.

In this study we find that the benefits to sedentary small scale agro-pastoralists who participate in wood and charcoal trade as well as those to large-scale crop farmers are higher than the costs.

In the case of pastoral livelihoods, the costs were found to be higher than the benefits and these costs are expected to escalate in the future if*Prosopis juliflora* is not controlled.

24) Controlling and/or using *Prosopis juliflora* in Spate Irrigation Systems

Matthijs Kool, Karim Nawaz, Yasir A. Mohamed, Hamis Nzumira GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia2014

Prosopis juliflora invades land and even worse encroaches on river beds and canal beds – blocking them and causing drainage patterns to uncontrollably shift. Yet *Prosopis juliflora* is a blessing as well, albeit mixed. It is a source of biomass in some of the most marginal lands and provides fuel wood, charcoal and fodder.This paper makes an assessment of how to manage this 'mixed blessing' in spate irrigation systems, based on first-hand experience and grey literature. In the last thirty years the hardy well rooted shrub made its way from Latin America to all parts of the world, covering millions of hectares in for instance India, Pakistan, Yemen, Sudan, Somalia or Ethiopia. In many places it was first introduced in sand dune stabilization projects. However *Prosopis juliflora* has the habit to 'overstay its welcome' and expand rapidly and not go away. The area estimated conquered by the invasive species in the last ten years in India. Pakistan, Yemen, Kenya, Sudan and Ethiopia are way above 10 million hectares. Particularly in areas where there is livestock grazing *Prosopis juliflora* spreads rapidly: the seedpods cling to the animal skins and are distributed widely.

Prosopis juliflora germinates easily and once it has settled in an area it is difficult to get rid of it. It takes over the natural vegetation, does not allow undergrowth and hence greatly reduces the grazing value of land. It also tends to creep into waterways – including dry riverbeds – choking them in the process and causing flooded rivers to run wild. The *Prosopis juliflora* thorns are poisonous and can even cause blindness. Livestock, particularly cattle, can become ill when they are almost exclusively fed with pods of *Prosopis juliflora*. Symptoms can be facial contortions and constipation, sometimes resulting in death. In the Tihama region in Yemen, farmers consistently ranked *Prosopis juliflora* in the top three of major problems.

Prosopis juliflora is not only a scourge. It also has benefits to its credit. It is important for people in providing fuel and timber. The sweet nutritious pods are eaten by all livestock and can be made into different foods and drinks. Honey is made from the flowers and the gum is similar to gum Arabic. The bark and roots are rich in tannin and the leaves can be used as mulch or to help in reducing pests and weeds. Also as a nitrogen fixing tree it improves the land and can reclaim saline soils. Furthermore in India charcoal generated from biomass of *Prosopis juliflora* improved the fertility of alkaline soils. On balance however if unmanaged it is a scourge that is steadily undermining the livelihoods of large populations in some of the most vulnerable dry agricultural & pastoralist areas.

Prosopis juliflora was widely distributed in Ethiopia as a biological soil and water conservation agent during the late 70s. Now it is considered a major threat because of its invasive nature. *Prosopis juliflora* has an aggressive invasive character invading pastureland, irrigated cultivated lands and irrigation canals causing an irreversible displacement of natural pasture grasses as well as native tree species.

However, *Prosopis juliflora* particularly when it is cut above ground, it simply regenerates and it has almost become impossible to get rid of it. Especially in the Afar Region, where the invasion of *Prosopis juliflora* is most severe, much effort has been done to manage and control the shrub. In Afar Region the production of charcoal from *Prosopis juliflora* was very much encouraged. The problem however was that the *Prosopis juliflora*charcoal was inferior to the one from acacia for instance. Instead of *Prosopis juliflora* charcoal the acacia was widely processed – accelerating the degradation of the common land. A total ban on charcoal trading was hence reinvaded in several parts of this region.Based on the diverse experience documented so far, the most viable strategy appears to remove *Prosopis juliflora* altogether and keep the land 'clean' by intensive usage - and especially ensure it does not encroach river beds and in areas where this is not possible, to make use of proposes juliflora products.

25) *Prosopis juliflora* Management Stakeholders Analysis in Afar National Regional State, Ethiopia

Wondimagegne Chekol GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia 2014

Prosopis juliflora has invaded about more than 1.2 million hectares of land in Afar Region. Its invasion rate is estimated to be more than 50,000 hectares in the region annually; estimates predict that the area covered by *Prosopis juliflora* could increase to 145.81 km2 (27.62 %) and further to 163.06 km2 (30.89 %) by the years 2015 and 2020 respectively in Amibara. This indicates that there is need for an immediate management of *Prosopis juliflora* in the area.

Even though, *Prosopis juliflora* has positive effects on soil fertility and microclimate the plant is generally perceived negatively due to its fast invasion rate and negative impacts like loss of biodiversity, physical injury on human being and livestock, blocking access roads to farms and irrigation canals and the huge amount of money spent for clearing. Thus, so far the prevailing management approach in Ethiopia is eradication although some scholars argue that complete eradication might be impossible, favoring management through control and utilization of the plant.

Recognizing the urgent need to address this problem, several governmental and NGOs have started to get involved in the management of *Prosopis juliflora*. But so far all isolated management interventions failed to bring a lasting solution to seize the invasion. This stakeholder assessment was conducted to provide baseline information on the knowledge and experience of the institutions on *Prosopis juliflora* management, as well as their respective strengths and weaknesses. It will be asked why all previous management interventions failed so far, arguing that increased institutional coordination and clear mandates will be vital for future *Prosopis juliflora* management.

The methodologies employed in this study were review of secondary data obtained from Afar Regional Government Office to map stakeholders involved in *Prosopis juliflora* issues. Moreover, interviews with project coordinator and community facilitator of FARM AFRICA, and CARE as well as focus group discussions with the communities and Kebele Administration members were done. To analyze the data collected a descriptive analysis was used.

Conclusion and recommendations

So far there is no sound governmental intervention to control the invasion. There is neither a leading institution responsible for prevention, control and management of *Prosopis juliflora* at national level nor a clear institutional mandate to deal with invasive weeds in the country. The previous interventions to manage *Prosopis juliflora* lack synergy and coordination to bring effective and satisfactory management results.

Interventions and experiences of some major stakeholders like Farm Africa, the Regional Government of Afar and Ethiopian Institute for Agricultural Research have paved the way to improve the management of *Prosopis juliflora* in the coming years. It is, therefore, an opportunity to have notable potential stakeholders at national and regional level that can bring a difference in the management of *Prosopis juliflora*. Formulation of Policy document by EAIR, issued regulation on *Prosopis juliflora* management by ANRS and the management practices used by FARM- Africa, CARE and other institutions could be taken as a positive action to go about against the invasion of *Prosopis juliflora*.

However, there is still an urgent need to integrate all currently isolated efforts of the stakeholders to arrive on sustainable *Prosopis juliflora* management. In addition to this action should be taken to implement the Policy document prepared by EIAR and the regulation issued by Afar Regional Government.

26) Experiences of managing *Prosopis juliflora* invasions by communities in Kenya: Challenges and Opportunities

Simon Choge, George Muthike GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia2014

The first introduction of the American *Prosopis juliflora* species to Africa dates back to 1820 and 1900 when they were introduced to Senegal and South Africa respectively (PASIECZNIK et al., 2001). It was introduced in the Greater horn of Africa (GHOA) through the Sudan in 1917 (BROUN & MASSEY, 1929). *Prosopis juliflora* has now naturalized in dry regions of most African and Asian countries forming an important component of dry land vegetation and landscape.

Despite the early introductions to Africa in general and eastern Africa in particular, it was not until early 1960s and 1970s that many regional governments and environmental agencies initiated large scale planting of *Prosopis juliflora* as a popular species through ASAL development programmes. Its invasive potential was then little known. The El Nino rains of 1997/98 accelerated the spread of the species as a weed in Ethiopia, Kenya, Somalia and other regional countries.

The Government of Kenya has already developed a draft national strategy under the new constitution. The strategy underlines the need for proper coordination of the *Prosopis juliflora* spp management activities at national, County and Sub County levels, with joint leadership of KEFRI and KFS in collaboration with other Government Ministries, NGOs, CBOs and development partners. The strategy focuses on management and control of *Prosopis juliflora* species through utilization, an approach that has received a positive endorsement from many developing countries around the world.

Use of community based groups as an approach

The experiences from Kenya are beginning to show that using community based groups is the popular and realistic approach to manage *Prosopis juliflora* species invasions.

The groups must have a reliable source of income that must benefit each member directly ona regular basis, without which it will disintegrate in a matter of time as members find alternative livelihood sources.

Prosopis juliflora spp is often considered as a common property resource because it grows on common grazing areas. Commercial production of charcoal therefore often attracts many community members most of whom are outside the formal groups. This has resulted in serious scramble for mature *Prosopis juliflora* spp trees, leading to sudden extensive vegetation clearance exposing the soil cover to erosion and degradation.

There are unconfirmed fears that as communities make substantial levels of income from *Prosopis juliflora* products, they will be inclined to grow more of the weed thus worsening the current invasion status of the species. It is therefore important that the Government supervises all the *Prosopis juliflora* management activities to ensure that the objectives of the strategy are effective. Monitoring and feedback by the coordinating institutions must be done regularly to allow revision of the strategy as need arises.

27) Socioeconomic and Ecological Impacts of *Prosopis juliflora* Invasion in Gewane and Buremudaytu Woredas of the Afar Region

Herrie Hamedu; GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia2014

Afar Region is one of the nine regional states in Ethiopia, located in the northeastern part of the country with a total population of 1,390,273 (CSA, 2007). Most of the people (about 90%) in the region are leading a pastoralist way of life while the remaining proportion are either agro-pastoralists or earn their living from other livelihood activities such as petty trade, charcoal making, labor wedge, etc. Livestock in Afar are the main livelihood assets which serve mainly as source of food and income. The livestock population in the region comprises 2,318,220 cattle, 2,499,640 sheep, 4,444,290 goats, 859,580 camels, 187450 asses, 3160 mules, and 900 horses (CSA, 2005). Livestock production in the Region is constrained by seasonal feed shortage, seasonal water scarcity, frequent occurrence of livestock diseases, low genetic potential of indigenous stock, cultural taboos against sales of livestock and livestock products, poor linkage of livestock production to market outlets, drought and institutional problems.

The problem associated with livestock feed shortage is further complicated by the introduction and expansion of unwanted bushes like *Prosopis juliflora*. The rapid expansion of *Prosopis juliflora* and other weed plants at the expense of important grass and tree species is considered as a major threat for pastoralist livelihood in the Region. *Prosopis juliflora* invasion is also hindering crop production through claiming agricultural lands and serving as a hiding place for crop pests and wild animals. Although there is no clear policy or strategy at national or regional level there have been a number of efforts made by government and non-governmental organizations to control the speared and prevent the impact of *Prosopis juliflora* on livelihoods of pastoral and agro-pastoral communities in Afar.

Studying the socioeconomic and environmental impacts of *Prosopis juliflora* from the affected communities' perspectives is essential to design and plan sustainable control and prevention strategies. It would enable one to identify the communities' perception regarding the plant, determine the negative and positive impacts of the invasion by *Prosopis juliflora* as perceived by the community and understand the solutions in the context of the local social, cultural and environmental conditions.

Prosopis juliflora invasion is now becoming a nightmare to communities in Gewane and BuremudaytuWoredas. They are out of words to express the negative impacts of the invasive tree on their communities.

This assessment revealed that the socio-economic impacts of the invasion by *Prosopis juliflora* are diverse and so complex touching every angle of the life style of pastoral and agro-pastoral communities in the studied areas. Virtually all livelihood systems are affected by *Prosopis juliflora* invasion but pastoralist way of livelihood is the most seriously threatened due to the severe impact of the invasion on rangelands and the overall ecology. The *Prosopis juliflora* invasion is also affecting the microclimate in the studied areas and hence causing imbalance in the ecology. This imbalance in the ecology is also changing the profile of the biodiversity of animal (both domestic and wild) and plant (edible and non-edible) species prevailing in the affected areas. The limited rangeland resource is also creating a fertile ground for resource based conflicts within and among Afar clans and neighboring ethnic groups in the affected areas.

The overall impact of the problem is affecting practically all sects of the communities without any significant distinction but due to age and biological factors the impact seems to be more serious on children, women and elders. Pastoralists in the affected areas have tried to their best to control the spread of the tree but it seems they are now defeated by the tree and desperate to get any solution from anywhere.

Some of the control measures employed so far like utilization of the tree by charcoal making are aggravating the situation and are becoming threats for the whole concept of eradication of the tree due to conflict of interest. The communities believe the most effective way of controlling the spread or even eradiating the tree is its removal by uprooting and continuous use of land reclaimed from *Prosopis juliflora* for development purposes like irrigation based agriculture and/or rangeland development.

28) Socio-economic impacts of *Prosopis juliflora*-related charcoal trade in Gewane Woreda, Afar Region

Mohammed Datona, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia, 2014

In Ethiopia, fuel wood and charcoal constitute the most important sources of energy for both rural and urban households. A wood energy survey of 1996/97 (EC) indicates that 230,000 tons of charcoal is used every year in the country. According to the Ethiopian Forestry Action Program (2011), fuel wood including charcoal contributes 66 and 62 percent, of the energy consumption in rural and urban areas respectively.

Charcoal production is a major threat to biodiversity because it eliminates indigenous species found in natural forests and accelerates deforestation.

In pastoral areas of Afar Region charcoal production is a rather new phenomenon. One of the main production sites currently is the Baadu area (Gewane and Buremodaytou Woreda), a floodplain with abundant grasses and few acacia forests in the past, located within the Middle Awash Basin. This area has been almost completely invaded by *Prosopis juliflora* within the last three decades so that pastoralists lost valuable dry season grazing areas along the Awash River. In a context of dwindling fodder resources people are under pressure to develop new complementary non-pastoral livelihood strategies and to adapt to the changing environment. It is argued that charcoal production and sale in Baadu is such a new livelihood strategy but which involves not only benefits but also serious social and ecological costs.

In a case study in Gewane woreda the socioeconomic impacts of *Prosopis juliflora* related to the production and trade of charcoal were analyzed.

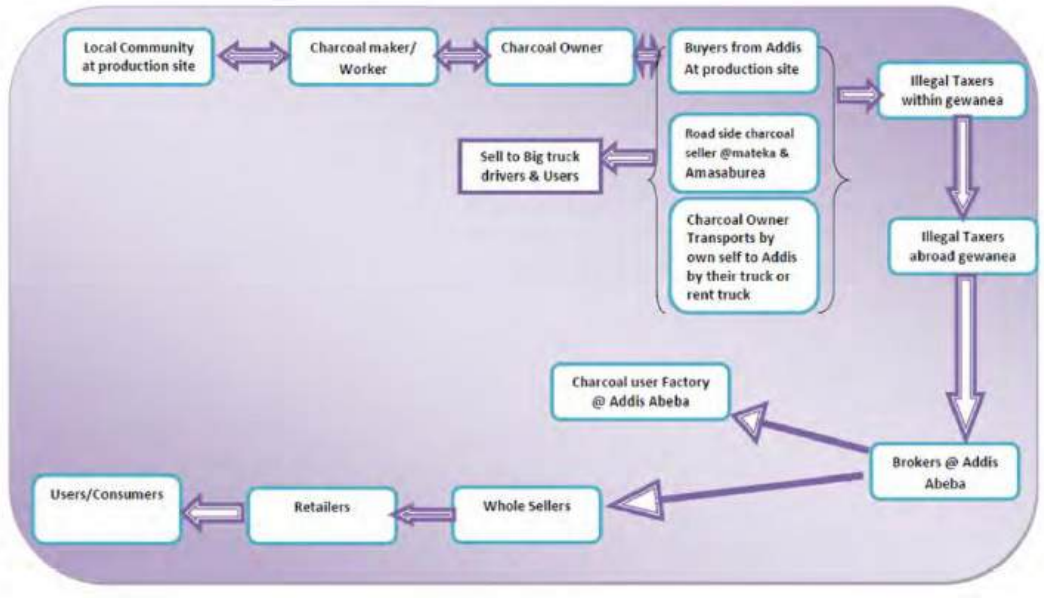


Figure 2: The charcoal commodity chain in Baadu, Afar Region (own draft 2014)

The main objective of the study was to investigate the socio-economic impacts of charcoal production. Questions addressed were: How is the production of charcoal organized and which actors are involved? What are the socially differentiated positive and negative impacts of charcoal production on local livelihoods? What is the role of the government in regulating the use of forest products for charcoal production?

Methods applied during 6 weeks of field work around Gewane included a quantitative survey on household level as well as qualitative interviews with key informants and focus group discussions. Observation methods played an important role during field trips, e.g. in cross-checking the amount of the currently illegal cutting of *Prosopis juliflora* and indigenous trees within the area and of the marketing chain of charcoal contraband trade.

Conclusions and the way forward

The paper outlined the organization of the fast growing charcoal business in the Gewane woreda and its impacts on an economic, ecological and social dimension. The main actors in the charcoal value chain can be identified as the charcoal owners, the charcoal makers and the sellers of charcoal. Work tasks are shared between the Afar living in the area and the highlanders who are coming from different regions of Ethiopia in search for work.

The results reveal that the benefits obtained from charcoal production from *Prosopis juliflora* attracted the interest of local communities, especially in a context of increasing impoverishment of pastoralists. But the current form of unregulated charcoal business is ambivalent: it improves the livelihood of some significantly, but at the expense of deforestation and desertification. As time goes on, the illegal cutting of indigenous trees has reached an alarming stage demanding to study the extents of damages to indigenous trees, especially Acacia. As the severity of the problem is known and this is clearly revealed in this study, it is suggested that the regional and local government officials directly responsible for the problem has to act soon by taking action on charcoal makers and owners for cutting and selling charcoal from trees other than *Prosopis juliflora*.

Besides, the government officials at all levels of administration do need to discharge their political commitment in close consultation with the local communities in ensuring the aggressive removal of indigenous tree before their complete destruction.

The following recommendations should be considered for a socially and ecologically sound and sustainable charcoal trade:

The local government should legalize charcoal trade from *Prosopis juliflora* and facilitate distribution of trade licenses to individuals so as to prevent indigenous tree distraction.

Increase of wood supply through agro-forestry in farming areas by introducing village woodlots. The depletion of forest resources due to charcoal production is the most serious environmental issue in the country.

Awareness raising on resource management and empowering communities to take the responsibility of protecting the environment and enhancing and helping local institutions is a key factor that will contribute for slowing down the current rate of deforestation.

The government should place more emphasis on managing land in collaboration with the local people. The participation of local communities in the interventions and decisions that will have impact on them is crucial for creating a sense of ownership and sustainability. An aspect of this management might be that charcoal to be burned only by people with permits in specified areas, but this is not realistic, currently as charcoal production has become a widespread occupation among pastoral communities.

29) *Prosopis juliflora*, Parthenium and beyond, challenges for an integrated strategy of IAS control in the Afar Region

Wondimagegne Chekol, Irmfried Neumann, GIZ- Proceedings of the Regional Conference, Addis Ababa, Ethiopia, 2014

Prosopis juliflora L. (hereafter referred to as *Prosopis juliflora*) is considered being the economically most damaging species amongst the 35 which are listed as IAS in Ethiopia. Therefore, *Prosopis juliflora* receives particular attention by the authorities and research and development actors.

Specific programmes for the control and management of *Prosopis juliflora* in the Afar lowlands started back in the years 2000 by Farm Africa. Based on these early experiences, the government of the Regional National State of Afar proclaimed a regulation issued to control, manage and eradicate the invasion of *Prosopis juliflora*, which describes the control strategy and provides institutions with the necessary mandate. The regulation still waits for its implementation as means provided are limited.

While *Prosopis juliflora* is currently high on the agenda of development actors, other IAS relevant for the Afar Region like Parthenium hysterophorus and Acacia nubica (hereafter referred to as Parthenium and Acacia) receive relatively little attention. The organizers of this Conference on *Prosopis juliflora* therefore invited this paper to widen the outlook on IAS control as a whole. On the one hand this allows reminding interested actors that the Project, "Removing Barriers to Invasive Plant Management in Africa", articulated a comprehensive proposal for a "National Invasive Alien Species Strategy and Action Plan of Ethiopia", which is based on an extensive analysis of IAS in the country und proposes the necessary measures for their control. The application of the proposed national strategy and action plan would make the control and management of *Prosopis juliflora* part of an overall IAS-strategy and avoid isolated solutions which might lead to duplication of programmes and institutional structures. The federal government is about to prepare new regulations for IAS control (State Minister of Livestock, 2014) which might take some time to become operational. On the other hand, no time should be lost and action taken to start the work of controlling IAS in the Afar-region and elsewhere. For every year of inactivity the price to be paid by local communities and the government will be considerably higher. A number of development actors are prepared to intervene instantly.

In order to prevent isolated and non-sustainable activities an intermediate strategy for a coordinated action is proposed in this article. The article gives a short account of Parthenium and Acacia in the Afar lowlands in order to illustrate the new challenges of IAS as examples for the necessity to address all invaders under one integrated strategy. The paper emanated from a preliminary study in the Afar Region which prepares practical interventions of improved land use.

From a development actor's view, this preliminary study allows for the following conclusions: Besides the massive problem created by the *Prosopis juliflora* invasion in the Afar Region, Parthenium and Acacia are now firmly established in some Afar areas and spreading on rangeland and irrigation plots. The pastoral communities are not able to cope with the demanding task of controlling IAS, particularly on rangeland.

There is no up-to-date survey on the real spread of IAS and their economic impact in the Afar Region. So, regional and national authorities and institutions have no precise picture of the current situation and the impacts. Local communities have a clear perception of the impact of Parthenium and Acacia on their land and livelihoods. Their spread resulted in loss of crop harvest and fodder resources and, in the case of Acacia, of access to the land and mobility for their herds. They express their concern and deplore their lack of means to encounter the invasion.

There are no experiences how to manage and rehabilitate Acacia- infested pasture land. Invasion of irrigated land by Parthenium is more easily addressed by agro-pastoralists. But there is little pre-

paredness to eradicate the plant along the irrigation channels, pathways and in settlement areas. Pastoralists have no means of controlling Parthenium spread on rangeland Development programmes and local communities are in a "reactive" mode concerning the appearance of a new IAS. Only when an IAS species is established and starts causing tangible problems, the menace is realized.

Preventive measures in terms of early detection and organized rapid response through eradication are not possible in this way and the halting of further spread of IAS to non-infested areas in the region not possible.

Local and regional institutions are not sufficiently equipped to provide communities and development organizations with the necessary support for action.

In the meantime the spread of IAS is going on. The need for starting coordinated action with a long-term perspective which covers the whole area of Afar Region is crucial.

Towards an intermediate strategy for instant action

On federal level, the Ministry of Agriculture has started activities (like the consultation with partners on the Rangeland Management Platform) that are likely to lead to the creation of a national policy, strategy and action plan on IAS management. EIAR prepared an extensive proposal for such policy development.

The urgency of the situation puts development actors into the difficulty to instantly act yet not having the full framework for effective and sustainable action of the new IAS-policy, which would help to avoid the risks of isolated activities without sustainable impact. The following list of activities sketch a proposal on how to prepare for an instant response to IAS threats in Afar, while maintaining the potential to integrate into a future national policy set-up.

Long term success of IAS control will largely depend on developing pastoral and agro-pastoral land use practices which are highly attractive to the local communities. Only the perspective of solid economic gains will mobilize sufficient motivation in local communities to engage in the tedious tasks of managing and preventing the spread of IAS. Hence, IAS-management has to be incorporated in an integrated strategy which takes in account social and economic differences of communities. The pastoral and agro-pastoral Afar communities are currently undergoing an economic and socio-cultural transformation process which needs adaptation of development strategies to local differences. Experimenting and elaborating livelihood strategies together with the different communities while taking into account gender related interests is a promising way to get into grip with the challenges ahead. Authorities and development partners should be prepared to accompany these transformation processes of local communities with a long-term commitment.

Annex II: Further Literature

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Annex III: Impressions from Field Survey

Some impression about the spread of Prosopis in Afar region

Large parts without much vegetation, some Acacia Nubia

Very scattered Prosopis was seen along the road

No Prosopis at cattle resting place

No Prosopis at camel route, but along the road

Water and wind erosion are very strong

Not much Prosopis around pastoral settlements


Some parts which could be invaded by Prosopis




Some Prosopis along the road


Now we found some Prosopis


Scattered patches of Prosopis, also showing drying up when water is not sufficient

Very scary – a dead forest, caused by draught

Now real Prosopis infestations

Prosopis in river bed

Prosopis along a roadside

Prosopis at a river bank

Prosopis as a fence of an irrigated, Prosopis free area

Some Prosopis along the road

no Prosopis at the well maintained channel

No Prosopis on camel trails

Prosopis around a lake

Not much Prosopis all over

A very dry part of Afar region (Korri)

Areas inside Korri also with nearly no Prosopis