Prosopis juliflora: Impacts and management in the face of climate change in Ethiopia's Middle Awash Valley

January 2019

www.assar.uct.ac.za

Written by Mekonnen Adnew, Mohammed Assen and Mathias Tesfaye

The five-year ASSAR project (Adaptation at Scale in Semi-Arid Regions, 2014-2018) uses insights from multi-scale, interdisciplinary work to inform and transform climate adaptation policy and practice in ways that promote the long-term wellbeing of the most vulnerable and those with the least agency.

Introduction

In semi-arid Ethiopia, a wide range of factors create barriers and enablers for local people to adapt to climate change. *Prosopis juliflora* (*Prosopis*), an introduced alien plant species, has had an impact on people's adaptation spectrum. We consider the climate change adaptation spectrum as the capacity of local communities to be resilient to climate-related shocks (e.g., droughts and floods) and non-climatic risks (e.g., food insecurity), which affect their livelihood strategies and food security status.

Prosopis was introduced to Ethiopia's Middle Awash Valley (MAV) in the 1970s. It was intended to combat desertification and to be used for landscape greening, firewood, and as fodder for livestock. While this species has achieved these original targets, its introduction has also led to unintended environmental and socioeconomic consequences. The plant has spread over large areas, invading rangeland, reducing pasture for livestock, blocking access to water, causing physical harm, and creating other negative impacts.

This report provides updated empirical information on *Prosopis*, which can be used by policy makers (e.g., Ethiopia's National Prosopis Task Force), practitioners, and environmentalists working on *Prosopis* management at different levels, including national, intermediate and grassroots.

Our approach

We evaluated how *Prosopis* has expanded under a changing climate (e.g., drier conditions in the MAV), and assessed the perception of pastoralists and agro -pastoralists on its impact and current management practices. We focused on two *Prosopis*-invaded woredas in Afar National Regional State: Awash Fentale and Amibara. Our findings are based on information collected from 89 people, who participated in focus group discussions, key informant interviews, and field observations. Four focus group discussions were held with community members representing different social groups (men, women, youth, and elders). We conducted key informant interviews with kebele leaders, local development agents, and natural resource and agricultural experts who work for local government and NGO institutions.

We also applied remote sensing (RS) and Geographical Information System (GIS) techniques to detect and map changes of land use/cover dynamics, which were used as a proxy to estimate *Prosopis* expansion for the period 1987-2016. Landsat imageries of TM (Thematic Mapper) for the year 1987, ETM+ (Enhanced Thematic Mapper) for the year 2002, and OLI/TIS (Operational Land Imager and Thermal Infrared Sensor) for the year 2016 were obtained from the United States Geological Survey website, and processed using appropriate GIS tools for change detection and mapping of land use and cover dynamics. We made intense field observations of the study area, in both in wet and dry seasons, in order to check the association of *Prosopis* with other indigenous natural vegetation in different land use/ cover categories.

Our analysis of RS data indicates an expansion of shrub land cover, largely consisting of *Prosopis*, in the MAV over the 29-year study period (Figure 1). Field observation confirmed that large tracts of community grazing, farm, and settlement lands have been invaded by the invasive plant. However, *Prosopis'* expansion has been restricted in commercial farms where heavy machineries have been used to demolish and uproot it.

Changing climate expected to exacerbate the spread of *Prosopis*

Prosopis grows in alkaline and saline soils. It adapts readily to high temperatures and low rainfall. Since first being planted along irrigation canals in the 1970s it has spread in all directions. Remote sensing data, for the period 1987 to 2016, shows an expansion of *Prosopis* cover over large areas in the MAV, particularly between 2002 and 2016 (Figure 1). As *Prosopis* has expanded, other useful indigenous plants have diminished in the study area.

During the periods 1987-2014, annual rainfall decreased at a rate of 35.5mm per decade, while mean annual temperature and annual evapotranspiration increased at rates of 0.36°C per decade and 125.5mm per decade, respectively (Figure 2). Model projections indicate an increase in temperatures, along with longer dry spells and shorter wet spells in much of Ethiopia as a result of global warming. As a result, the expansion of this alien species is expected to worsen in the coming decades.

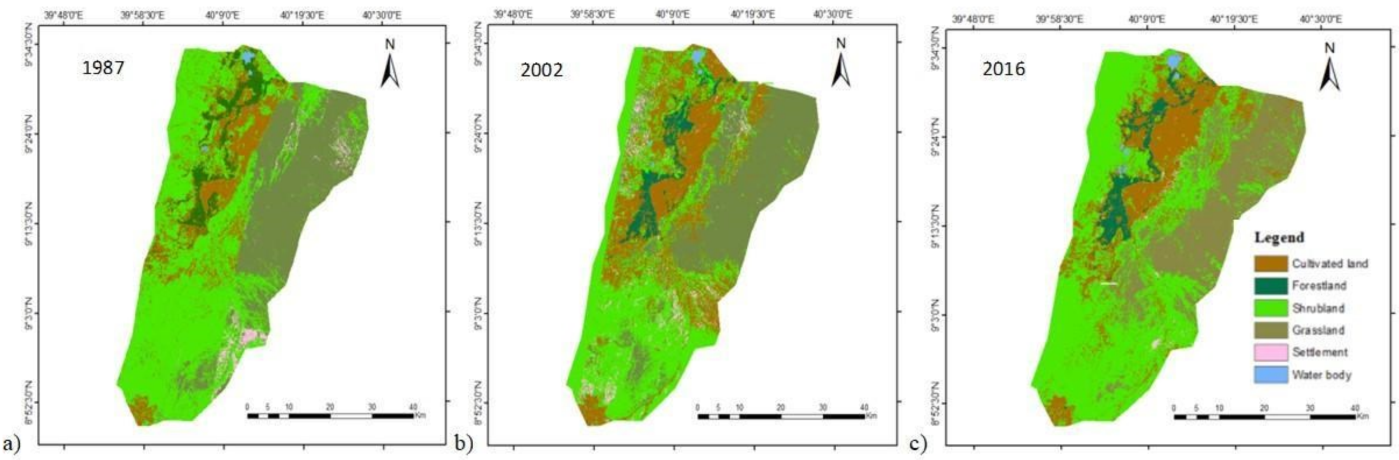

Figure 1: a) Land use/ cover of 1987, b) Land use/ cover of 2002 and c) Land use/ cover of 2016.

Livestock and wild animals also assist in the spread of *Prosopis*. They eat pods containing *Prosopis* seeds during times of pasture scarcity. The animals digest the pods and excrete the seeds, often over the course of long-distance seasonal migrations. The seeds then go on to germinate in their new environments. *Prosopis* also spreads through floods that carry the pods – which soften in the water – and eventually release seeds. This results in the plant growing mainly along flood channels and riversides.

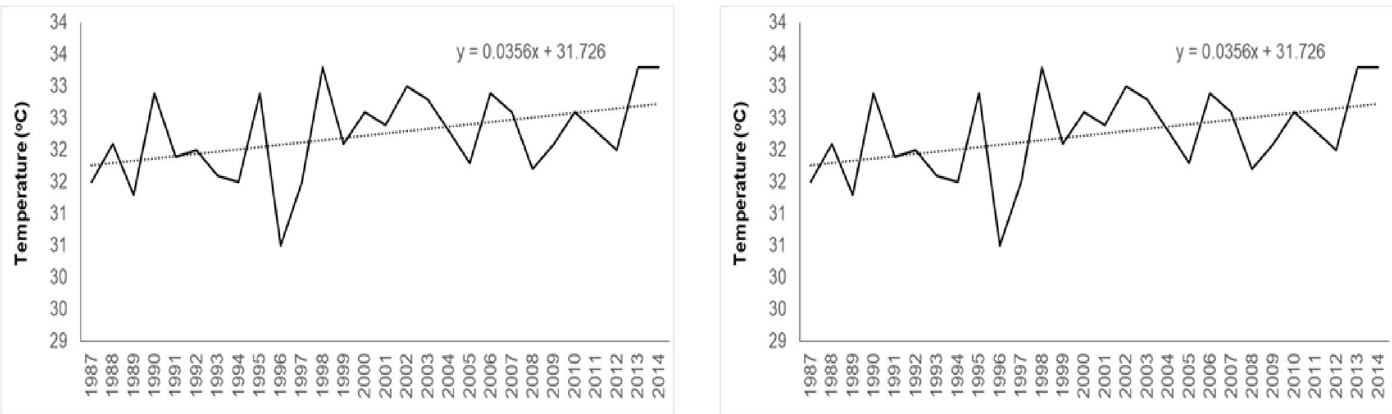

Figure 2: Trends in a) mean annual temperature, and b) total rainfall and evapotranspiration at Worer town (Amibara woreda).

Perceived impacts of *Prosopis* in the Middle Awash Valley

Prosopis has multiple positive and negative impacts on ecosystem services and pastoralists' livelihood systems. Our findings show that its negative impacts significantly outweigh the positive. The perceptions, views, and aspirations of the local community and experts differed in characterising the impacts of *Prosopis* on ecological and socioeconomic systems.

Perceived positive impacts

Although not well acknowledged by the local community, *Prosopis* is used for firewood supply; constructing homes and byres; fencing for dwelling compounds and farmlands; and shade from sunburn (Figure 3). People also use the pods to feed livestock in periods of severe feed shortages.

With policy support, there is potential for pastoral communities to generate income from *Prosopis*, through using it to produce biofuel energy, charcoal, forage, and furniture. Local experts and university professors acknowledged the ecological benefits of *Prosopis* (e.g., carbon sequestration, wind-break, flood protection, landscape greening, and treatment for soil salinity).

Figure 3: Use of *Prosopis* for a) fencing and b) shade from sunlight.

Perceived negative impacts

Prosopis has become a menace in the MAV. It has significantly reduced the resilience of ecosystem services and local communities to climatic (e.g., drought) and non-climatic (e.g., food insecurity) risks.

As one focus group discussion participant in Haladegie kebele explained:

> *"This tree is now largely affecting our livelihoods. The number and productivity (meat and milk) of our livestock has largely decreased due to the shortage of pasture. As a result, the income generated from livestock is highly reduced. The livelihoods of Haladegie people are dependent on livestock and our livelihoods are now at risk due to the shortage of pasture. We could not sell our livestock for a good price as the weight of livestock becomes low."*

Another participant in the same kebele said:

> *"In the past, this area has grown very good grass during rainy season, but now it is invaded by Prosopis. It is only at the hillside, which is found at a distant location, that we found grass for our livestock due to the lower Prosopis density in those parts."*

The multidimensional negative impacts of *Prosopis* on ecology and socioeconomic activities, as reported by study participants and observed during field visits, are summarised in Table 1.

Table 1: Summary of perceived negative ecological and socioeconomic impacts of *Prosopis.*

Major sectors	Specific resource/ sector	Description of the negative impacts
Ecological resources	Water resources	Excessively consumes surface and underground water table; blocks access to water points and flow of water for irrigation (Figure 4d).
	Biodiversity and rangeland	Kills valuable indigenous plants, resulting in degraded rangelands and feed shortages, migration of wild animals, increases in fierce wild animals and reptiles (e.g., snakes and insects).
Socio-economic impacts	Irrigation and livestock system and productivity	Thorns cause physical injury to animals and health complications; increases in livestock killed by predators; lowers livestock productivity; and conceals crop-damaging wild animals (e.g,. warthogs) and flocks of birds.
	Household income and livelihood	Reduces income from livestock sector; food insecurity; displacement from settlement areas; reduces community resilience to the effects of climate-related risks (e.g., drought).
	Human health	The hard and poisonous thorn causes physical injuries to human skin and deforms the human body (Figure 4a). One participant indicated the strength and impact of the thorn by saying, "the thorns of *Prosopis* are as strong as a metal spear and are a killer." Women, children, and elders are the most affected social groups. For example, women are vulnerable as they are responsible for collecting wood for domestic energy, and most children walk barefoot.
Impacts on development projects	Kesem Sugar Factory and Awash Basin Authority	Invades farmlands; blocks movements and incurs additional costs for clearance (Figure 4e); creates problems for land surveying and evaluation studies.
Impacts on national parks	Awash and Halaydegie National Parks	Reduces valuable tree and grass species; narrows movement corridors for wild animals.
Impacts on urban areas	All towns in MAV	Invades secondary urban roads; used by thieves as places to hide so that they can rob people; creates problems for urban beauty and water distribution.

Figure 4: Impacts of *Prosopis* on a) human health, b) costs to remove from farmland, c) invasion of irrigation cropland, d) narrowing of irrigation ditch and blocking water access, e) cost to clear from road, and f) narrowing roads.

Lessons from past and current *Prosopis* management practices

Different management strategies have attempted to curb the spread of *Prosopis* in the MAV over the past 20 years. These include cutting and burning, using *Prosopis* to make charcoal, and using chemical agents to eradicate it. To date, however, these efforts have struggled to control the plant's spread and address its impacts. Some have failed to achieve their expected goals (Table 2 and Figure 5).

Table 1: Summary of *Prosopis* management strategies.

Major focus	Management strategies	Current condition	Advantages and disadvantages
Eradication	Manual cutting above the ground and burning (Figure 5a)	Functional in many sites	Widely practiced and managed with local knowledge and low cost. But, tiresome, risky, less effective due to plant's high copiccing capacity; and less feasible for large areas.
	Manual cutting and uprooting, and burning root	Functional at selected sites	Perceived as an effective method. But, requires heavy labour; is tiresome, risky; and not feasible for large areas.
	Clearing by bulldozers	Functional at selected sites	Perceived as effective (e.g., is able to be applied over large areas in short space of time, easily uproots big trees with no risk of injury). But, it is costly and damages indigenous plants and grasses.
	Weeding	Functional at selected sites	Enables the removal of newly emerging *Prosopis*. Perceived as an effective way to protect further expansion into new areas. But, not applicable for big trees and less feasible over large areas; requires much labour.
Economic use	Charcoal production	Failed	Benefited few members of the community and affected indigenous trees and soil, organic stock, and grass seed stocks. It has also caused conflict among people.
	Fodder and furniture production	Failed	Created jobs and income for few members of the community; but could not be functional due to technology mismatch, the tiresome task of collecting pods, lack of market, and the risks associated with *Prosopis* thorns and wild animals.
	Converting to other land uses	Semi-functional	There have been attempts to convert *Prosopis*-covered land to irrigation farmland and rangelands in a few kebeles. But, the efficacy of this approach has been challenged by drought, water shortages, and the high capital needed to clear *Prosopis*.
Managed as ecosystem functions	Saline soil and erosion protection; landscape greening; carbon sequestration	Functional but needs further studies	*Prosopis* is used by some institutions and commercial farms for salinity treatments (e.g., Worer Agricultural Research Center and Kesem Sugar Factory). Local experts promoted its benefits as erosion control, habitat for some wild animals, and as a mechanism for carbon sequestration.

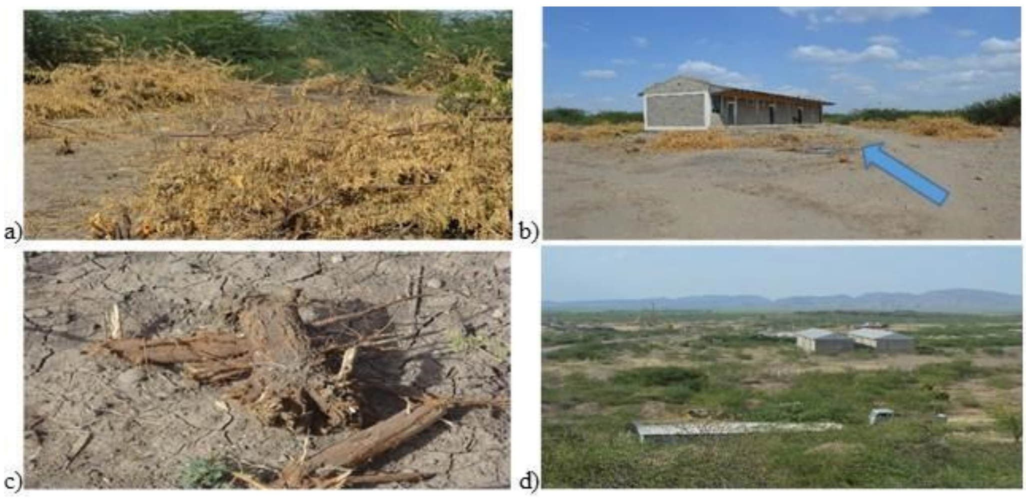

Figure 5: Some management strategies: a) cutting, b) cutting and burning, c) cutting and uprooting, d) planned biofuel manufacturing factory.

Reasons applied management strategies have not been effective

Many environmental and socioeconomic factors were found to negatively affect the success of *Prosopis* management practices. These include the hardy nature of the species, and natural and socioeconomic factors. Examples are listed below:

1. *Prosopis* has **high copiccing capacities**, which means it quickly grows new shoots from its stump when cut down above the ground (Figure 6).
2. **The pastoral livelihood system**: both pastoralist and agro-pastoralist communities in the MAV practice migration (transhumance) during wet and dry seasons and drought periods. Thus, livestock continuously spread *Prosopis* seeds into new areas, through the mechanism explained previously.
3. **The presence of spreading agents, which cannot be controlled by local people:** there are different types of wild animals (e.g., warthogs, rodents, monkeys, apes, and birds), and natural events like floods that cause the spread of *Prosopis* seeds.
4. **The mismatch between management strategies and the rate of *Prosopis* expansion:** the size of land invaded by *Prosopis* is larger than the size of land cleared from *Prosopis* in a given year.
5. **Conflict between local communities and indiscriminate use of indigenous tree species for charcoal production and other uses:** This was partly due to the absence of equity in benefit sharing among the community members. Only a few members of unions were able to benefit from *Prosopis* exploitation. The remaining large marjority was not participating, and got into conflict when other people came to use available *Prosopis* on their land.
6. **Inappropriate technologies, risks, and low return from some economic uses:** For example, attempts to produce different furniture and fodder from *Prosopis* partly failed due to inappropriate technologies (e.g., the type of mill bought to produce fodder in villages from *Prosopis* pods was unable to grind the pods due to their gummy nature).
7. **Some technologies were not easily accessible and expensive for the local communities.**
8. **Local community and experts indicated that a lack of sustainable support from NGOs and/or government, and lack of commitment from government and communities was an issue.**

Figure 6: The coppicing capacity of *Prosopis.*

Communities call for support

Local community members and experts indicated that a lack of sustainable support for *Prosopis* management from NGOs, federal government, neighbouring regions, and national and international communities, is an issue.

An interviewee in Haladegie said, "*Why don't the neighbouring regions fear the potential spread of Prosopis into their regions/areas and why do they not support us? We request support from other regions to kill this plant where it is now, before it spreads into their areas*."

In some areas, communities identified the need for resources (e.g., water) and technologies (e.g., water pumps) to convert cleared *Prosopis* land into land for crops and grazing. The same respondent from Haladegie kebele said, "*There is a big potential in this area to eradicate Prosopis and convert the land for other economic utilisation. We have sufficient and fertile land; we have labour to clear Prosopis; and there are enough underground water sources in the area. What we miss is the mechanism and/or motor pump to extract the underground water to use for irrigation*."

However, in Kebena kebele a group discussion participant said that "*from our past experience, we learned that it is impossible to eradicate Prosopis by human power since it covers very large areas and causes physical injuries. Thus, it will be good if the eradication can be done with machines (bulldozers). The cleared land should be converted into other land uses, such as pasture growth or irrigation agriculture, with continuous management work to control new Prosopis growth – and this can be done with human labour*."

Implications for policy and practice

This study has confirmed that *Prosopis* continues to expand rapidly under a changing and drier climate. Drier conditions are expected to increase livestock mobility as well as the likelihood for *Prosopis* pods to be eaten by animals due to pasture scarcity. *Prosopis* has also the capacity to cope with changing climatic conditions (e.g., increased temperature and variable rainfall). It has become a leading environmental and socioeconomic problem, significantly affecting pastoral and agro-pastoral livelihood systems. Thus far, management strategies have struggled to control the spread of the invasive plant. The current impact and spread of *Prosopis* is greater than the existing management capacity and exceeds the abilities of local communities. The situation calls for new, more efficient, management strategies to control further *Prosopis* expansion, or interventions to support enhanced economic utilisation of *Prosopis*.

RECOMMENDATIONS

- Available technology makes it difficult to completely remove *Prosopis* from the landscape. This may not even be necessary. It is advisable to develop management methods that comprise both the use of *Prosopis* in some less productive areas, and removal from some of the most productive irrigation cropping and rangeland areas.
- *Prosopis* has invaded much of Afar and its neighbouring regions. Thus, it is recommended that a national policy for *Prosopis* management is developed, and all regions are supported as part of a national agenda.
- The introduction of any management strategies should be based on careful evaluation of the short-, medium- and long-term impacts on the environment and sustainable socioeconomic development, to avoid further unintended consequences.
- Management strategies and policy developments should consider the views of local people. They should consider how different interventions could have different impacts for different groups, paying close attention to which social groups are most vulnerable to the impacts of *Prosopis*.
- Further studies on the potential of *Prosopis* for carbon sequestration and environmental greening/ ecosystem functions are required, since there is currently little evidence and insight on this.
- To raise awareness about the *Prosopis* threat, and the need for support for communities, regional government and researchers could communicate the severity of the problem through workshops and electronic media (e.g., radio, television, online).
- In some areas, communities need resources and technologies to convert cleared *Prosopis* land into land for crops and grazing. Management interventions need to consider local capacities to deal with *Prosopis*.
- Government and NGOs should create a platform to provide sustainable support for those management strategies that are introduced, until these achieve their intended outcomes.

For more information: ASSAR - www.assar.uct.ac.za or email Mohammed Assen (moh_assen@yahoo.com)

This work was carried out under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development (DfID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not necessarily represent those of DfID and IDRC or its Board of Governors.

Editing: Brendon Bosworth · *Layout*: Caitlin Kelly and Tali Hoffman· *Photos*: Mark Tebboth, Jennifer Leavy