Invasive species in the semi-arid lands of Ethiopia: Implications for climate change and food security of pastoralism economy

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Introduction

Deliberately introduced invasive plants in the Middle Awash Valley (MAV) (Central Ethiopia) including *Prosopis juliflora* often provide some ecological and socioeconomic benefits, but later created unforeseen environmental and socioeconomic problems as it widely spreads (Shackleton et al., 2015). *P. juliflora* becomes the most successful invader in the semiarid (SAR) agroecology, saline and infertile soils and high temperatures (over 26^{o}C and less than 500 mean annual rainfall) (Shiferaw et al., 2004). Thus, the predicted future climate change in SARs (i.e. increasing temperature and decreasing and variable rainfall) (IPCC, 2014) creates favourable environmental conditions for *P. juliflora*. Therefore, the objectives of this study were to assess land use/cover dynamics in relation to invasive species with emphasis on *P. juliflora* and its implications for climate change and livelihood and food security of pastoralism economy.

Methods of the study

The study was made in the Middle Awash Valley (MAV), Central Ethiopian Rift Valley (Figure 1), which forms a part of the Great East African Rift Valley. It is found in the Afar region of Ethiopia, and covers 2789.7 km². It lies between 8^{o}30' 12"N and 9^{o}50' 03"and 39^{o}50' 20" E and 40^{o}32'0 E. The MAV has flat topography consisting of semi-arid agro climatic zone.

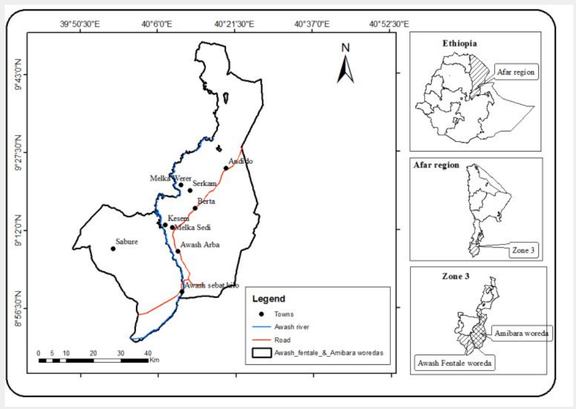

Figure 1: Location map of the study area

Data sources

Data were collected from selected sites at different times (2014-2017) using qualitative, field observation and Remote Sensing analysis methods. These were key informant interview (KII), focus group discussions (FGDs), workshops with the local communities and experts in different fields. Remote Sensing (RS) analysis and GIS were applied to detect changes of land cover and expansion of invasive species. Field observations were made for dry and wet seasons existing vegetation cover observation in four study sites/ villages in the MAV.

Results and discussions

Land cover dynamics

Analysis of RS data indicated an expansion of *P. juliflora* cover in the MAV over the 29 year study period (1987 to 2016). Field observation confirmed that a large tract of community grazing, farm and settlement lands have been invaded by this invasive plant. The shrub land largely composed of high proportion of *P. juliflora* covered 50% in 1987, 38% in 2002 and 47% in 2016 of the total study area (Figures 2a, b, c).

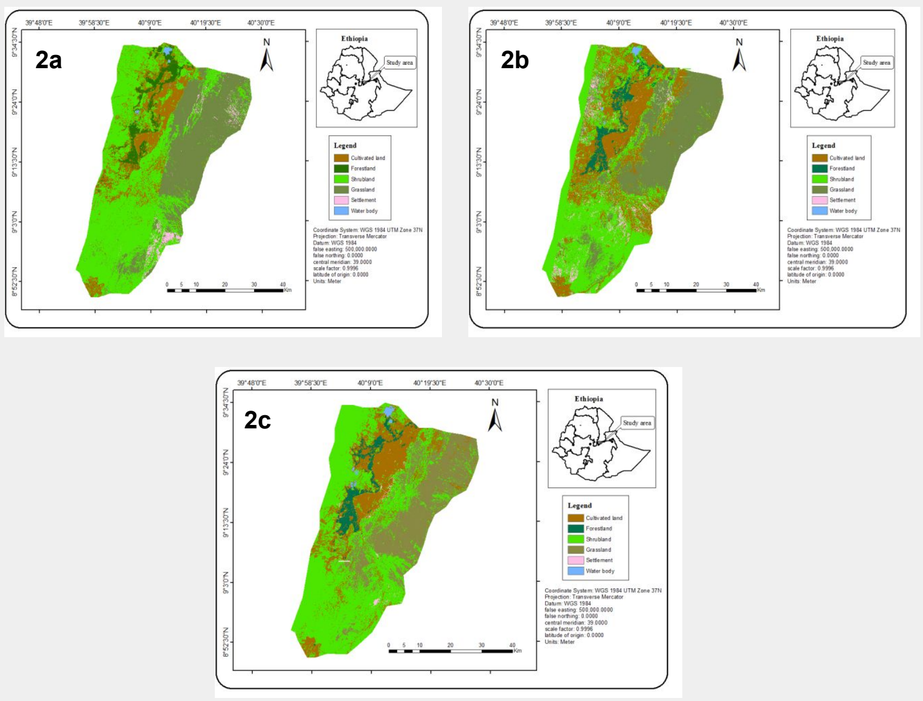

Figure 2: a) Land use / cover of 1987, b) Land use / cover of 2002, c) Land use / cover of 2016

Local people perception on the expansion of *P. juliflora*

P. juliflora was first observed in irrigation farms. It was introduced by researchers in early 1970s. Local community was encouraged to plant *P. juliflora* in order to enhance the vegetation and forest cover of the area, and thereof to prevent desertification and soil erosion, use its pods as a fodder for livestock and as a source of firewood and raw material for small scale furniture industries. *P. juliflora* spread into other parts by different mechanisms. The seed is spread by domestic and wild animals, irrigation water and flood, vehicles, wind and shoes of man.

Impacts of P. juliflora on the ecosystem and socioeconomic activities

P. juliflora has multiple positive and negative impacts on ecological, livelihood strategies and other socioeconomic systems in the SARs. This study evidenced that negative impacts outweighed the positive impacts.

Positive ecological impacts - these include:

- Used for soil salinity treatment, carbon sequestration, protect soil erosion, flood control, serve as shade from sunlight and wind break and increased landscape greenness (Ilukor et al., 2016).

Positive socioeconomic benefits - these include:

- Used for domestic energy (firewood) supply, constructing byres, fencing houses and farmlands, shade from sunburn, and house construction. The pods used to feed livestock in periods of severe shortages of feed. However, some participants of community members failed to acknowledge many of these benefits. They mentioned that this plant is associated with various risks and its poor quality as compared to other indigenous tree species as well as its impacts on their livestock resources by causing physical injury.
- Source of income generation by producing charcoal and forage through collecting and splitting/ grounding its pods as well as used for the production of furniture from *P. juliflora* wood.

Negative impacts include:

- Increased community vulnerability to climatic (e.g. drought) and non-clime risks e.g. food insecurity, conflict and poverty. The damages included: ecological (invasion of grazing and farm lands, reduce soil moisture, and kills indigenous valuable plants); socioeconomic (shortages of pasture, reduce access to farm and grazing lands, physical injury by hard thorn, reduce human and livestock mobility, etc.). It affects different social groups (adult, women, children and young groups) (Figures 3 to 4). The invasion and lowering of quality of grazing lands resulted in shortages of fodder (Figures. 3 and 4).

Figure 3: a) *P. Juliflora* serving as soil cover and greenness b) *P. juliflora* free grazing land

Figure 4: a) Impacts of *P. juliflora* invasion of settlement b) Prevention of access to river by *P. juliflora*

Climate change and P. juliflora expansion

- The prevalence of dry periods and existence of high temperature in the study area would create a favourable expansion environment for *P. juliflora* in the MAV. FGDs indicated that over time the rainfall amount has decreased and became highly variable, frequency and severity of drought increased during the last ten to twenty years. Temperature has also increased. As a consequence, invaluable indigenous plant and grass species were diminished to a larger extent.
- The excessive water consumption power of *P. juliflora* likely decreases the availability of surface and underground water.

Management strategies and practices

Eradication and economic utilization management strategies *of P. juliflora* have been attempted in the MAV. There was also a plan to produce biofuel from *P. juliflora*. Most of these technologies and strategies were not successful. Local community preferred its total eradication as their best option of management practices mainly related to negative benefits of *P. juliflora*. Experts perceived the combination of eradication, economic and systematic ecological utilizations as feasible adaptation options e.g. soil salinity treatment and carbon stock enrichment as part of climate change mitigation strategy.

Conclusion

P. juliflora was intentionally introduced in the MAV to protect soil erosion and create green environment. It has partly achieved the intended original goals for greenness of environment and protects land from erosion. However, it invaded most productive lands of rangelands and consumes available surface and ground water over time. This has negatively influenced the availability of fodder to animals (main resources of pastoralists) and has negative implications on food security and livelihood strategies. It is difficult and expensive as well as unwise to remove *P. juliflora* completely from environmental benefits point of view. It is important to design policies that could address both its importance for protection of the environment and at the same time not damaging the food security and livelihood strategies of local community.

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