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# Assessing the distribution and impacts of *Prosopis juliflora* through participatory approaches

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ABSTRACT

Invasive species pose global biological and economic challenges. Over the past four decades, *Prosopis* taxa have emerged as a major invader of the arid and semi-arid regions of the world. *Prosopis juliflora*, one of the highly invasive *Prosopis* species, is dominantly present in the Afar region of Ethiopia and continues to spread into the surrounding areas. The objective of this study was to aid the mapping, utilization, and management of the invasive *P. juliflora* in Afar, by employing participatory research techniques. We assessed the introduction history, impacts, uses, and control strategies of invasive *P. juliflora* by interviewing 108 pastoralists and agro-pastoralists. In addition, we used Participatory Mapping (PM), Geographic Information Systems (GIS), Global Positioning System (GPS), and remote sensing technologies and approaches to map sites invaded by *P. juliflora*. Sketch maps were produced by men, women, pastoralist and agro-pastoralist groups. Experts aggregated, scaled and reproduced the sketch maps with support from the Afar communities. We provided GPS and GIS trainings to selected community members who assisted us in collecting the GPS locations of more than 70 key features and landmarks. The sketch maps were digitized and geo-referenced by experts using the 70 GPS records as control points. Geo-referenced community maps were superimposed on pan-sharpened Landsat 8 satellite images and presented to the communities for verification. We overlaid the verified community maps on ancillary land-cover layers, and detected the land-cover classes that were most affected by *P. juliflora* invasion. Despite its uses as source of fire wood, charcoal, and animal fodder, the species has adverse impacts on native species and livestock resources. Afar communities mapped *P. juliflora* infestations, particularly those that occurred near their villages, using high and moderate density classes. The two highly invaded land-cover categories were dense grassland, and exposed sand & soils. Participants collaborated in creating the produced maps, suggesting that participatory research approaches are another tool for early detection of invasive species and guiding fine-scale management strategies.



## 1. Introduction

In the 1970's, international organizations and a number of East African countries introduced *Prosopis* species to the horn of Africa to control desertification (Coppok et al., 2005; Wakie, Evangelista, & Laituri, 2012; Zollner, 1986). Following this internationally coordinated effort, *Prosopis juliflora* was deliberately planted in southern parts of Afar, north-eastern Ethiopia. *P. juliflora* was promoted as a “wonder plant” that provides multiple benefits and services such as fire wood, shade, animal fodder and soil amelioration (Pasiecznik et al., 2001, pp.172). However, the negative impacts and invasive properties of the species were not communicated to the Afar people at the time of its introduction (Rettberg & Müller-Mahn, 2012). Currently, the invasive *P. juliflora* (also known by the names *weyane*, *weyane hara* and *dergi hara*) has dominated the Afar landscape, displacing useful native plant communities, creating shortage of livestock forage, and negatively affecting traditional livelihoods (Admasu, 2008; Wakie et al., 2012). Further impacts driving the region's rapid environmental change are recurring drought, ethnic conflict, and land-grabs by large-scale commercial agriculture (Rettberg, 2010; Lavers, 2012). Afar is one of the top four regions in Ethiopia that are affected by land-grabs, a

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phenomenon where foreign companies acquire huge tracts of land from developing countries for long durations at very cheap prices (Abbink, 2011; Lavers, 2012).

The objective of this study was to aid the mapping, utilization and management of the invasive *P. juliflora* in Afar by employing participatory research techniques. Incorporating the spatial and cognitive knowledge of local communities is essential in designing and implementing successful conservation and development projects. Projects that lack community involvement and support are often unsustainable. Participatory research approaches are increasingly being used to map resources (Baldwin & Oxenford, 2014; Herlihy & Knapp, 2003), identify and prioritize social and economic problems of rural communities (Chambers, 1994a; Wiber, Berkes, Charles, & Kerney, 2008), and find sustainable solutions to agriculture and natural resource management related problems (Dangles et al., 2010; Fliert & Braun, 2002; Pretty & Shah, 1997; Wheeler & Hoces, 1997).

The origin of participatory research methods can be traced back to Participatory Rural Appraisal (PRA) techniques of the 1970's, which are a suite of approaches and methods that are designed to enable rural people to share, enhance and analyze their knowledge of life and conditions to plan and to act (Chambers, 1994b). Participatory research techniques can include interviews (e.g., focus groups, key informants), transect walks, timeline analyses, and other participatory mapping approaches. Participatory Geographic Information Systems (PGIS) and its equivalent Public Participation GIS (PPGIS) were created when researchers merged simple PRA techniques with GIS (King, 2002; Brown & Kytta, 2014). Meanwhile, new terminologies, such as Participatory GPS and Participatory Remote Sensing, have been recently introduced into the Participatory Research vocabulary (Baldwin & Oxenford, 2014; Blanke, Troster, Franke, & Lukowicz, 2014). As a concept and a tool both PGIS and PPGIS need precise definition (Baldwin & Oxenford, 2014; Herlihy & Knapp, 2003). Here, we use the two widely recognized terminologies, participatory research, and participatory mapping (PM).

Participatory Mapping (PM) recognizes the cognitive spatial and environmental knowledge of local people and transforms this into more conventional forms that can be shared within a community as well as with governmental agencies (Herlihy & Knapp, 2003). Participatory maps, also known as community maps or indigenous maps, are creatively produced by participants through locally available materials (e.g., Kalibo & Medley, 2007). Participation is a key component of the process whereby community members fully participate in the planning, mapping, and implementation phases. In a true participatory mapping process, the researcher's task is to facilitate the participatory mapping and research process rather than to extract data. Participatory mapping methods can range from those that are simple and ephemeral such as drawing maps on sand, to advanced Global Positioning System (GPS) and web-based mapping methods. Currently used PM methods include ground mapping, stone mapping, sketch mapping, scaled 2D mapping, web-based and interoperable GIS mapping, GPS mapping, and 3D mapping (Cadag & Gaillard, 2012). Other commonly used techniques include placing transparent papers on top of aerial photographs and satellite images, participatory 3D modeling (P3DM), and multimedia mapping (Rambaldi & Kyem, 2006). Laituri (2011) points out that the relationship between the researcher and local informants is a critical aspect of indigenous mapping projects, especially when local expertise for creating final map products is limited. In order to gather information, the researcher first needs to gain the communities' trust, which can be achieved through clarification of objectives, community coordination, and long-term relationships. Participatory mapping practitioners should avoid sharing sensitive information with outsiders to protect the indigenous communities from exploitation and abuse. For instance, if showing particular spatial information on a map leads to the forced displacement of the indigenous people, then the facilitator/practitioner should refrain from displaying the feature on the community map (Rambaldi, Chambers, McCall, & Fox, 2006).

Community maps generally have two broad uses; the first is to act as counter-maps that challenge existing spatial documents, while the second is to supplement formal planning through incorporation of local knowledge (Robbins, 2003). Currently, participatory research approaches are used across different disciplines to address a range of issues including ethnobiology (Gilmore & Young, 2012), disaster risk reduction (Cadag & Gaillard, 2012), management of natural resources (Kalibo & Medley, 2007; Mapedza, Wright, & Fawcett, 2003; McCall & Minang, 2005), resolving land and natural resource related conflicts (Herlihy & Knapp, 2003; Sandström et al., 2003), empowering local communities (Bauer, 2009), development of land-use plans (Sandström et al., 2003), and mapping of illegal settlements (Livengood & Kunte, 2012).

Although participatory research approaches are widely used in land-use planning and conflict resolution, the techniques have not been sufficiently tested in invasive species research and management applications. Through communication with all stakeholders, map products can be used to create awareness about invasive species, to inform local level land-use planning, and to aid invasive species utilization and control efforts. In this research paper, we present the results of a three-year participatory research endeavor conducted in Afar, Ethiopia between December 2011 and 2014. Collaboratively working with Afar indigenous communities, experts,[1] governmental and non-governmental organizations (GOs and NGOs), we used participatory research techniques to understand the introduction history, spread, density, impact, use, and control strategies of the invasive *P. juliflora* plant in Amibara *woreda* (district) of Afar, north-east Ethiopia. Our specific objectives were to: a) identify major resource related problems of the region; b) map the distribution of the invasive *P. juliflora* over a fine geographic scale; c) investigate its introduction history, spread, use and control strategies; and d) assess its impacts on the regions' land-cover, native vegetation, wildlife, and livestock resources.

## 2. Methods

### 2.1. Study site

Afar is located within the arid, semi-arid and desert agro-climatic zones of Ethiopia. The aridity gradient in Afar increases in the south-north direction. Southern Afar has a relatively mild climate with mean annual rainfall of 580 mm and mean annual temperature of 26.6° C (EMA, 2012). Afar has elevation ranges between 125 m below sea level to 2870 m above sea level. The native grasses, forbes and woody vegetation include dry land adapted *Chrysopogon*, *Cymbopogon*, *Cyndone*, *Sporobolous* and *Acacia* species (Abule, Snyman, & Smit, 2007; Tikssa, Bekele, & Kelbessa, 2009). The region is home to 81 mammal species, and over 640 bird species of which six are endemic (Beyene, 2006). The human population in Afar is currently estimated at 1.65 million (CSA, 2012). The main sources of livelihoods in the study sites are pastoralism, agro-pastoralism and farming. The important domestic animals herded by the Afar people include cattle, camels, goats and sheep, while the major agricultural crops grown in the region include cotton, corn, sugar cane and vegetables.

We conducted the participatory research and interview by selecting seven representative villages from the Amibara district

[1] Throughout this article, the term expert is used to refer to the GIS and natural resource management professionals who came from GOs and NGOs in Ethiopia, and from Colorado State University.