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Distribution, biomass and local importance of tamarind trees in south-western Madagascar

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ABSTRACT

The multipurpose tamarind (*Tamarindus indica* L.) tree is important for people's livelihood and considered as sacred in the Mahafaly region of south-western Madagascar. However, the ongoing overexploitation of this species has caused a decline of tamarind trees. In this study, the species distribution, changes in tamarind biomass and the role of traditional taboos for the conservation of this species were determined to identify opportunities and constraints for its conservation and appropriate land management planning. Semi-structured interviews ($N = 63$) were conducted in 10 villages in the study region to obtain information regarding the utilization of tamarind trees. During field surveys, the diameter at breast height (DBH), height, wood volume and wood biomass were measured for already felled trees ($N = 25$). Additionally, 318 trees were inventoried by measuring their DBH, height and GPS location. Using high resolution satellite images from 2004/2005 and 2012 the crown areas of all tamarind trees in six village areas were identified. Allometric equations were established to predict their wood biomass from DBH, crown surface and wood volume. Tamarind trees are mainly used as supplementary food, as well as for traditional ceremonies, charcoal production and medicinal purposes. Altogether, 0.06–0.35 trees ha^{-1} were observed. A regression analysis yielded high coefficients of determination for the relationships between DBH and wood biomass ($r^2 = 0.98$), DBH and crown area ($r^2 = 0.72$), and crown area and wood biomass ($r^2 = 0.71$). From 2004/2005 to 2012, wood biomass losses of 12%–90% were caused by charcoal production and slash and burn agriculture. The traditionally sacred status of the tree has become insufficient to secure its conservation in the Mahafaly region.

1. Introduction

Wild fruit trees, such as tamarind, provide a range of ecological and economic services and may play an important role in the livelihoods of rural communities acting as a source of food during lean periods or as an alternative source of income (Jama et al., 2008; Fandohan et al., 2010a; Dawson et al., 2014). The tamarind (*Tamarindus indica* L.) is indigenous to Africa and typical of wooded savanna ecosystems (Diallo et al., 2008; El-Siddig et al., 2006), but nowadays it is distributed in more

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than 50 tropical countries (El-Siddig et al., 2006). In Asia (India, Thailand, Sri Lanka and Indonesia) and South America (Mexico, Brazil, Venezuela and Costa Rica), tamarind trees are often cultivated for commercial fruit production, whereas such commercialization is not yet developed in Africa. Here, tamarinds are mainly used for home-consumption (De-Caluwé et al., 2010; Van-der-Stege et al., 2011) to provide food and traditional medicinal products and for cultural practices (Havinga et al., 2010; Norscia and Borgognini-Tarli, 2006; Van-der-Stege et al., 2011). Despite its cultural and economic importance, there is still a lack of knowledge on the reproductive ecology, population genetics, biomass production and natural distribution of tamarinds (Diallo et al., 2008; Fandohan et al., 2011b).

In Madagascar, the drought-tolerant tamarind occurs in the dry and semi-arid regions of the country's south (Schatz, 2001) and trees were often planted when a village was founded (Blanc-Pamard, 2002). In the south-western region of the country, tamarind trees are often sacred and protected by local taboos (*fady* or *faly*) due to their cultural and nutritional value (Bayala et al., 2003).

Faly means 'you shall not' and is an important component of social–ecological systems in Madagascar. Such taboos are part of the laws inherited from the ancestors and reportedly have a strong impact on human behaviour and local resource management, including the regulations of forest access and the use of species (Lingard et al., 2003; Tengö et al., 2007; Jones et al., 2008; Rabearivony et al., 2008; von Heland and Folke, 2014).

According to local traditional beliefs, the tamarind constitutes a mediator between living people and the ancestors. The spirits of the ancestors are believed to reside in tamarind trees and local people use them in traditional ceremonies in which ancestral benediction is requested (Stiles, 1998; Blanc-Pamard, 2002). The tamarind is also one of the few available local fruit trees (Faust et al., 2015), rendering it important for people's diet, especially in south-western Madagascar, where people are recurrently confronted with food insecurity (WFP, UNICEF, 2011; Mathys and Maalouf-Manasseh, 2013). Furthermore, due to low economic development, lack of infrastructure and harsh environmental conditions, smallholder farmers rely on diversification of income including earnings from forest products (Neudert et al., in press).

Some Mahafaly households produce charcoal to obtain supplementary income (Mana et al., 2001; Randriamanarivo, 2001). Similar to Sub-Saharan Africa (Zulu and Richardson, 2013), in Madagascar charcoal constitutes a major energy source in urban areas (Mana et al., 2001; Randriamanarivo, 2001) due to its competitive price compared with petroleum or gas (Montagne et al., 2010). Charcoal production, therefore, is a strong contributor to the rampant deforestation process in the southwestern region (Casse et al., 2004; Brinkmann et al., 2014). Although officially prohibited (Montagne et al., 2010; Randriamanarivo, 2001), tamarind trees are one of the main species used for charcoal production in the Mahafaly region (SuLaMa, 2011).

Studies on the distribution and utilization intensity of tamarind trees in southwestern Madagascar are scarce (Bayala et al., 2003; Ramalanjaona, 2013; Mertl-Millhollen et al., 2011), and little is known on the effects of the changing traditional belief system on tamarind use. However, such information is urgently needed for sustainable management of tamarind populations (Okello et al., 2001) in order to avoid overutilization of this multipurpose tree (El-Siddig et al., 2006; De-Caluwé et al., 2010; Havinga et al., 2010; Van-der-Stege et al., 2011). Therefore, the aims of this study were to (i) assess the importance of tamarind trees for the local population in the Mahafaly region, (ii) analyse the tamarind distribution and wood biomass availability and (iii) evaluate the changes of the tamarind tree distribution and biomass throughout the recent years using remote sensing data. We hypothesized that the sacred status of tamarind trees is no longer sufficient to ensure their conservation in south-western Madagascar.

2. Materials and methods

2.1. Description of the study area

The study was conducted in the Mahafaly region of south-western Madagascar, located 90 km south of Tuléar (Fig. 1). This region is one of the country's poorest regions with an altitude varying between 0 and 400 m and a semi-arid climate characterized by a dry period lasting eight to nine months and very irregular rainfall with long term annual averages < 500 mm (UPDR, 2003). The region comprises different habitats from the coastal area to the plateau including the dry spiny forest thickets of the Tsimanampetsotsa National Park with a high number of endemic species (Mamokatra, 1999). Coastal shrublands on unconsolidated sands and saline soils (Besaire, 1946) dominate in the coastal zone, with an annual precipitation between 150 and 300 mm (Hanisch et al., submitted for publication). The local population near the border of the sea (Mozambique channel) mostly belong to the *Vezo* tribe, who traditionally earn their living from fishing and the collection of sea products, whereas the livelihood strategies of the *Tanalana* and *Mahafaly* people in the inland are based on animal husbandry and crop production. The plateau area at the eastern border of the Tsimanampetsotsa National Park is characterized by limestone and siliceous red soils (Besaire, 1946) covered by dry spiny forest patches, shrublands and savannah. Annual rainfall varies between 500 and 700 mm with a mean temperature of 24 °C (Hanisch et al., submitted for publication). Due to the scarcity and irregularity of rainfall and the low chemical fertility of the weathered sandy soils, crop yields are mostly too low to cover subsistence needs of the local population mostly too low to cover subsistence needs of the local population. Recently, the presence of cattle raiders (*Malaso*) increased the production risk in animal husbandry (Goetter, submitted for publication) and alternative income activities have thus become even more popular to sustain people's livelihood.