# Ethnopedological knowledge and soil classification in SW Madagascar

Katja Brinkmann [a,*], Laetitia Samuel [b], Stephan Peth [b], Andreas Buerkert [a]

[a] Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Universität Kassel, Steinstr. 19, D-37213 Witzenhausen, Germany
[b] Soil Science, Universität Kassel, Nordbahnhofstr. 1a, D-37213 Witzenhausen, Germany

## ARTICLE INFO

## ABSTRACT

In the semi-arid Mahafaly region of SW Madagascar productivity of predominant low-input subsistence agriculture is limited by several constraints and food insecurity is a serious problem. Due to the lack of water, dwindling land resources and low soil fertility, improved cropping systems that use available resources in a more efficient and sustainable way are urgently needed. Here, indigenous soil knowledge can help to identify sustainable management approaches of land use. In this context, our aim was to investigate indigenous soil knowledge in three selected villages using participatory approaches, analyze the physical and chemical properties of local soil types and compare indigenous with scientific soil classification systems.

Based on the World Reference Base for Soil Resources most of the studied soils were Lixisols and Arenosols. Malagasy farmers classified the soils mainly according to color and texture of the topsoil. Soils with a darker color were determined to be more productive and "Mainty" (black soil) and "Mena" (red soil) were considered as of highest fertility. Although many of the soil names coincided, there was a striking difference between villages, which probably reflects differences in environmental conditions, but also differences in ethnic origin and traditional livelihoods and belief systems. Overall, the local perception of farmers on low soil fertility corresponded to the scientific soil assessment. Given that currently local strategies for soil productivity enhancement are weak which reflects lacking long-term experience in crop management of the agro-pastoralist communities, the results of this study may help to develop recommendations for such strategies that fit traditional belief systems.

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## 1. Introduction

Soils in the Mahafaly region of drought-ridden, semi-arid SW Madagascar are poor in organic carbon as a result of their origin, the widespread use of slash and burn agriculture (locally called "Hatsaky") with cropping cycles as short as four years (Brinkmann et al., 2014; Milleville and Blanc-Pamard, 2001) and lacking use of soil fertility enhancement strategies. In combination with further agricultural constraints (cyclones and locust infestation), this leads to low crop production resulting in high levels of malnutrition among agro-pastoralists that largely depend on subsistence agriculture (Andriamparany et al., 2014; Noromiarilanto et al., 2016). Traditionally, in the Mahafaly region manure is rarely applied as a fertiliser although the agro-pastoralists have cattle herds and thus also access to large quantities of animal excrements (Bayala et al., 1998). Reasons for the rare use of manure seem to be high labor demand for its transport and application, higher disease pressure in crops, taboos and lack of knowledge (Hanisch, 2015). Mineral fertilizers and pesticides are usually not used

because of their high costs (Milleville and Blanc-Pamard, 2001). On most soil types, this low-input cropping causes a depletion of plant nutrients and after 3–5 years of cultivation, farmers are either forced to re-cultivate fallowed fields or use slash-and-burn techniques for the establishment of new fields, which is one of the main causes for deforestation in this area (Brinkmann et al., 2014). Due to dwindling land resources and low soil fertility, intensification of cropping systems in the Mahafaly region is urgently needed. In order to use available resources more efficiently and allow for sustainable land use, a better understanding of the soil conditions and the spatial distribution of soils in the Mahafaly region is necessary. This also requires soil surveys that provide detailed quantitative, spatially explicit information to develop specific land use recommendations.

So far only few studies exist about indigenous Mahafaly knowledge systems (Besairie, 1946; Roederer, 1971; Sourdat, 1977) which also comprise a surprisingly large, untapped traditional ethnopedological component. The role of indigenous knowledge in scientific research has become increasingly important, especially in agriculture and soil management (Fairhead et al., 2017; Sillitoe, 2017). Ethnopedology analyses local perceptions of soil properties and processes, local soil classification and taxonomy, local soil use and management and how soil is locally valued (Barrera-Bassols and Zinck, 2003). Previous research on

* Corresponding author.
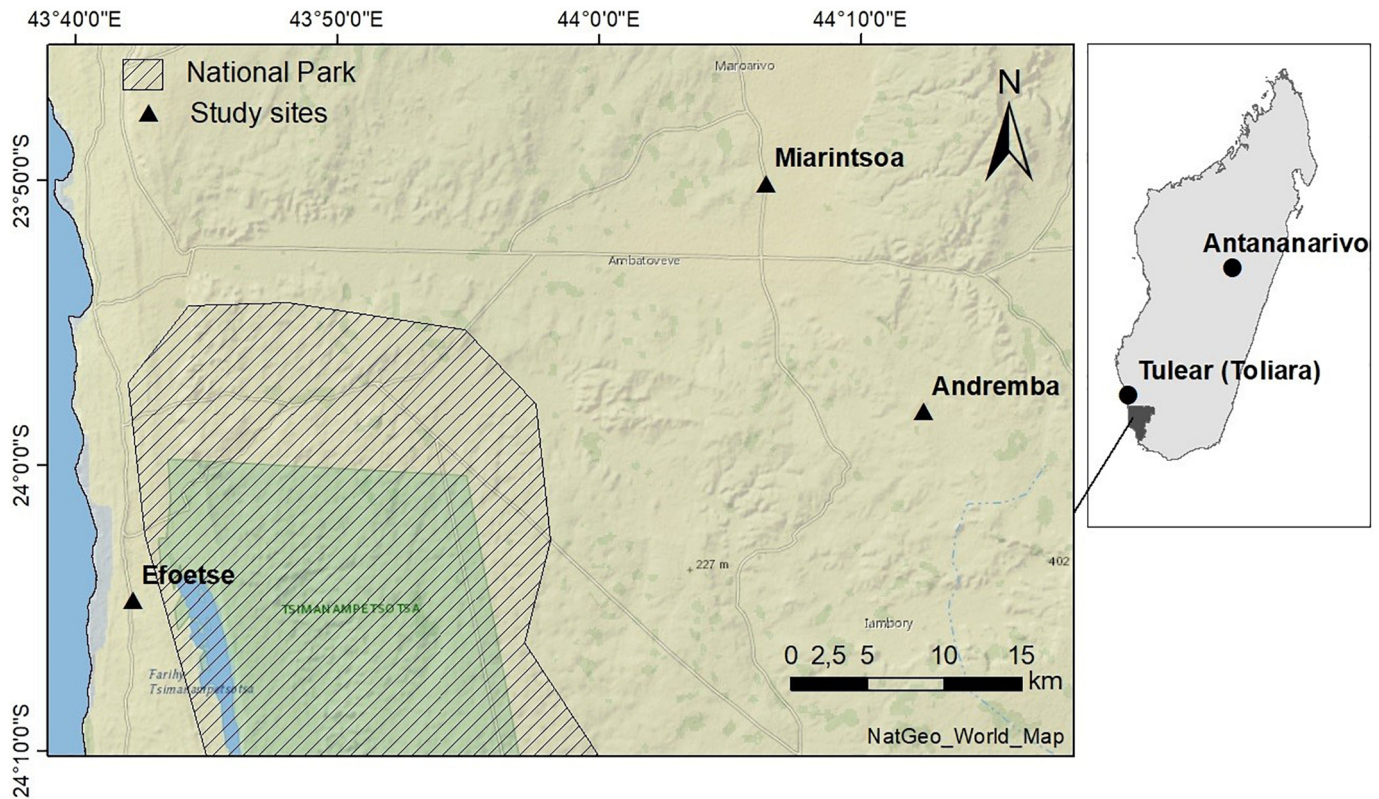E-mail address: tropcrops@uni-kassel.de (K. Brinkmann).

Fig. 1. Map showing the three studied villages Miarintsoa, Andremba and Efoetse in the Mahafaly region of SW Madagascar (Brinkmann et al., 2014).

ethnopedology in other regions of the world has shown the importance of such knowledge in developing sustainable farming practices at the village level (Barrios and Trejo, 2003; Barrera-Bassols et al., 2006; Fairhead et al., 2017; Nethononda and Odhiambo, 2011). However, for the Mahafaly region only one study exists for forest areas that uses an indigenous soil classification approach to characterize soil types determining yam species distribution (Andriamparany et al., 2015). For other regions in Madagascar only six papers address the ethnopedology of this highly diverse island (Fujisaka and Team, 1990; Fujisaka, 1990a; Fujisaka, 1990b; Fujisaka, 1991; Rakoto Ramiarantsoa, 1995; Rakoto Ramiarantsoa and Lemoigne, 2014). Most of these studies were conducted in the country's central highlands, which are characterized by a relatively long history of agricultural use. In the Mahafaly region of SW Madagascar, which has been colonized relatively late (Lebigre and Réaud-Thomas, 2001), landusers are traditionally mobile pastoralists lacking long-term experience in crop cultivation. During the last decade increased sedentarisation of transhumant pastoralists (Kaufmann and Tsirahamba, 2006), immigration of farmers from other regions and increasing population pressure made crop production more important for peoples' livelihoods. As a consequence cropland expanded drastically (Brinkmann et al., 2014). Understanding the complex knowledge system of the local people about their land and soil resources will help to effectively address local needs of resource use (Barrera-Bassols and Zinck, 2003).

In view of the above our objectives were to (i) record indigenous knowledge on specific soil types and properties and investigate its possible relationship to local crop production and land management within and between different regions/villages using participatory approaches; (ii) analyze the physical and chemical properties of local soil types, assess their differences and map their spatial distribution along a transect from the coastal plain to the plateau area and (iii) compare indigenous with scientific soil classification systems while identifying the main functional differences between these systems.

## 2. Materials and methods

### 2.1. Study site

The research was conducted in the three villages of Miarintsoa, Andremba and Efoetse located in the Mahafaly region, south of Toliara in the Atsimo Andrefana region of SW Madagascar (Fig. 1). This region is characterized by a semi-arid climate with an unimodally distributed annual average rainfall of <500 mm and an annual mean temperature of 24 °C (Brinkmann et al., 2014). The rainy season typically lasts from October/November to March but may completely fail for several years at the local scale. Geologically the region can be divided into two parts: the Mahafaly Plateau, which is part of a calcareous embankment from the Eocene reaching about 70–100 m above sea level (asl) near the Tsimanampetsotsa Lake. The bedrock is perforated with hundreds of karst caves. The second formation comprises the coastal plain which consists mainly of sand- and limestones that are derived from accumulated quaternary marine sediments (Sourdat, 1977). Derived from these parent rocks the plateau is covered with red or yellow sandy ferruginous soils or skeletal soils on limestone with red 'fersialitic'[1] soils in the depressions (Roederer, 1971).

In the coastal plain unconsolidated decalcified sands of red color dominate from which unfertile soils usually very poor in organic matter and nitrogen are derived (Milleville and Blanc-Pamard, 2001). The natural vegetation consists of dry and spiny forests on the plateau and dry forests in the coastal plain, surrounded by xerophytic bushland and savannah with vast grasslands on degraded sites. The local population mainly belongs to the Tanalana ethnic group living in the coastal plain and on the plateau. The Tanalana people predominantly depend on

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[1] "fersialitic" from the French "fersialitique" (French CPCS soil classification system) are equivalent to Acrisols, Lixisols, Plinthosols or Arenosols of the World Reference Base (WRB) (Hiepe, 2008).