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Soil management and soil properties in a Kenyan smallholder irrigation system on naturally low-fertile soils

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ABSTRACT

In this study we examine the impact of soil management practices on soil properties in a landscape with naturally relatively poor soils on and below the dry slopes of a Rift Valley escarpment in Kenya that have been dominated by extensive smallholder investments in canal irrigation over the last 300 years. We show that farmers in the area have been able to keep up agricultural production in the face of growing population. The actual practices of soil management at one moment in time appear to be of minor importance to soil improvement, as indicated by the low correlation between Soil Management Index (SMI) and soil chemical data. However, cultivation triggers a process of slow soil improvement manifested by a positive correlation between nutrient levels and duration of irrigated cultivation and soil management, which likely explains farmers' confidence in soil productivity. However, we also identify sodicity as a risk connected to intensified irrigation in the area. Finally, we stress the need for further studies integrating investigations of local irrigation and soil management with soil and water quality analyses. These will be crucial to shape sustainable place-based and farmer-led solutions for African agricultural growth.

1. Introduction

Since the early 20th century, loss of productive capacity of agricultural landscapes, due to soil erosion, has been a key theme in development and environmental research and policies dealing with African smallholder farming systems (e.g. Erskine, 1984; Koning & Smaling, 2005; cf.; Scoones, Reij, & Toulmin, 1996). As a contrast to this, a body of literature reporting on indigenous or locally developed sustainable intensive production systems has developed over the last few decades (Adams & Anderson, 1988; Widgren & Sutton, 2004). Currently, the debate on how to close the yield gaps in African smallholder agriculture, where sustainable intensification (SI) or ecological intensification (EI) is proposed as alternatives to global and national Green Revolution (GR) policies and non-smallholder modes of production, is again highlighting soil and nutrient management as a key development and environmental challenge (Collier & Dercon, 2013; Moseley, Schnurr, & Kerr, 2015; Pretty, Toulmin, & Williams, 2011).

The central concern in both SI and GR approaches for closing African yield gaps, is to increase yields on land that is already cultivated. Solutions put forward are aimed at both improved soil management, e.g. Integrated Soil Fertility Management (ISFM), and the improvement and expansion of irrigation systems (Burney, Naylor, & Postel, 2013; Vanlauwe et al., 2014; Woodhouse et al., 2017). Accordingly, in the GR debate, modernisation often is conceptualized as the replacement of one technology with another. Through the use of integrated physical and human geographical analysis we argue that successful technological modernisation can only come about by pragmatically examining how specific local socio-ecological dynamics play into the goal of improved agricultural productivity.

In this study we examine the impact of sustainable intensification practices (SIPs) on soil properties in a landscape with naturally relatively poor soils on the dry slopes of a Rift Valley escarpment in Kenya

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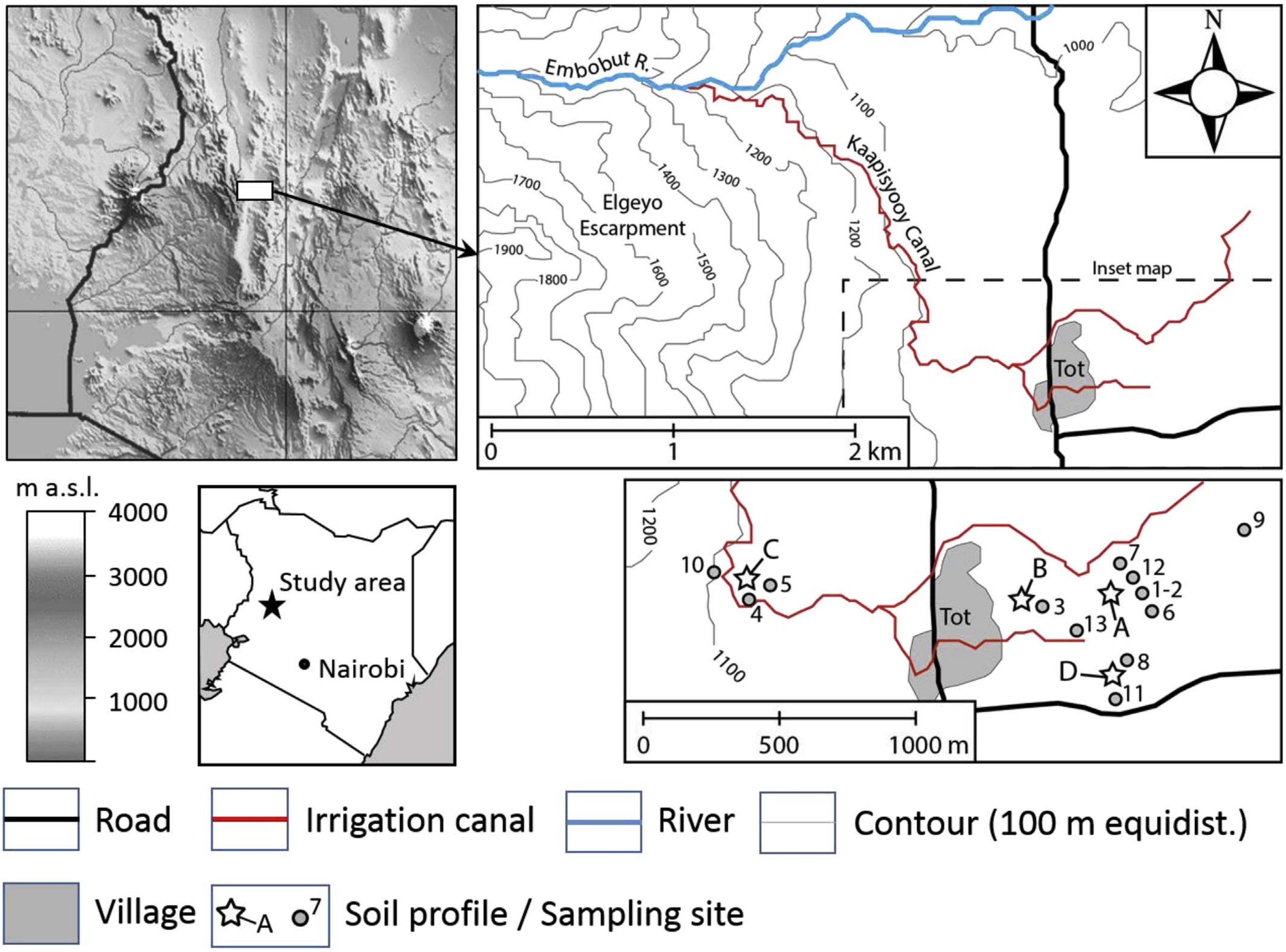

Fig. 1. The study area around Sibou. Note, only one of many irrigation canals is presented in the map. Approximate location of the canal from Davies et al. (2014). Location of investigated sites (Table 1) is shown as numbered stars and filled rings in the inset map. Hillshaded map licensed by © 2011 Vidiani.com, under Creative Commons Attribution-ShareAlike 3.0 Licence (http://www.vidiani.com/large-detailed-kenya-topographical-map/).

that have been dominated by extensive smallholder investments in canal irrigation over the last 300 years. We investigate how farmers in this seemingly sustainable system have managed soils to avoid environmental risks and maintain productivity, and if there were any lessons to draw from this in the light of current debates on agricultural intensification in Africa. Despite numerous studies that engage with the sustainability and productivity of locally developed farming technologies and practices (Burney et al., 2013; Pretty et al., 2011; Huchon & Maisonhaute, 2010; e.g.; Vanlauwe et al., 2014), there is a lack of integrative case studies of African smallholder irrigation systems that combine investigations on land and water management with soil analysis. Such studies are needed to expose potentials and risks of intensification and investments in smallholder irrigation systems in more detail.

We conducted the study in Sibou, Marakwet, Kenya (Fig. 1). Previous research on this system has treated the system's physical layout, history, origins, labour organization, water distribution, gender issues, rules, and practices (e.g. Adams, 1996; Caretta, & Börjeson, 2015; Author, 2015; Davies, Kipruto, & Moore, 2014; Östberg & Carettara, 2017). Besides irrigation management, agricultural practices have not been investigated in detail, nor has soil fertility assessments to date been published.

2. Methods

This study is grounded on a mixed methods case study.

Ethnographic fieldwork was carried out in repeated sessions between 2011 and 2013 for a total of three months. In repeated instances, 60 farmers were interviewed while they were farming or in their fields. Seven focus groups, engaging in total c. 60 farmers, concentrated on farming routines and agricultural practices. Participatory mapping, consisting of discussions on land use changes, field locations and community histories on the basis of satellite images and historical aerial photos, was carried out with six groups of farmers for a total of 50 farmers. In addition, soil structure, organic matter status, infiltration capacity and ability to store water, as well as agricultural practices and influences of flora and fauna were discussed.

A survey on seven plots was conducted by field assistants every three months between January 2012 and November 2013, focusing on agricultural practices, their timing, yields and gender division of labour. Five of these plots, and a complementary six plots, including non-cultivated land (Table 1), were also categorised according to labour input. To this end a soil management index (SMI) was framed according to the survey data and the qualitative data we had gathered. Farmers were interviewed about soil management practices, and asked to rank these according to their relative importance. Thus, a hierarchy of soil management practices was established and each practice was given a value along an interval scale according to the perceived importance of