Soil Related Constraints for Sustainable Intensification of Cereal-based Systems in Semi-arid Central Tanzania

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Introduction

FAO estimates that agricultural intensification contributes about 80% of increased crop production in developing countries. Thus sustainable intensification (SI) will requires, among other things, better use of land resources upon which production depends. This is critical given that most of the arable land in Africa has soil related problems, leading losses of nutrients and land cover (Heng et al. 2015). In this context improved land management is critical to overcome soil related constraints to sustainable food production and in targeting agricultural interventions. However, limited availability of site-specific nutrient management guidelines for semiarid zones in Tanzania undermines efforts to target technologies in the specific biophysical conditions in which smallholder farmers operate. Thus technologies adopted under these circumstances are risky as they may fail to address key drivers of enhanced crop production or land degradation. We characterized soils in Kongwa and Kiteto districts to assess fertility status and drivers of land degradation so as to inform the development of integrated land management options for SI under the Africa RISING project. This approach helps to link soil management recommendations to soil conditions and in targeting interventions.

Study Sites and Methodology

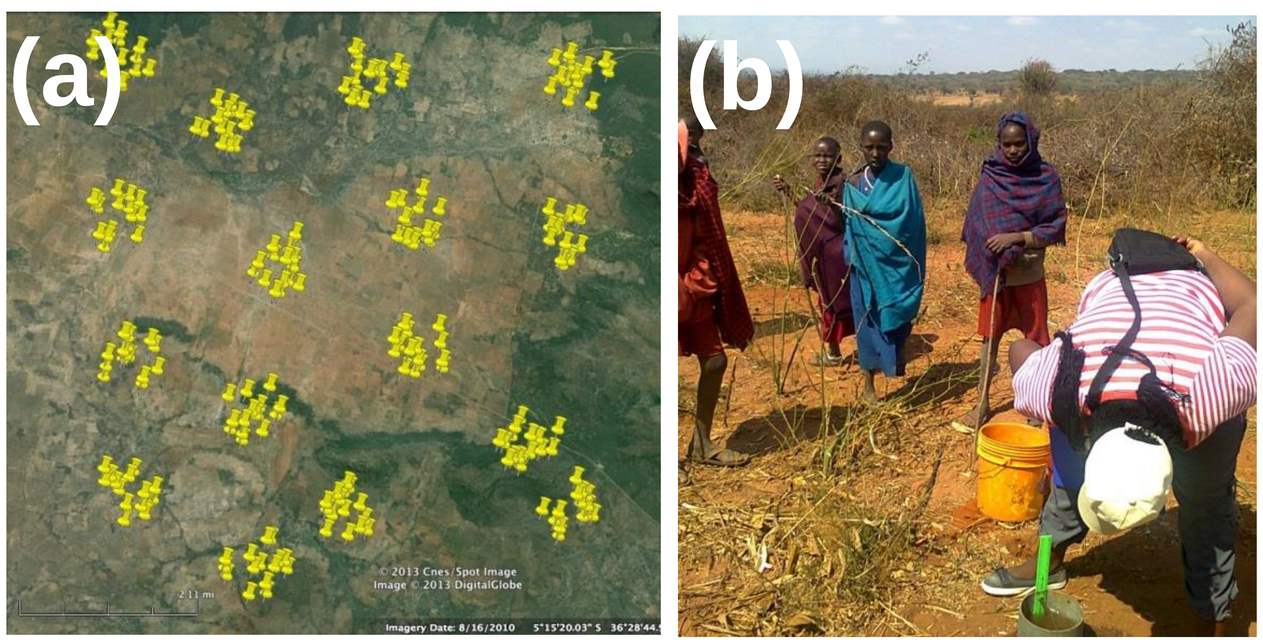

Fig. 1: Google map of the sentinel site in Kongwa district showing 16 clusters of plots within a 10 km x 10km block (a) and infiltration measurement (b)

Study site is Kongwa and Kiteto Districts. Landscape- (Land Degradation Surveillance Framework-LDSF) and field-based sampling approaches were used to collect soil data (nutrients, carbon levels, infiltration rates and types) and ecological data (land use types tree cover and density etc.). Field level work involved selected on-farm sites where experiments were laid out.

Vegetation Conditions

About 14% of land (890 ha) in the Njoro sentinel is under cultivation. The rest (5652 ha) is grazing lands and forests dominated by Acacia woodlands and grasses. Tree density is low (84.3 stems ha^{-1}) compared to 268.9 stems ha^{-1} for shrubs. The carrying capacity for livestock exceed 1 livestock unit per 2.5ha, which is the maximum density unimproved natural grazing lands typical in the study sites.

Soil Conditions

Table 1: Selected Soil Chemical Properties of the Top (0-15 cm) Soil

Village	pH	EC	OC	N	P	K	CEC
	(H_2O)	(mS/cm)	(%)	(%)	(mg/kg)	(Cmol/kg)	(Cmol/kg)
Molet	5.9	0.09	0.51	0.04	4.67	0.66	7.25
Mlali	6.2	0.08	0.50	0.05	5.38	0.86	6.32
Njoro	6.3	0.06	0.54	0.05	6.39	0.80	8.72
Manyusi	6.2	0.12	0.72	0.08	7.16	0.76	8.20
Laikala	6.3	0.06	0.32	0.05	5.16	0.51	7.89

The soil pH is medium acidity which is suitable for crops growth (Table 1). However, solubility and availability of some micronutrients, especially Zn, Fe, Mn, Cu and Bo; may decrease at pH 6.5 -7. Given the soil pH levels noted here, these nutrients need to be the focus of nutrient management strategy in the study sites. The use of naturally occurring Minjingu phosphate rock and fertilizer materials rich in micronutrients can mitigate potential limitations of these elements in the soils. The N (< 0.1%) and P (< 7 mg/kg) levels are also very low and will results in deficiency symptoms if not corrected. The levels of K is generally within the sufficient range (> 7 Cmol/kg; Landon 1991) as noted in other studies (Kimaro et al. 2009; Mkoma, 2015). Most soils have OC of 0.5%, which is very low. Low OC reflect loss of crop residues through grazing and as hay for draught animal and as firewood.

Aridity indices revealed that Moleti has steppe characteristics while other villages are semi-arid with very short growing period of 2-3 months. In addition, the soils have high root restrictions and low infiltration rates in the top 50cm.

Soils in the study sites requires integrated approach to address multiple nutrient deficiencies, build up OC mitigate moisture limitations and address other physical constraints to sustained land productivity. These will include organic (manure) and inorganic amendments (especially N and P) and/or integration leguminous trees/shrubs to improve vegetation cover, soil health and resilience to climate change.

For more information: http://africa-rising.wikispaces.com/

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