Tropentag 2010

TECHNISCHE UNIVERSITÄT DRESDEN

Institute for Cartography

The effects of different landuse types on soil compaction and infiltration rate in the drylands vertisol of Gadarif Region, Sudan

Khalid Biro, Biswajeet Pradhan, Manfred Buchroithner and Franz Makeschin

E-mail: khalidturk76@yahoo.co.uk

International Research on Food Security, Natural Resource Management and Rural Development
ETH Zurich September 14 - 16, 2010

Background

Gadarif region is one of the important mechanised rain-fed agricultural areas in Sudan and produces more than one-third of total national production of sorghum – the main food stuff in the country. Dryland farming throughout the region is practiced at various scales. In the past three decades, different land use types were occurred throughout the region. Soil strength and infiltration rate are important variables for understanding and predicting a rate of soil processes. This study investigated the effects of three different land use types namely; cultivated land, fallow land and woodland on soil compaction and infiltration rate.

Study Area

The Gadarif state is located in eastern Sudan between Latitude 12º N and 13º N and 33º E and 37º E (figure 1). It covers a total area of approximately 78,000 km². The annual rainfall in the northern part is less than 500 mm. Mean monthly temperature range from 26º – 32º C. While mean maximum temperatures rise up to 41º C. Soils are heavy dark cracking clays; the clay content is very high amounting to 70 % to 80 %. Organic matter and nitrogen content of the soil are low, but as there is no deficiency of other plant nutrients: the soils are moderately fertile. Landuse system in the area is dominated by agricultural activities, which include sorghum and sesame cultivation, livestock rearing and forestry.

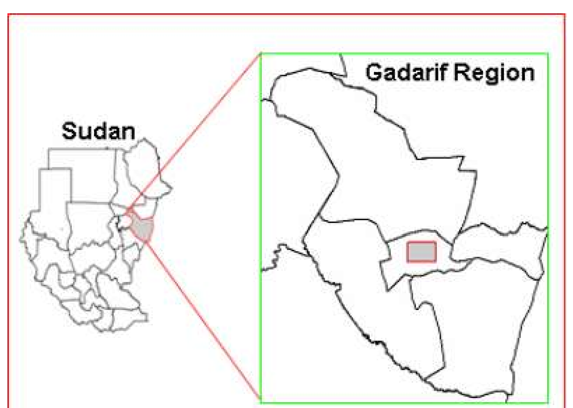


Figure 1. Location of the study area

Methodology

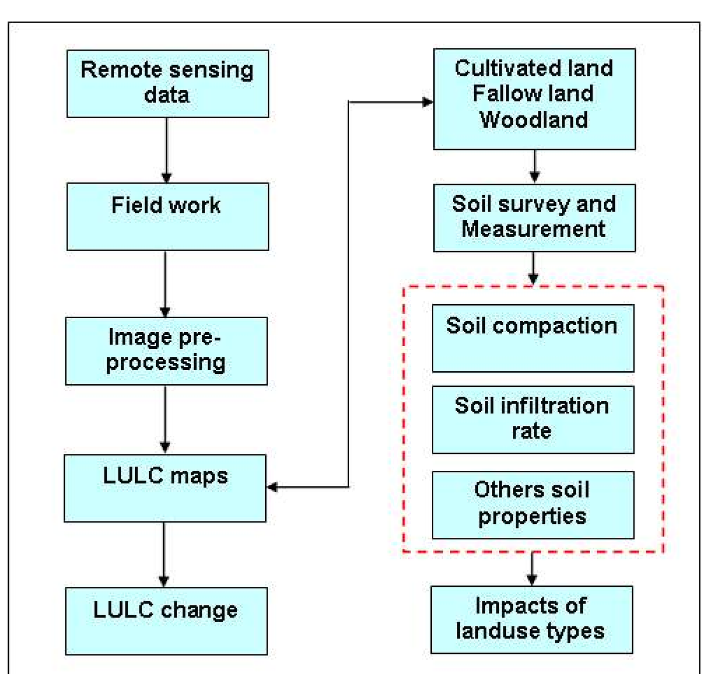
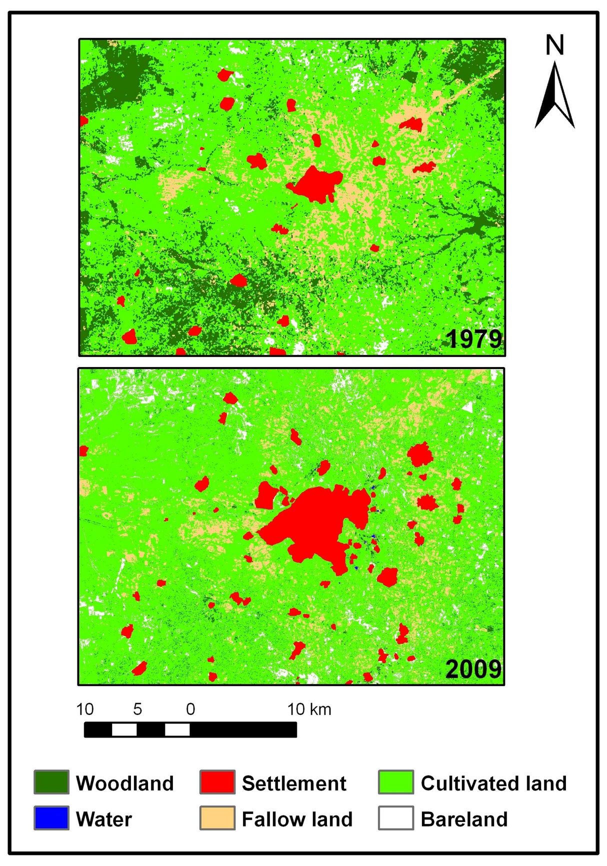


Figure 2. Methodological Flowchart

From figure (2), Remote sensing data was used to map landuse/land cover (LULC) for the study area.The penetration resistance of the soil was measured into three depths using manually operated cone penetrometer. Infiltration rate was measured in the field using a double-ring infiltrometer. In addition to reference soil profiles, soil samples were collected to determine the variables that affect soil strength and infiltration rate viz. particle size, dry bulk density, soil moisture content and organic carbon content. All field measurements and soil samples were collected for each of the landuse types.

Results



LULC change of the study area over three decades shows that cultivated land areas increased significantly, including taking 81.42 % of the 1979 woodland, because of the expansion of mechanised farming. High urban expansion during the three decades has led to a significant increase in the settlement areas.

Figure 3. LULC maps of the study area from Landsat MSS, 1979 and ASTER, 2009

The results showed that with compared to the woodland, the soil penetration resistance was 29 % and 14 % larger and infiltration rate was 60 % and 45 % smaller for the cultivated land and fallow land respectively (figure 4 & 5).

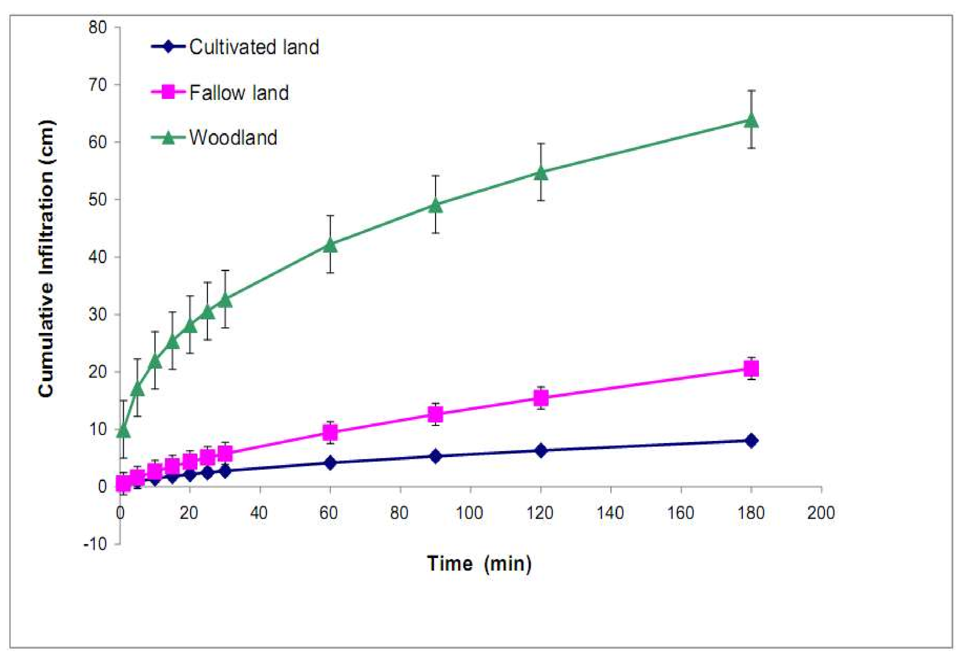


Figure 4. Cumulative infiltration curves for the tested landuse types (bars represent standard error)

The reduction in infiltration rate from wood to cultivated or fallow land may be attributed to compaction and soil structural degradation in the near surface horizon.

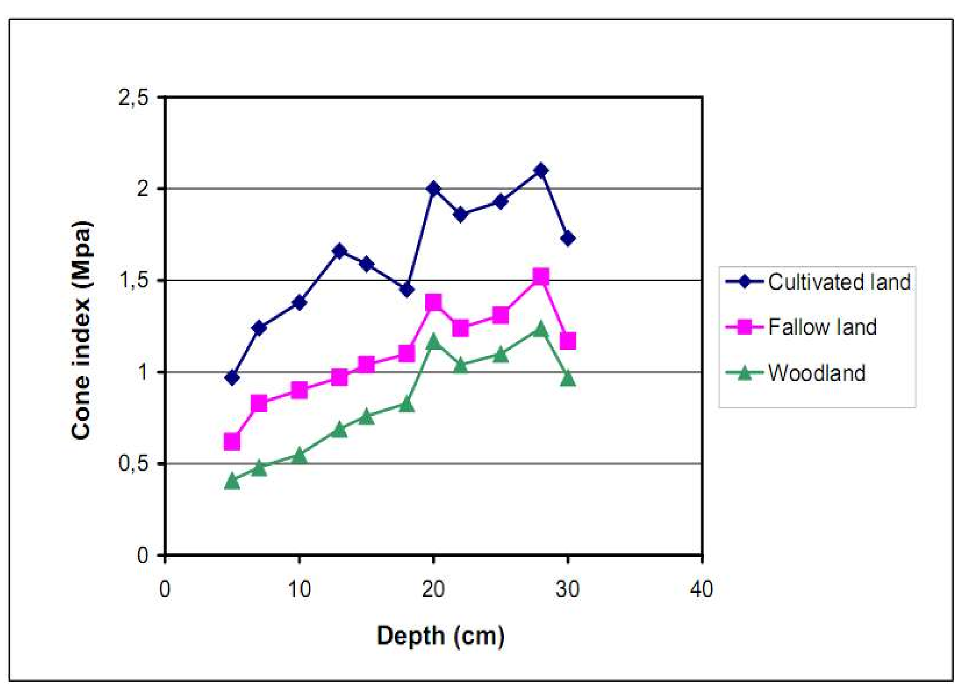


Figure 5. Penetration resistances for the tested landuse types

There were significant differences (P < 0.05, Table 1) in soil texture with land use type and soil depth.

Table 1. Soil particle size in relation to landuse type at 5 - 15 & 5 - 30 cm depths (mean values, n = 25, SE in parenthesis , different letters within one row indicate significant difference at P < 0.05)

Variables	Depth (cm)	Cultivated land	Fallow land	Woodland
Sand (%)	5 – 15	14.92 (0.24) c	6.40 (0.34) b	3.72 (0.17) a
	15 – 30	13.40 (0.10) c	7.76 (0.24) b	3.88 (0.19) a
Silt (%)	5 – 15	14.92 (0.24) a	23.76 (0.20) b	26.40 (0.44) c
	15 – 30	23.44 (0.27) b	20.12 (0.36) a	29.84 (0.65) c
Clay (%)	5 – 15	63.04 (0.38) a	69.84 (0.33) b	69.96 (0.41) b
	15 – 30	63.20 (0.28) a	72.12 (0.25) c	66.28 (0.65) b

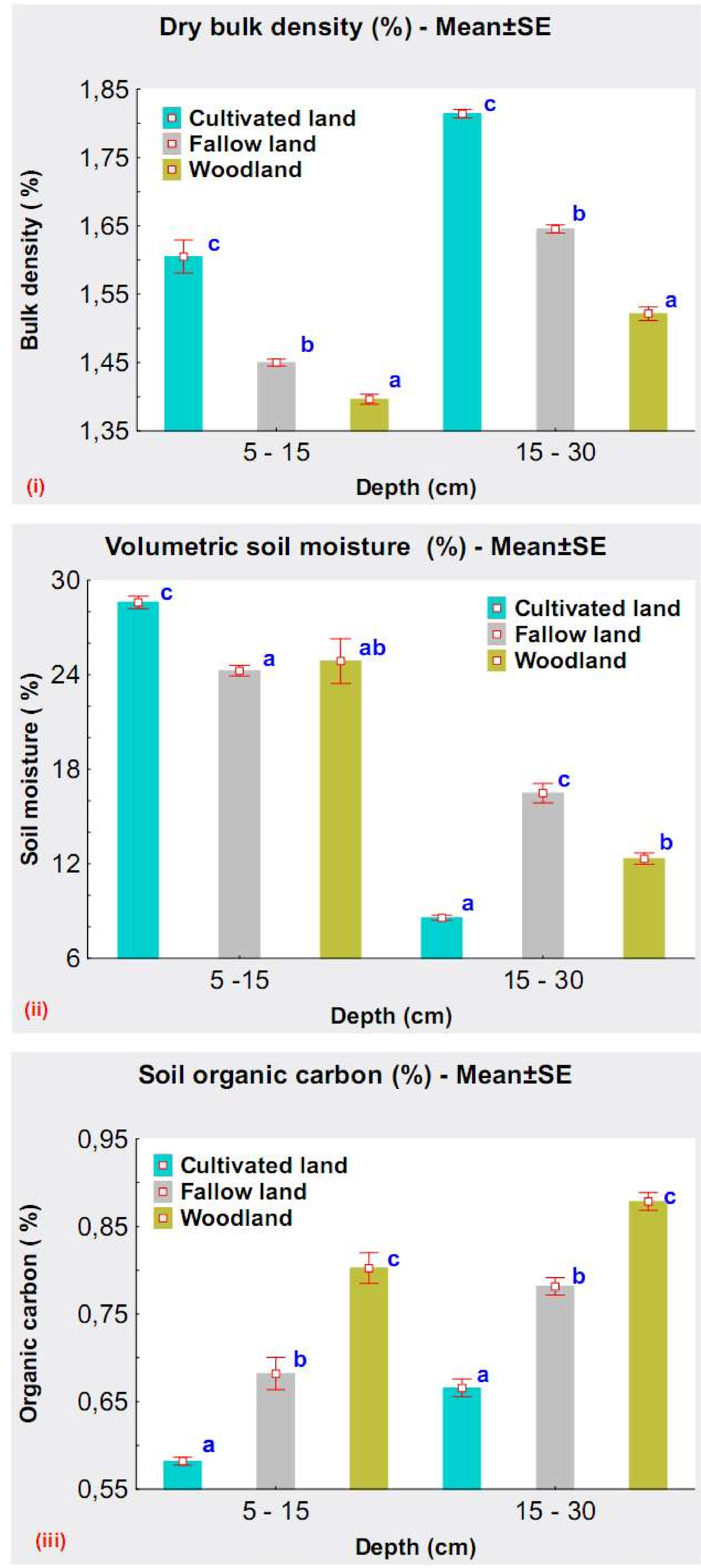


Figure 6. Dry bulk density (i), volumetric soil moisture (ii) and organic carbon (iii) for landuse types at tow depths (n = 25, bars represnet standard error, different letters indicate significant difference at P < 0.05)

Soil texture, organic carbon and bulk density are critical factors in influencing soil structure and thus infiltration. Dry bulk density was significantly different in the three landuse types at the two depths (figure 6-i). The soil moisture content did not differ significantly in the first depth between wood and fallow landuse types (figure 6-ii). Soil organic carbon was significant different with landuse and soil depth (figure 6-iii).

Conclusions

Tillage operations at constant depth and animal trampling in wood and fallow lands coupled with a smaller soil organic carbon content are likely to be the main factors causing the decline in the infiltration rate and increasing the hazard of soil compaction after changing of woodland to cultivated and fallow lands.

Literature Cited

Jensen, John R. 2005. Introductory to Digital Image Processing, 3rd edition. Upper Saddle River, NJ: Prentice Hall.

Smith, Keith A. and Mullins, Chris E. 2000 Soil and Environmental Analysis: physical methods. 2nd edition Marcel Dekker, Inc. New York, Basel.

Acknowledgment

We would like to express our gratitude to Dr. Mengisto Abiy from the institute of soil science and site ecology-TUD for his help and support.