AgriServe
Business Incubation Platform (BIP), IITA

Consultancy for Sustainable Agriculture

Land and Soil Suitability Assessment of Eruwa and Fasola Farm Settlements, Oyo State

Project: **Soil Survey and Analysis as part of the Preparatory Stage of Revamping of Eruwa and Fasola Farm Settlements to Farm Estates**

Project Execution: IITA-BIP/AgriServe

Client: **Oyo State Government**
(Oyo State Agribusiness Development Agency)

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- Mr Augustine Ekeke, Geospatial Lab, field survey and sample collection
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Acronyms

AoI	Area of interest
BIP	Business Incubation Platform
CEC	Cation Exchange Capacity
ECEC	Effective Cation Exchange Capacity
FUNAAB	Federal University of Agriculture Abeokuta
GIS	Geographical Information System
IITA	International Institute of Tropical Agriculture
LU	Land unit
masl	meters above sea level
NASA	National Aeronautics and Space Administration
ODK	Open Data Kit
OYSADA	Oyo State Agribusiness Development Agency
PPDP	Public-Private Development Partnership
SOC	Soil Organic Carbon
SME	Small and Medium Scale Enterprise
SRTM	Shuttle Radar Topography Mission
USGS	United State Geological Survey

Executive Summary

This report provides a concise overview of the soil survey and analysis of Eruwa and Fasola farm settlements as part of preparatory stage to convert the settlements into farm estates through Public-Private Development Partnership (PPDP). IITA-BIP was commissioned to assess the suitability of the land for mechanized commercial agriculture. This assessment is therefore to be considered a general assessment that characterizes the area in various ways and for different agribusiness purposes. The various approaches and methodologies which were used in the study are properly documented. A detailed description of the land use and land cover, topography, terrain and soil conditions and their implications in relation to large scale mechanized agriculture as apply to Eruwa and Fasola have been provided. The soil characteristics were examined following standard operating procedures, and important soil functional properties are discussed and mapped. Land units are delineated based on land use and land cover characteristics, terrain and soil characteristics, such that the units are relatively homogenous in terms of land and soil properties. What could be done in each of the land units are suggested with associated management practices. In Eruwa, land units Group 1 to 4 are the most suitable for commercial crop production. These areas allow for sustainable intensive crop production provided that the soils are properly managed and are suited for many arable and permanent tropical crops. Group 5 should be used for less demanding crops and for plantations such as cashew and Citrus. Groups 6 and 7 it is suggested that alternative uses to crop prodcution are shought. This could be for cattle barn, establishment of office complex, storage and processing facilities, and residential area, for example. Similarly, at Fasola, land units Group 1 to 2 (49% of the farm area) are the best portions of the land in terms of overall suitability for commercial crop production. At Fasola, land units Groups 4 to 6 are considered very marginal and unsuitable for crop production due to several constraints which might make agricultural enterprise unprofitable and unsustainable in those land units. Groups 4 and 5 are therefore best intended for residential use, office buldings, structures for keeping livestock, storage and processing facilities, and other, while permanent vegetation should be maintained on thel and units of Group 6. Comparatively, Fasola farm settlement has more potential for commercial crop production than Eruwa farm settlement. These are seen in terms of better accessibility because of well-connected roads, better drainage networks and more favourable soil conditions. The more favourable soil conditions lie in deeper soils, less gravel content and more fertile soils. General recommendations are provided, further specific recommendations to optimize fertilizer use will depend on the attainable yield level of the specific crop to be planted, the agricultural practice and a more detailed and precise assessment of the soil properties of the field in which the crop is cultivated. This will require nutrient response trials on the most important land units. However, for the selection of the possible crops to be considered for the farm estates, this assessment suffices. We do hope that the information contained in this report provides the insight required to make investment decisions on the land for agricultural purposes. If the objective remains the establishment of Farm Estates, and to develop these farms for investment in modern mechanised agriculture, IITA-BIP will be happy to support further planning of possible pilot projects or general planning for the development of the Farm Estates.

INTRODUCTION

Oyo State is often referred to as the food basket of Southwestern Nigeria. However, with the current level of food production and the rise in human population in the State, there may be food insecurity due to ageing population of farmers; inadequate youth engagement in agribusiness and inadequate land utilization It is on this premise that the present government of the State under the leadership of the Executive Governor: Engr. Oluseyi Abiodun Makinde decides to prepare and implement a robust master plan for the development of agribusiness in Oyo State using the State's agricultural comparative advantage to boost her economy through Public-Private and Development Partnership (PPDP).

The government decided to transform the farm settlements into farm estates. This action was expected to focus on integrated farming system; production; processing and marketing all clustered farms within each farm estates as a model. It was expected that for the first year, over 2,000 youth and farmers would be engaged and grow to establish Agro-based Small and Medium scale Enterprises (SMEs); the next four years would have engaged 100,000 youth through multiplier effect; women would have benefitted and be transformed from subsistence farmers to commercial farmers; private sector involvement and development partners would also be able to harness their resources in an enabling environment for profitable and sustainable agribusiness.

The goal is to develop Agro-based economy that would establish Oyo State as the model for an Agribusiness hub in Africa by creating a cohesive satellite of private sector-driven farm estates in the State, enhancing the development of SME among young leaders and particularly women; and creating enabling environment for agribusinesses to thrive through PPDP for economic growth and development.

Akufo and Eruwa farm settlements were selected to be the pilot areas for the development of the agribusiness hub in Oyo State. Later, Akufo was replaced with Fasola farm settlement. Eruwa has 3,067 ha and Fasola has 812 ha. The government understands that both Eruwa and Fasola farm settlements are underutilized; lack basic infrastructure and are presently not suitable for agribusiness. Some portions of the land are either degraded or nutrient deficient, neither attractive nor conducive for private sector engagement. Hence, the need to fully develop and convert the farm settlements to farm estates through PPDP. The two estates would therefore serve as a model for the development of other settlements and non- farm estates into agribusiness hubs in the State.

As part of the preparatory stage of revamping the farm settlements into farm estates, the State government through OYSADA engaged the IITA-Business Incubation Platform to conduct the soil survey and analysis of the two farm settlements. This was necessary to provide the basis for further planning of the project and as input for whole farm planning, concerning the allocation of land resources to the production of the target crops as well as to identify the works that are needed to make the land suitable for large mechanized production, infrastructural development required as well as other input required for a sustainable and profitable agribusiness. This report presents the results and the findings from the land and soil suitability assessment.

METHODS and DATA SOURCES

Approach

IITA-BIP was asked to make an assessment of the suitability of the land and soils for commercial farming. The suitability assessment took into account aspects that are considered important in making investment decisions:

- Accessibility of the terrain
- Topography: slope and relief
- Water resources and availability of water
- Land use and land cover to identify available land and possible implications for land clearing
- Soil properties and site characteristics

The general requirements which are relevant to modern and mechanised farming are defined. Constraints were identifoed and described in relation to these requirements. For accessibility that means the terrain needs to be accessible for smaller trucks, tractors etc. For the slope/landform the requirements are that the land needs to be flat to gently undulating to allow for mechanized operations and slopes need to be straight and not converging. For the water resources focus was on surface water only; that is the drainage network, streams and rivers that may serve as a source of water for (supplementary) irrigation. Investigating the ground water resources is outside the scope of this study. The current land use and land cover are assesed to identify potentially cultivatable land and to identify the requirements for land clearing.

For suitability assessment of the soil, the following criteria were considered:

- Stoniness at soil surface and in the soil profile in relation to possibility for mechanised field operation
- Soil depth (effective), in relation to possible rooting depth restrictions
- Soil drainage in relation to possible drainage restriction and water logging risk related to soil aeration
- Soil texture and physical properties in relation to water holding capacity, infiltration, workability and soil degradation
- Soil fertility in relation to possible nutrient limitations for crop production, including soil reaction, organic carbon, macro and micronutrient levels in the soil.

Map layers were generated for the following themes, based on which the evaluation is done:

- Road network (access roads, tracks)
- Drainage network, rivers and streams
- Topography: elevation, slope and contour
- Land use and land cover
- Rock outcrop
- Built-up area and settlements

Mapping of these different features is done using satellite imagery. The most recent, commercially available, high-resolution imagery of the area and the publicly available imagery were acquired. Recent imagery is used for mapping of the features mentioned above by image interpretation and on-screen digitizing, and these are verified in the field. Elevation is mapped

using existing STRM data.

In the field, observations are made on land use and land cover, terrain, and soil characteristics. The sampling design included 120 and 60 sampling points for Eruwa and Fasola respectively using a fixed grid sampling approach to determine the locations in the field. The observations in the field are made according to standard operating procedure and data was recorded electronically using ODK Collect, and forms designed for this purpose and adapted to this study. The data collected were used for ground truthing for the image interpretation and for the validation of data and maps generated.

At each point of observation soil samples are taken from the topsoil (0-20 cm) and subsoil (20 - 50 cm) for analyses in the laboratory. The soil samples were analysed for gravel content, particle size, organic carbon, exchangeable acidity, total nitrogen, available phosphorus, exchangeable potassium, exchangeable sodium, exchangeable calcium, exchangeable magnesium, sulphur, manganese, zinc, boron, copper, and iron using a combination of spectral and wet chemistry standard analysis procedures.

Activities

Activities have been carried out in the chronological order as indicated in the table below.

Table 1. Chronology of activities for Eruwa and Fasola farm settlements' land and soil suitability assessment

Timelines	Activities
January 11 – 15, 2021	Preparation and logistic arrangements: Organizing the field work, recruitment and orientation course for the field workers on field survey procedures; Getting ready all equipment and materials for the field work
January 18 – February 2	Soil survey and sample collection at Eruwa
February 4 - 8	Soil survey and sample collection at Fasola
February 8 – 19	Soil sample registration and sample preparation for chemical and spectral analyses at IITA Ibadan
February 23 – April 22	Laboratory analysis – Wet Soil analysis at IITA Ibadan
April 12 – June 30	Laboratory analysis – Wet Soil analysis at IITA Ibadan
July -August	Data quality control and data analyses, Image interpretation and GIS mapping
September 2021	Report writing
October 7 – 18	Review of draft report and Validation meeting to discuss the findings with OYSADA and finalize the study
October 20 - 25	Corrections of draft report and finalizing the study
October 29	Submission of final report

Data sources

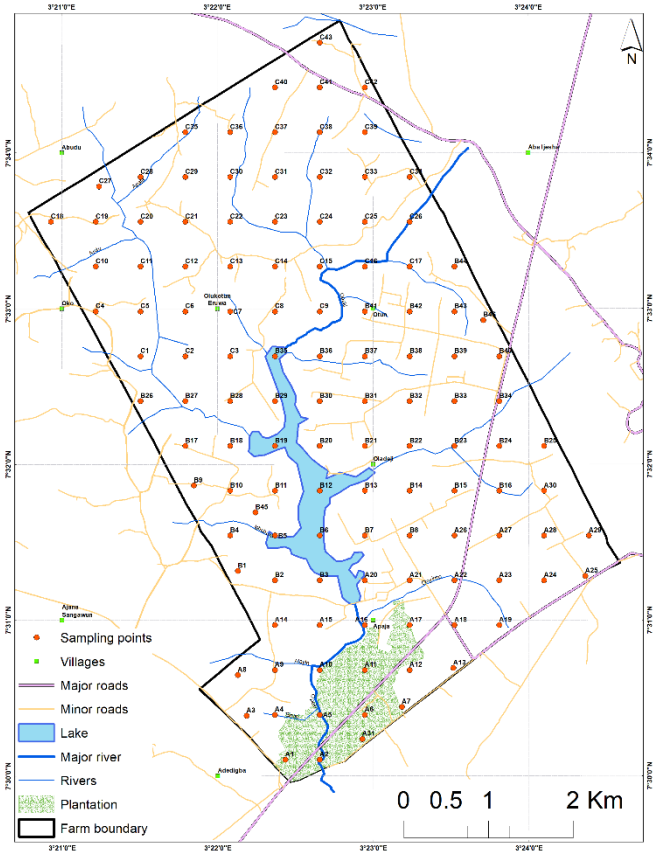
Table 2 Data sources used for this study

SN	Type of data	Data source	Spatial resolution	Usage
1	WorldVIEW 2	Digital Globe (https://www.digitalglobe.com/)	0.4m, 1.6m	Creation of drainage network, road network, Rock outcrop
2	NASA Shuttle Radar Topography Mission (SRTM)	USGS Earth Explorer (https://earthexplorer.usgs.gov/)	30m	Creation of Contour, slope & land unit map

RESULTS | ERUWA FARM SETTLEMENT

Location and general landscape characteristics of the Area of Interest

The area is located about 70 km northwest of Ibadan and a short distance from Eruwa Township. The area measures about three thousand hectares. The Area of Interest (AoI) is a cultivated area, meaning that those parts that allow for cultivation are in use. The area falls within the transition zone of the derived savanna to the southern guinea savanna ecological zone. However, there are no forest patches remaining and there are cashew plantations and woodland patches scattered within the landscape. Majority of the trees have been cut for cultivation and the total cropped area account for over 60% of the farm settlements while the remaining land is either fallow, cashew plantation or water bodies. This observation was made using data from satellite imagery, validated by information gathered on the ground (ground truthing).



Map 1. Map of Eruwa farm settlement showing the boundary of the study area, roads and tracks, drainage networks and locations of the sampling points

The landform and soils are typically those that are derived from the basement rock complex, which consist of hard crystalline and metamorphic rocks (granite and gneisses), on which soils have developed in-situ. The landscape is classified as level to hilly with slope classes ranging from 'flat to almost flat' to 'sloping'.

Around the higher elevation there are find large rock outcrops though these are effectively at the fringes of the farm. The soils in the AoI have developed on the same type of rock and are of light texture. The soil depth may vary considerable depending on the depth of the bedrock and patterns of erosion and sedimentation which relates to the historical land use. Map 1 presents the locations where soil samples were collected and field observations made.

Access to the terrain, Road and Tracks

There are two main access roads, one originating from Eruwa Township, another from Abeokuta-Igboora-Iseyin road that run more or less parallel but bridged within the farm settlement. These roads unlock the different parts of the terrain. The larger central and northern parts of the terrain are accessed through a network of dirt roads (all-weather) that enter from

both the east and the west. The Abeokuta-Igboora-Iseyin road is a tarmac road in good condition and this passes through the farm from the West to the East in the Southern part of the farm. The north-west section of the terrain is accessed through a minor road which may give difficulty during the rainy season.

There are many single dirt roads that connects the different sections of the land. Generally, accessibility to the terrain is good. The only section that might be difficult to access currently is the section in the northwest extremity of the land. The accessibility of this part of the area needs to be improved by the construction of an access road. The whole southern section is having a better road infrastructure. There are fine networks of tracks that seem to be in good condition. The road network is mapped in Map 1.

Water resources and drainage network

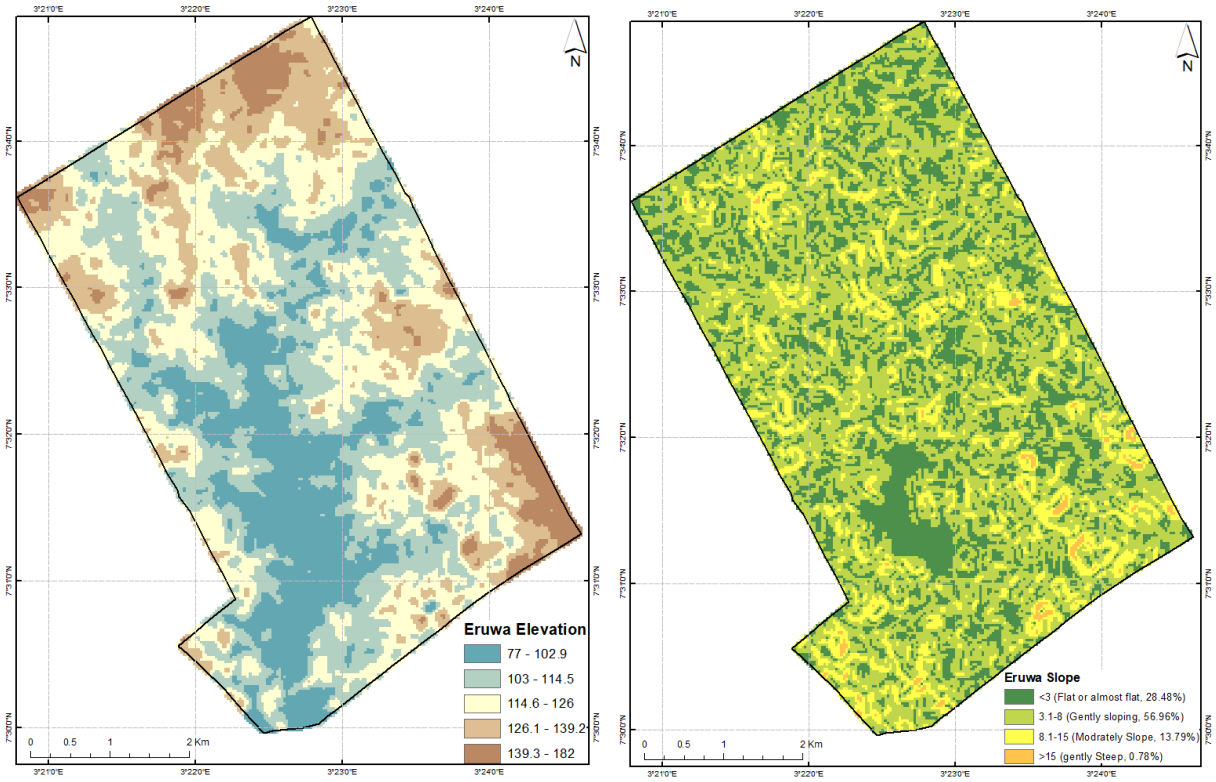
The main drainage channels run in the general direction from north-east to south-west. The drainage pattern is dendritic. There is an artificial lake which effectively occupies the centre of the farm settlement that is create by the dam that has been constructed for the purpose of power generation. It is no longer in use as such, and the lake could be an important source of irrigation water at least for areas directly surrounding the lake. The whole area is part of one, quite large catchment area, upstream of the lake. It means that all the water that falls within the catchment will be concentrated at this point and the dam has enormous potential to provide sufficient water for irrigation throughout the year if well managed.

Topography

The elevation ranges from around 77 to 182 masl, with the highest elevation found in the fringes of the land both in the south and in the north. The lowest elevation points are associated with the lake and the main river running from north-east to south-west (see Map 2). Also, there are several hill tops located at the extremities of the land area. In this landscape developed on the basement rock complex, The landforms are characterised by hills with often rock outcrop on the top, giving rise to an undulating to rolling landform with a radial pattern in the direction of the slope (Map 2). In the case of Eruwa farm settlement, rock outcrops are found only at the outer limits and even outside the AoI. The slope gradient class varies from ‘flat to almost flat’ to ‘moderately steep’. Flat areas hardly occur and the whole area is sloping to varying degree. The larger part of the areas falls within the ‘flat to almost flat’ and ‘gently sloping’, slope steepness classes, and should not pose any problem to mechanised operations.

The shape of the slopes in this eastern section is convex, and the length may be up to 500 meters but is generally less (though more than 200m), which allows for the construction of fairly large plots, but not enough for large scale mechanized farming operations. There is very little flat terrain and most of the land is gently undulating to sometimes rolling or sloping terrain. (See Figure 1 for the profile of the west to east transect).

Similarly, the north - south transect is part of the valley system in the middle of the land. The landscape is undulating, and slope class is predominantly ‘moderately sloping’. There are more variations in the elevation class and the slope map shows relatively more yellow colours.



Map 2 Map of elevation and slope classes of the AoI

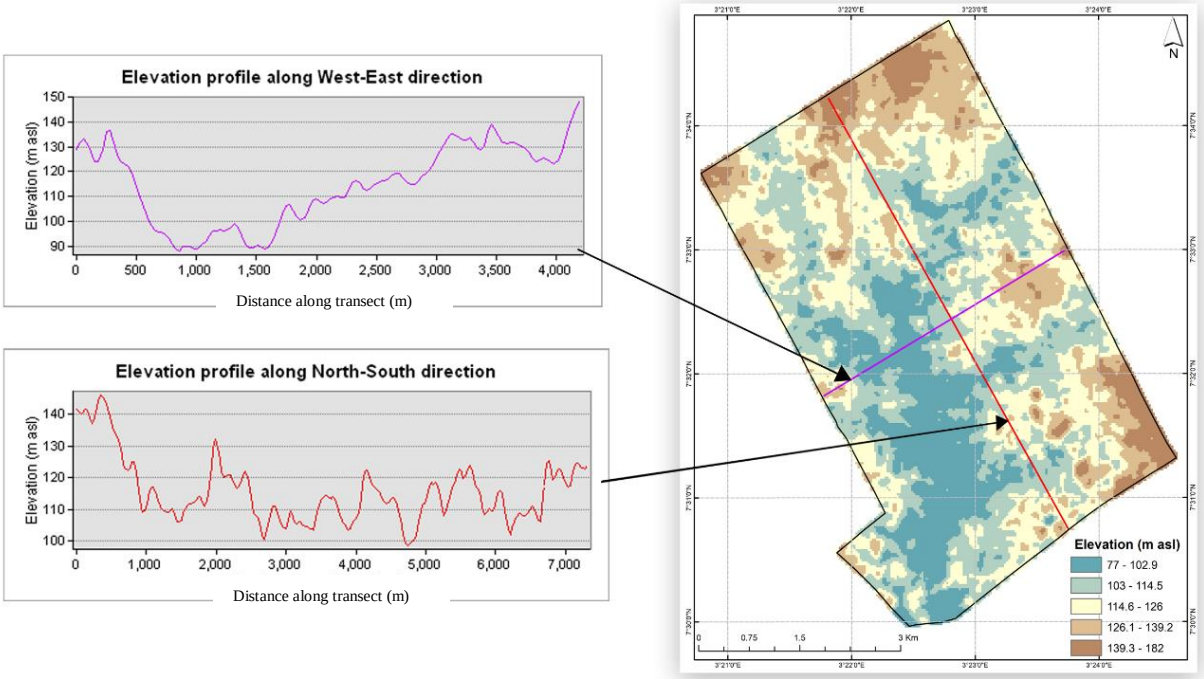
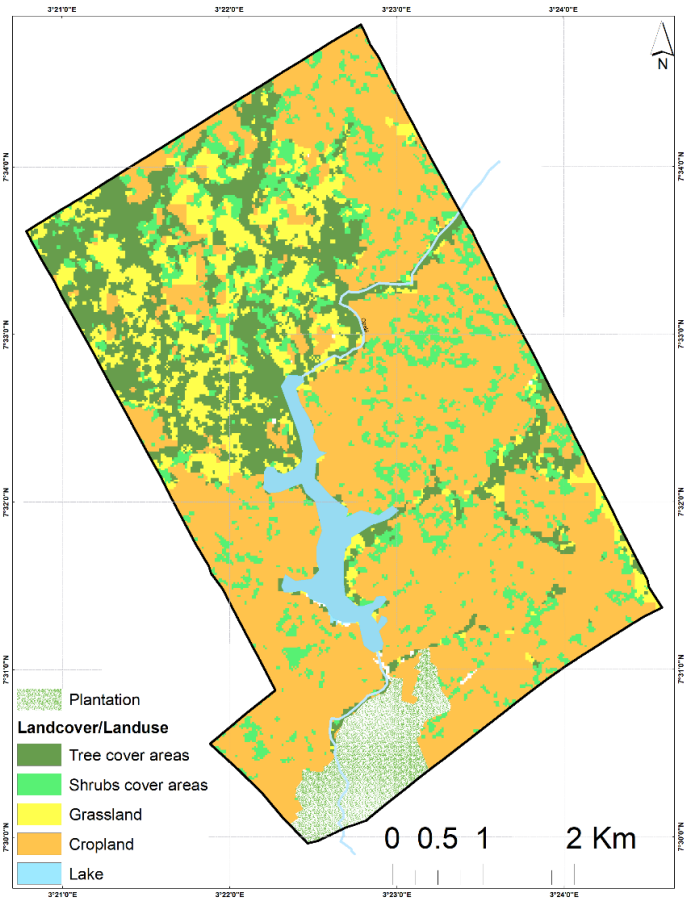


Figure 1 Elevation profiles of the sections of the Eruwa farm settlement

Land use and Land cover

Most of the land has been cleared at some point in time and currently 56% of the Aol is cropland (Map 3). All the southern, the eastern and the north-eastern parts are open and presently being used for farming. The north-western sections of the farm are either occupied with Teak plantation or with secondary regrowth. There is a teak plantation in the southwest corner covering an area of 161 ha. There are numerous patches of cashew plantation across the entire land.

The vegetation is generally very open, with low tree densities and some shrub vegetation or herbaceous vegetation as understory. Major parts of the woodland are teak and cashew plantations (rather than considering these to be part of a long-term fallow system). These woody vegetation patches are therefore indicative of less suitable land and soil conditions. The cultivated land is mainly used for cassava, maize and soybean cultivation.



Map 3 Land use and land cover map

A typical idle land with savanna vegetation

Harvested maize field on a gentle undulating terrain

A typical cashew plantation within the AoI

A piece of land near the dam around the northeast of the farm

A lowland area with few palms close to the lake

A teak plantation that was recently burned around the western section

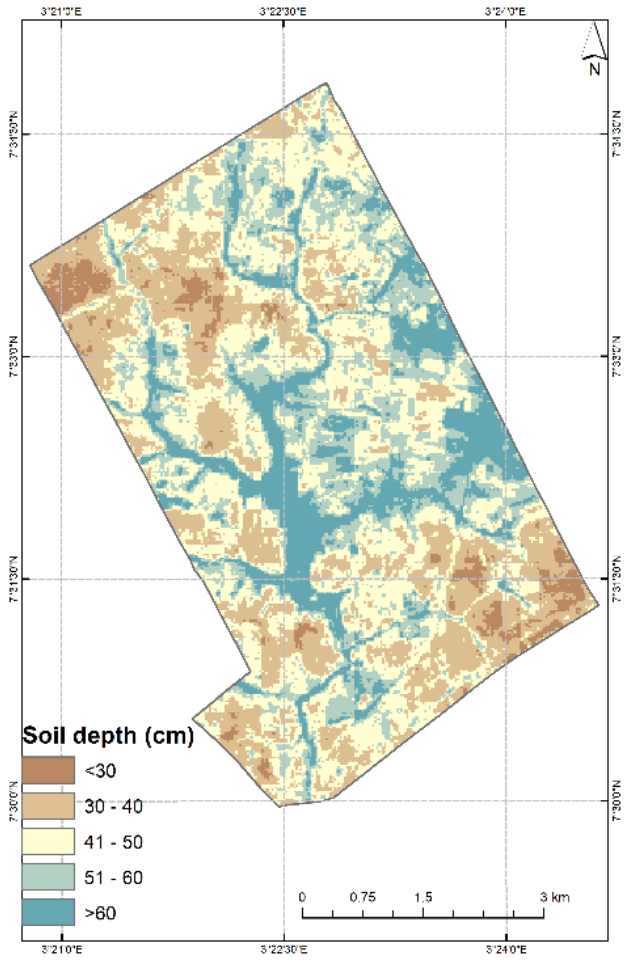
Land presently not in use with some trees at different stages of growth

This is a typical fallow land use type within the land consisting of herbs and grasses

Soil characteristics

Soil depth and texture

Soil depth restrictions are measured by augering, indicating the depth at which one cannot further drill down in the soil. Depth restriction does not equate to rooting depth restriction but is a good indicator of effective soil depth. Restrictions generally occur because of the increasing gravel content with depth associated with plinthite formation. Crop roots will have difficulties penetrating such soil layers. The soil depth varies from very shallow (<25cm) to deep (>100cm). The very shallow soils occupy about 35% of the AoI, whereas 45% is shallow (>25 cm<50 cm depth), and 20% deep (<50 cm >120 cm). See Map 4 for the variation in soil depth across the farm. The extreme southeast, southwest and fringes of the western and the north-western sections are areas of very shallow soils with an average of 57% gravel content where the highest gravel content in this section of very shallow soil is about 77%. This will very much impact on the possibilities for crop production in the area, with the area suitable for arable crops being effectively less than 30% of the land. The deep soils are located at the lower slopes and valley bottom and vary in gravel content from 4 to 21%.



Map 4 Soil depth distribution within the farm settlement

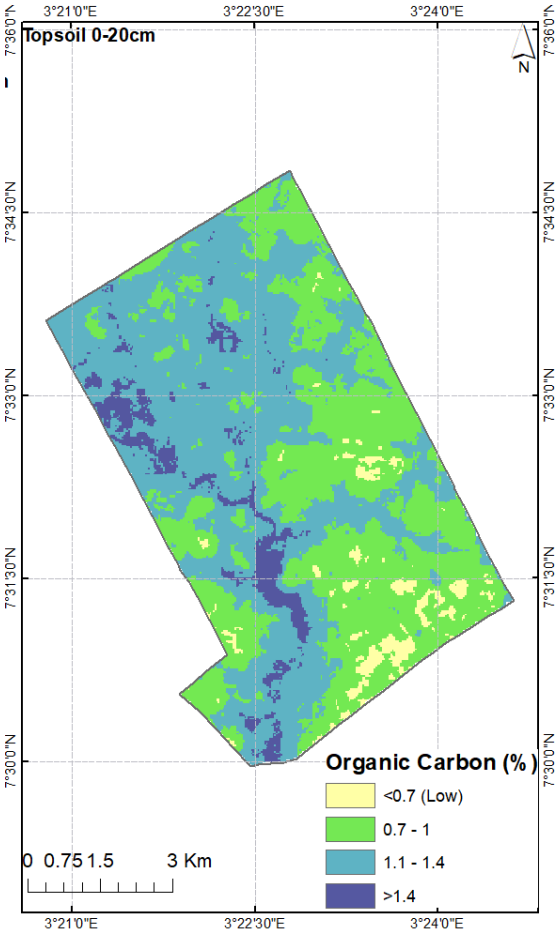
Gravel content was determined for all soil samples. Gravel content varies widely from 1 to 77% and the regions of high gravel content (40 -77%) are widespread and are not localized to a particular section within the AoI. On average the gravel content of the soil is 21%. Gravel content is associated with the soil depth. The shallower the soil, the higher the gravel content is likely to be. The probability of finding soil depth restriction is high (35%) and when these occur the restrictions are also severe with soils having a depth of less than 25 cm. The implication of high gravel content is that the soils have an effectively lower clay and silt percentage, which may put them effectively in a different soil textural class and which will negatively affect the hydrological properties (i.e., water holding capacity especially). However, also the SOC content and available nutrients in actual sense will be lower than the measured values (because the analysis is done on the samples from which the gravel has been removed). This needs to be taken into account when interpreting the results of the analysis.

Soils in this area are derived from the Basement Rock Complex, which generally results in

light textured soils. The soil textural class varies between loamy sand (51%) and sandy loam (42%), though quite a few of the soils have a textural composition that puts them on the transition between the 'loamy sand' and 'sandy loam' textural classes. Occasionally there are soils with higher clay content (up to 23%) that shifts the textural class to sandy clay loam, and these are prevalent in the area immediately surrounding the lake. Based on the textural composition, over 90% of the sampling points are categorized as belonging to either the 'less' or 'least desirable' soil textural type, implying a low moisture holding capacity and indicating the moisture available for plant uptake at field capacity is rather low. The soils have been classified as 'well' to 'extremely well' drained in all cases and there is very little structural development.

Together with the shallowness of the soil this means that there is a strong risk for shortage of water available for plant uptake at particular moments, even in intermedia and high rainfall areas if the rainfall distribution pattern is somewhat irregular. Moisture deficit may occur only after a few dry days and irrigation needs to be done quite regular to prevent it. Moisture deficit affects the availability of nutrients and impacts on the uptake of the nutrients by plants. The sandy and gravelly texture and little developed structure affect root development as well. Soil amendments are needed to improve the soil physical characteristics and the only practical measure is to increase soil organic matter by adding manure, compost, or other organic resources.

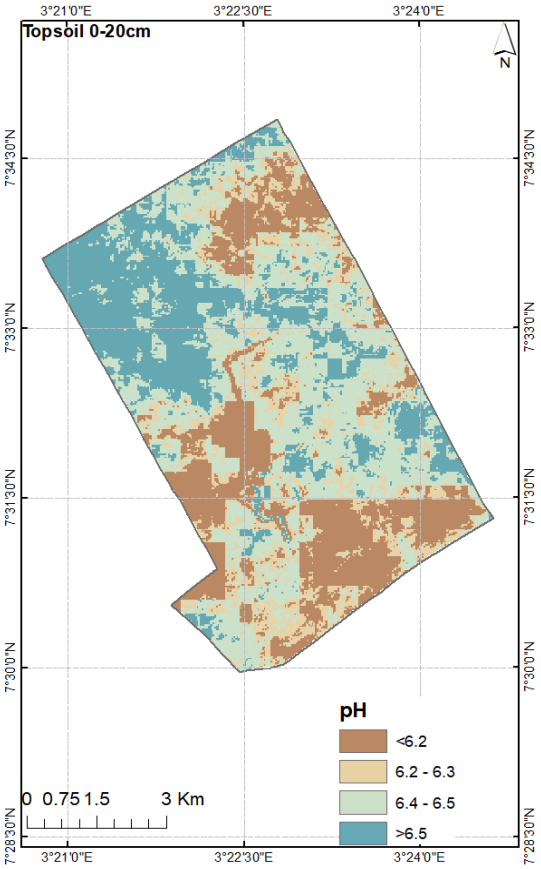
Soil organic carbon



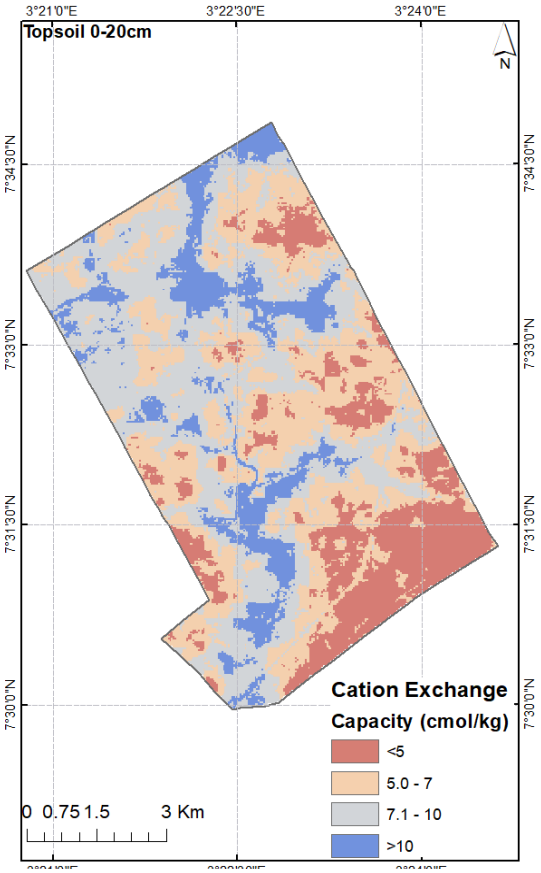
Map 5 Soil organic carbon distribution

The soil contains considerable and varying amounts of gravel, and the gravel percentage is used for correction of the soil nutrient concentrations in order to reflect the effective amounts of plant nutrients available for plant uptake. The rating of sufficiency levels is based on these corrected values.

Soil organic carbon (SOC) is an important quality indicator as it supplies many plant nutrients and regulates many other soil properties. About 78% of the Aol has soils which are either very low (SOC<0.7%) or low (<1.2%) in soil organic carbon (OC) but the low OC soils are prevalent. Soils with adequate to high level of organic carbon only occupy 22% of the Aol. The SOC variations reflect land use and land cover pattern across the AoI (Map 5), in which the very low and low SOC areas are associated with the intensively cropped areas. The SOC has a strong influence on other soil properties especially for



Map 6 Soil pH distribution



Map 7 Distribution of the effective cation exchange capacity of the soil

the sandy soils of the farm, whether related to hydrologic properties, soil chemical properties or soil biological properties.

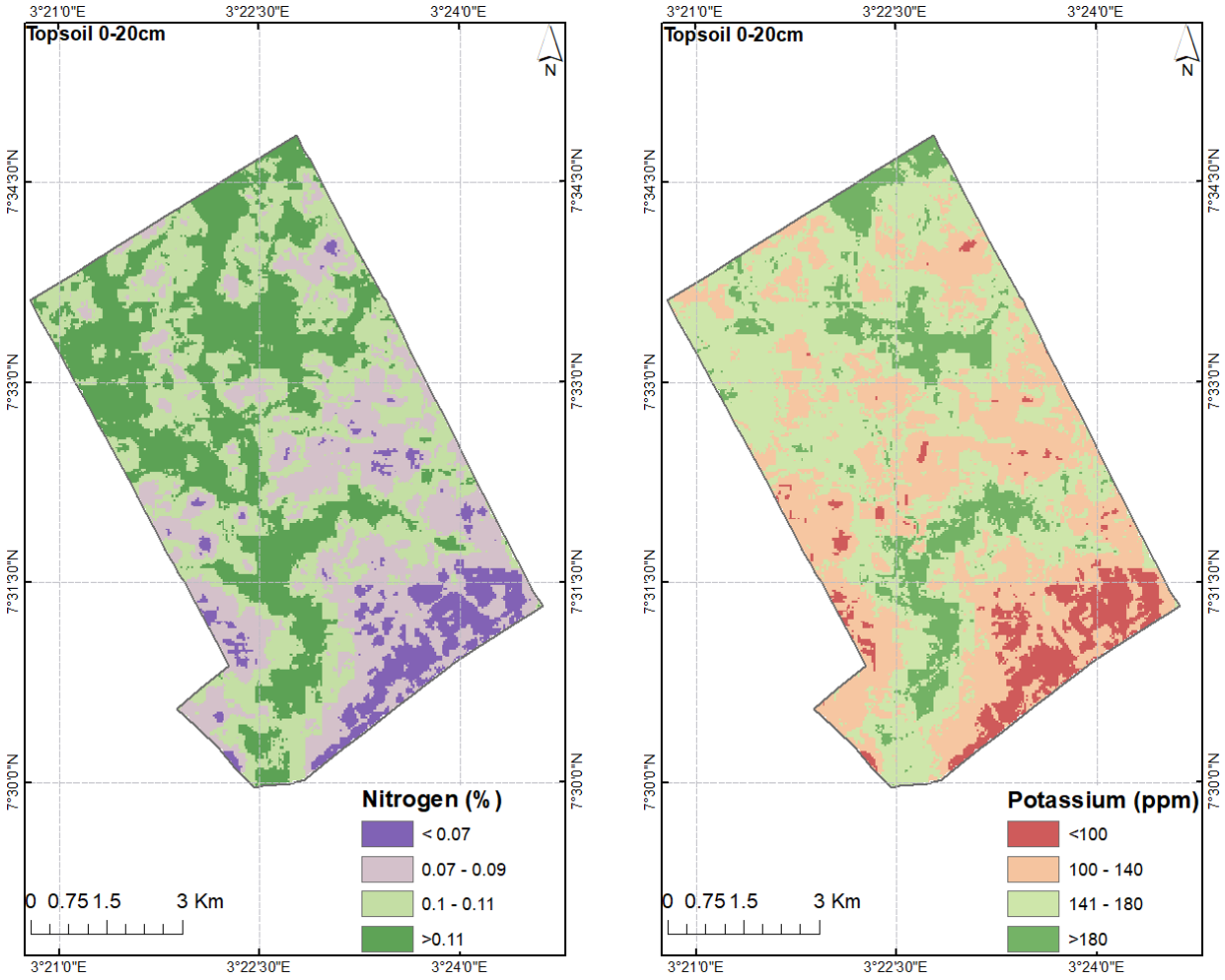
Soil pH

Soil pH is a master variable in soils because it controls many chemical and biochemical processes operating within the soil. pH is a measure of the acidity or alkalinity of a soil. Soil pH is very important in crop production due to the fact that soil pH regulates plant nutrient availability by controlling the chemical form of the different nutrients and herewith also influences their chemical reactions. As a result, soil and crop productivity are linked to soil pH value. Soil pH is generally at optimum level within the Eruwa Farm settlement with about 97% of the soils having optimum pH (5.5<pH<7.0) of the topsoil (Map 6). There are no management concerns with respect to the soil pH.

Soil nutrient

The capacity of the soil to hold nutrients other than N and P (that is Ca, Mg, K and Na, as reflected in the ECEC), is strongly related to the soil organic carbon content, for this type of soils. The ECEC is considered critically low in 34% of the land, low in 57%, adequate in 8% and high in 2% of the land. Regions of extremely low ECEC are prevalent in the south end of the land (Map 7). The soils of the AoI are limiting in nitrogen with over 90% of the land being very low in soil nitrogen and follows a similar pattern of variations as that of the ECEC across the land (Map 8). Phosphorus is critically low in 39% and low in 57% of the AoI. Regions of adequate phosphorus content are about 4% of the total farm settlement area. Potassium is relatively adequate in the soils at Eruwa where 60% of the farm has adequate level of potassium in the soil. Among the other soil nutrients, calcium is the most sufficient with over 90% of the AoI being at adequate level. Magnesium is however low in about 83% of the land. In terms of the micronutrient

content, manganese, iron, copper, and zinc are at adequate levels in over 95% of the land. Meanwhile boron is limiting in over 90% of the AoI (See Appendix). Generally, the soil fertility is rated low and therefore requires nutrient application in form of mineral fertilizer and manure for sustainable crop production. Tables and maps of soil nutrients characteristics are included in the Appendix.



Map 8 Distribution of nitrogen and potassium in the top and subsoils of the farm

Land use zoning and suitability assessment

Land units have been defined based on a combination of land and soil characteristics that are defined in terms of the soil type. These characteristics are: land use and land cover, soil depth, slope, soil organic carbon and cation exchange capacity (CEC). For land use focus is on the field patterns. The maps of these properties are overlain, and by looking at the spatial distribution patterns of these properties it is possible to delineate land units that are homogeneous in terms of the composite characteristics with clear differences between the units in terms of the property values. The units are subsequently characterized in terms of pH, fertility status, soil texture, soil depth, etc. Based on these characteristics, an integrated evaluation of the suitability of the land for commercial agricultural use is made, which looks

at suitability for mechanised operations, suitability for the different types of crops and soil fertility. All units are labelled and are grouped based on these characteristics the groups subsequently rates in terms of suitability. The various groups have been given their unique colour coding (See Map 9).

Group 1 (LU 5, 23, 25, 26, 31, 33, 36, 40, 49 & LU 56)

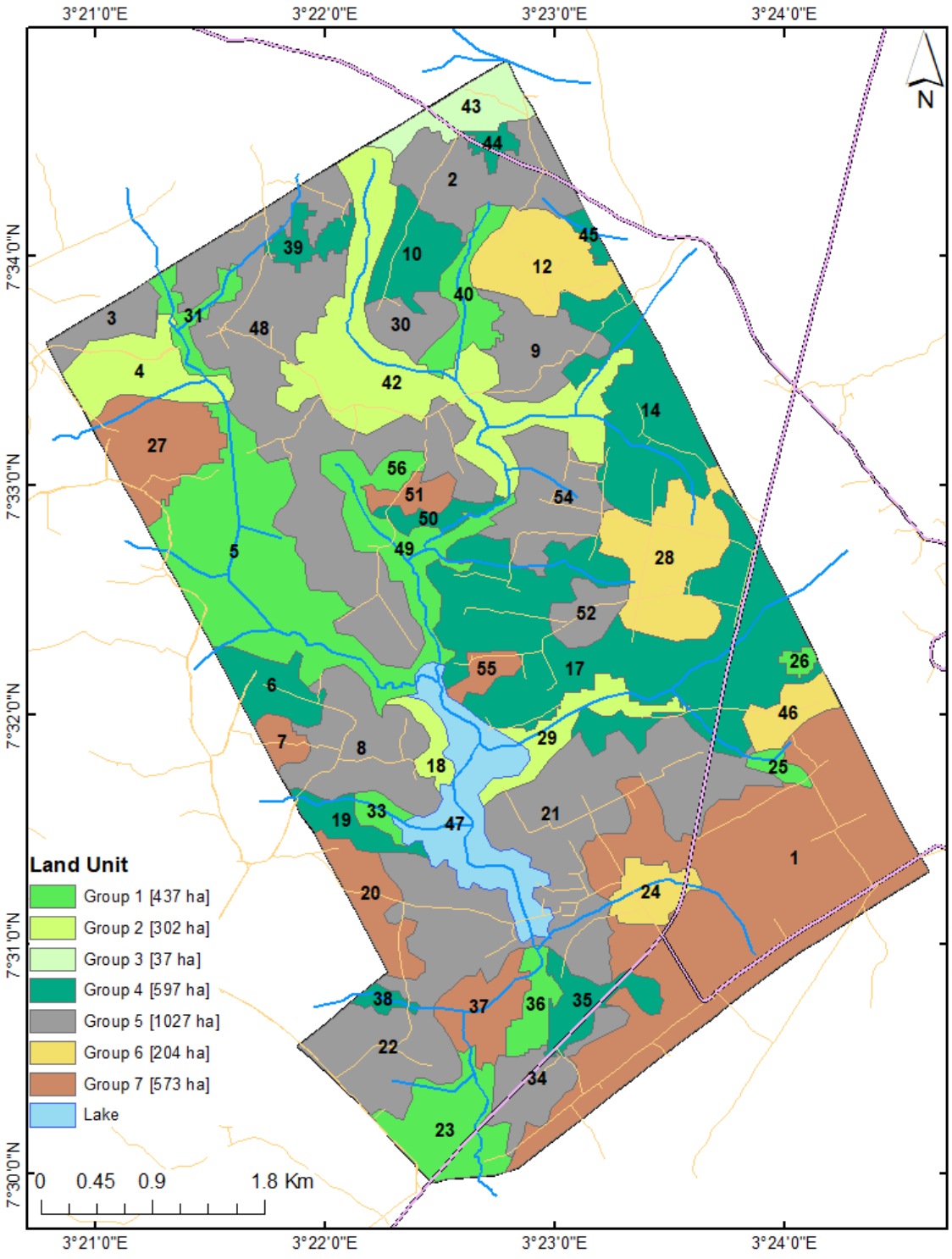
Units of group 1 are located in different parts of the AoI and seems to be associated with the area surrounding drainages. LU 23 and LU 36 are found in SW of the Aol while LU 25 and LU 26 are in the southeast. Group 1 essentially lies in the lower elevation area; some units coincide with the main river course, while others are associated with some of the main tributaries. The soils seem relatively fertile because of the relatively high SOC content, which may be attributed to their position in the landscape and the debris that might have been deposited here as a consequence, or, on the other hand, be attributed to the seemingly less intense land use that will also have contributed to an accumulation of organic matter. This group and the individual units are a mix of shrub and grassland and cultivated land. The soils are of light texture (sandy loam), though with a relatively high clay content of about 16% clay, which makes these soils fall in the class of favourable textural properties. The soils are moderately deep and has a favourable soil pH. The soils contain relatively high levels of organic carbon, nitrogen, phosphorus and potassium. The soil organic carbon and potassium levels are adequate for most arable crop. Water availability is not a concern, and the topography is very gentle undulating making mechanization possible without any major restrictions. This encapsulates the best units of the land in terms of soil fertility conditions, water availability, road accessibility and suitability for mechanization (topography). Group 1 is suitable for the cultivation of many arable crops, among which the more demanding crops like maize and rice to some degree. But these are relatively small patches rather than extensive areas. LU 5 measures 193.5 ha, LU 23 measures 65.4 ha, LU 25 measures 8.3 ha, LU 26 measures 4.9 ha, LU 31 measures 22.6 ha, LU 33 measures 10.9 ha, LU 36 measures 21.3 ha, LU 40 measures 36.3 ha, LU 49 measures 63.1 ha and LU 56 measures 10.3 ha. Group 1 measures an area of 436.6 ha and covers 14% of the entire farm settlement.

Group 2 (LU 4, 18, 29 & LU 42)

Group 2 is situated along the main drainage networks and their distributaries of the Aol and lies in the low elevation area, like Group 1. The soils fall within the sandy loam textural class and occassioanlly there are more clayey soils which shift the textural class to sandy clay loam, thus making the soil texture to fall within the desirable class. The soils are moderately deep and the pH is favourable for the growth of most arable crops. The soil organic carbon is relatively high and not less than 1.1% in most cases. The soil nitrogen is highest for these units (Group 2) relative to the other portions of the Aol.

Potassium and other macronutrients are at adeqaute levels while the micronutrients are also within the sufficiency thresholds. The soil fertility is rated high for this kind of highly weathered soils. The decomposition of debris deposited along and around the river course and its distributaries may account for this observation. On the other hand, there are dense woody vegetation in this riverrine area and along the drainage channels. The soils of the units within Group 2 are suitable for intensive agriculture, like the soil in Group 1. However, these units are

mostly narrow strips of land along the drainages/streams and rviers and therefore not suited for large scale mechanised farming, but maybe suited for specific and dedicated forms of land use (e.g., vegetables). Soil fertility should, however, be maintained for sustainable crop production. LU 4 measures an area of 55.6 ha, LU 18 measures 15.0 ha, LU 29 measures 36.9 ha and LU 42 measures an area of 194.6 ha while the enitre Group 2 measures a total area of 302 ha and covers 10% of the AoI.



Map 9 Eruwa Land unit map

Group 3 (LU 43)

Group 3 is only LU 43 and it is situated in the extreme northeast of the AoI. This is a relatively high elevation area but with flat to almost flat lands. The unit is under intensive cultivation with contiguous fields and all woody vegetation has been cleared. The soil is sandy clay loam though still gravelly but falls within the class of favourable textural properties having good water holding capacity. Soil depth varies from being very shallow to moderately deep but there are more occurrences of the moderately deep soils. The soil pH is optimum for sustainable production of many tropical crops. Soil organic carbon content is high with values up to 2.2%. There do not seem to be nutrient limitations, whether related to macronutrients or micronutrients. This unit is a spot of highly fertile soils. LU 43 measures an area of 37.1 ha which is 1% of the farm settlement.

Group 4 (LU 6, 10, 14, 17, 19, 35, 38, 39, 44, 45, 50)

Group 4 also falls within the low elevation area but is not associated with the drainage network like Groups 1 and 2. A large part of this group falls within the eastern section of the Aol. The units are intensively cropped area and cassava is the dominant crop. The soil pH is optimum for a wide range of agricultural crops. The soil organic carbon content ranges between 0.7 and 1.10%. The soil is moderately deep in most cases with average of 60 cm depth. The soil has low nitrogen content whereas potassium and other macronutrients are at adequate levels though phosphorus level is also low. Soils of these units are well supplied with micronutrients such as iron, zinc and copper. The capacity of the soil to hold nutrients is low with ECEC values of less than 7.0 cmol/kg in most cases. In terms of soil fertility and general suitability for agricultural use Group 4 comes after Groups 1 and 2. LU 6 measures an area of 32.6 ha. LU 10 measures 41.7 ha. LU 14 measures 113 ha. LU 17 measures 302.4 ha. LU 19 measures 22 ha. LU 35 measures 31.8 ha. LU 38 measures 6.9 ha. LU 39 measures 18.7 ha. LU 44 measures 8.3 ha. LU 45 measures 6.2 ha and LU 50 measures 13.2 ha. In total, Group 4 measures an area of 596.8 ha and covers 19% of the AoI.

Group 5 (LU 2, 3, 8, 9, 21, 22, 30, 34, 48, 52 & LU 54)

These land units spread across the entire land from the north to the south. These units are associated with the mid-slopes. The units are neither close nor associated with the rivers and streams (the valleys) or with the upper slopes and hilltop area. The drainage channels or streams are not very far away though. Apart from LU 3 and 48 which are more of shrublands, others are cropland with large to moderate sized fields of cassava and soybean. The topography is gently undulating and does not vary within this group, making mechanization a possibility without major restrictions, though measures need to be taken to control erosion. Soil depth varies between very shallow (<25 cm depth) and shallow (<50 cm) with associated high gravel content. The gravel content in the topsoil reduces with increase of soil depth. The soil textural classes are sandy loam and loamy sand textural classes, with the sandy loam class occurring more frequently. However, when considering the gravel content, the soil texture will effectively be lighter than what the sand, silt and clay percentages as determined by analysis indicate (the actual clay and silt percentages are less than indicated), with the implication that the soils fall within the class of less desirable textural properties. That is, light textured soils with very limited water holding capacity and therefore with limited capacity to provide water for plant

uptake. This will have most severe consequences for annual crops with less developed root systems.

The soil pH does not vary much and is within the desirable range for most arable crops. The soil organic carbon percentage is low though relatively high (mean SOC = 1.0%) for this type of sandy soils. The soil nitrogen and phosphorus follow similar patterns as the SOC. These types of soils are quite vulnerable to loss of soil organic matter, and because soil organic matter is such an important aspect of soil quality and has an important role to play in maintaining soil functions especially in these sandy soils, extra attention needs to be directed to the management of soil organic matter and maintaining and actually improving SOC content.

Most of the micronutrients are at adequate levels, particularly Mn, Fe and Zn. The capacity of the soil to hold nutrients (ECEC) is low for all land units in Group 5. If low soil fertility and water availability are addressed, the units can be used for less demanding crops; that is sorghum, cassava (if soil depth permits), soybean, and others, but less suitable for maize for example. LU 2 measures an area of 79.2 ha, LU 3 measures 24.6 ha, LU 8 measures 85.8 ha, LU 9 measures 50.8 ha, LU 21 measures 250.6 ha, LU 22 measures 84.7 ha, LU 30 measures 26.5 ha, LU 34 measures 42.6 ha, LU 48 measures 291.4 ha, LU 52 measures 22.8 ha while LU 54 measures 67.7 ha. Group 5 measures a total area of 1,026.7 ha which is 33% of the entire farm area.

Group 6 (LU 12, 24, 28 & LU 46)

These units are found in the eastern section of the Aol and are associated with the mid-slopes. Similar to Group 5, the units are also not connected with the rivers and streams with the exception of LU 24. Group 6 is a cropland with large to moderate sized fields of cassava. The topography is gently undulating, making mechanization feasible without major restrictions, though measures need to be taken to control soil erosion. Soil depth varies between shallow (<50 cm depth) and moderately deep (<100 cm) with average gravel content of 22%. The soil textural class is predominantly loamy sand, with the implication that the soils fall within the class of less desirable textural properties. This implies that the soils are light textured with very limited water holding capacity. Thus, the soil capacity to make water available for plant uptake is limited. The consequence is severe (more severe than Group 5) for annual crops with shallow root system.

The soil pH varies from 5.9 to 6.5 being moderately acid to slightly acid but still within the desirable range for most arable crops. The soil has organic carbon content that varies considerably from 0.59 to 1.66% but with an average of 0.94%. The soil has low level of nitrogen but moderate level of phosphorus. The soils of Group 6 fall among the vulnerable soils described in Group 5.

Most of the micronutrients are at adequate levels, particularly Mn, Fe and Zn. The capacity of the soil to hold nutrients (ECEC) is low for all the land units. This group may be used for less nutrient demanding crops as specified under Group 5. LU 12 measures an area of 65 ha, LU 24 measures 26.8 ha, LU 28 measures 88.1 ha, LU 46 measures 24.2 ha. Group 6 measures a total area of 204 ha and covers 7% of the AoI.

Group 7 (LU 1, 7, 20, 27, 37, 51, 55)

Group 7 is an extensive area of land covering mostly the southeast section of the AoI and some spots along the western border of the land. This is a relatively high elevation area, and the land varies from being gently sloping to moderately sloping. This type of terrain is still suitable for mechanised operations, but erosion control measures need to be put in place.

There are few streams (river tributaries) that run through LU 1, 27 and LU 37. The units are at some distance from the lake and from the main river. The streams are seasonal, which makes water availability a challenge, particularly during the dry season.

The land is used for continuous cropping predominantly, and there are few scattered patches of shrubland. The soils are very shallow and, in most cases, less than 40 cm deep. The gravel content is high (up to 40% in most cases) which increases with depth. The sand fraction of the soil increases towards the north from about 74% to 80%, resulting into less desired soil textural classes which in this case vary from sandy loam to loamy sand but with a higher incidence of loamy sand soils. This implies that the water holding capacity of the soil is very limited. The soil pH in this group is least among others but still suitable for most arable crops and tree crops. The soil organic carbon is low, while nitrogen, phosphorus and potassium levels are very low. The effective cation exchange capacity of the soil, which is the ability of the soil to hold nutrients is rated low. The group perhaps has the lowest soil fertility and the least desirable attributes for sustainable cultivation of arable crops, but with sound agronomic practices and careful selection tree crops could thrive. Alternatively, one could think of grassland (or trees in combination with grassland), also as a possible strategy for enhancing the soil quality. LU 1 measures 388 ha, LU 7 measures 12 ha, LU 20 measures 38.6 ha, LU 27 measures 66 ha, LU 37 measures 40 ha, LU 51 measures 15.6 ha while LU 55 measures 13.1 ha. Group 7 measures an area of 573.3 ha and covers 19% of the farm settlement.

The Lake

LU 47 is not a land unit as such but a lake constructed along the main drainage course that passes through the Aol. The artificial lake covers an area of 96 hectares and situated almost at the centre of the settlement. Presently there are extensive fishing activities going on within the lake and the lake is also being used by some peasant farmers for irrigation. Some of the dwellers of the settlement also use the lake as a source of potable water. The reservoir has great potentials to provide water for irrgiation during dry spells or dry season thereby making all year round food production a possibility. Over the years, the lake has accummulated a lot of debris thereby reducing the volume of water it contains. Transforming the farm settlement into farm estate will require that the lake be dredged to remove all accummulated sediments.

Summary, Conclusion and Recommendations

In summary, there are some major constraints for the development of Eruwa farm settlement to make it suitable for commercial agricultural use. In the end it is about weighing the options for the commercial exploitation of the land, considering the conditions and investment required to amend the constraints to make the land suitable for its potential and intended use. At this point this report indicate and map the constraints giving a general recommendation as to the type of land use that can be considered.

There is a dense network of dirt roads that provides access to the whole area. However,

these dirt roads need to be upgraded to improve access and allow easy traffic within the area for cars and light trucks to facilitate the development of the area for commercial farm operations. The upper western section of the land is the least accessible, but it is at the same time also the area with the lowest priority for being developed. The access roads, especially the road that provides access to the eastern and northern parts of the area of interest will require upgrading.

Most of the land that is suitable for agricultural use has been cleared. There may be secondary regrowth and shrubs and bushes, but it will not require heavy machinery for land clearing. The teak plantation in the southwest corner (clearly mapped out in the land use and land cover map) should be maintained.

The topography is such that mechanized crop production is possible in most places; however, the shallow depth (very shallow and shallow soils) being the main obstacle for any mechanised operation, and especially land preparation. Based on the soil depth map a considerable area can be excluded for mechanised farming, but the units belonging to Group 1, 2, 4 and 3 (to a lesser degree) have limited restrictions and should, therefore, be prioritized for developing the area for mechanised and commercial agriculture. Group 4, having larger stretches of land that is not intersected by drainages, providing the best opportunities to establish larger plots suited for mechanised operations. Land units 31, 33, 40, 42, and 49, amongst others, that have favourble soil conditions, but are stretched out as narrow finrges of land along the drainage channels give less opportunity for establishment of larger plots required for large scale mechanised operations.

In terms of slope there do not seem to be major impediments. For slope class 2 ‘Gently sloping land’ there is also no impediment, but soil conservation measures need to be taken to control erosion. This should consist of ploughing along the contour lines to limit runoff and the construction of contour bunds (graded bunds). However, because of the light texture the bunds can be constructed at some distance from each other. For slope class 3 ‘Moderately steep slopes’ there are still no major restriction for tractor operation (at least up to 10% slopes), though it becomes less practical and less efficient. More far-reaching measures will need to be taken to control erosion, like strip cropping or use of vegetation strips or terracing. The possibilities for terracing in this case are limited because of the relative shallow soils.

The soil condition requires attention. The light texture, sandy soils in combination with the low soil organic carbon content, requires careful management of the soil to increase the soil organic matter and herewith also the fertility of the soil. It makes this type of soil (Group 5 and 6) less suitable for high demanding crops like maize. The soil fertility is low and it can be corrected by using fertilizer but only in an integrated approach, in combination with other measures to increase the SOC content for example and applying agronomic practices adjusted to the soil conditions to make sure that there is proper response to the fertilizer application (micro-dosing and spot application for example).

Of the various land units that have been identified, Land units in Group 1 to 4 have the most favourable conditions and these occupy 44% of the AoI. The area is suitable for arable cropping, for grain crops and root and tubers, but attention should be given to good agronomic practice to maintain and build up the soil fertility status. These are small units and strips of land along the river and could be prioritized for pulses and vegetable and rice production maybe at

a small scale. Group 3 preferably should be prioritized for nutrient demanding crops like maize particularly during the rainy season. Group 4 should be prioritized for large scale mechanised operation.

Group 5 and 6 are considered marginally suitable for high nutrient demanding crops like maize. Group 5 can be considered for the cultivation of oil palm for example where the soil condition is more moist which may help to satisfy the water requirements of oil palm in the dry season. Otherwise, perennial crops such as cashew could be considered. If the low soil fertility is addressed, culivation of cassava and soybean could be considered, but expectation of high yields should be moderated.

Group 7 land units are less suitable for arable cropping. The steeper slopes require measures to control erosion and the occurrence of shallow soils limits the possibilities for terracing. There may be patches of land that are suitable, but these are not very extensive. The low soil fertility is a further limitation. Under these conditions a tree crop would likely be a more suitable solution. Cashew with its lateral root system would probably do well. Citrus and other tree crops such as teak could probably be considered but would also suffer from the low soil fertility status.

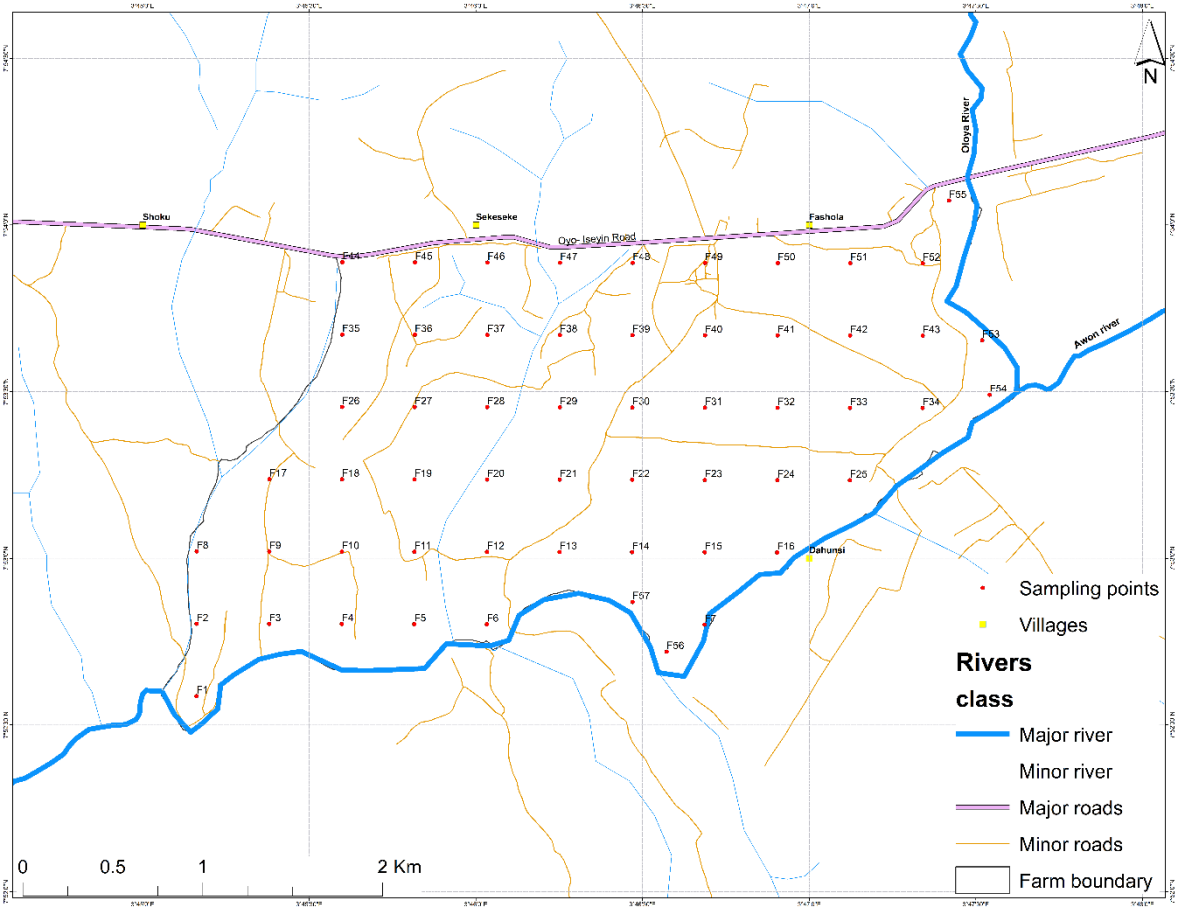
Groups 6 and 7 cover about 26% of the farm settlement. These two groups have units that spread across the different sections of the farm. They are not suitable for crop production. They are however suitable for various forms of animal husbandry, office complex, processing centres and residential buildings such as staff quarters.

RESULTS | FASOLA FARM SETTLEMENT

Location and general landscape characteristics of the Area of Interest

The area is located about 75 km north of Ibadan, Oyo State and it measures eight hundred and twelve hectares. The Area of Interest (AoI) is a farm settlement located directly opposite Fasola Township. The AoI is not actually in use as such, but there are several cropping and grazing activities going on within the 'farm' premise. There are few buildings and some infrastructures on the land, most of which are in dilapidated condition. There are extensive areas of cultivated land spread across the settlement and crops grown include cassava, soybean, yam, maize and rice. There are some plantations of Gliricidia Teak in the eastern part of the AoI. Fulani herdsmen herd their cattle within the farm in considerable numbers. The area falls within the transition zone of the derived savanna to the southern guinea savanna ecological zone.

The landform and soils are typically those that are derived from the basement rock complex, which consist of hard crystalline and metamorphic rocks (granite and gneisses), on which soils have developed in-situ. The landscape is classified as level to hilly with slope classes ranging from 'flat to almost flat' to 'sloping'. Map 10 presents the location of the sampling points, the drainage channels and the road networks. There are rock outcrops at the fringe of the south-south boundary but too small to appear in the satellite imagery. The soils in the AoI have developed on the same type of rock and are of light texture. The soil depth varies considerably



Map 10 Map of Fasola farm settlement showing the boundary of the study area, roads and tracks, drainage networks and locations of the sampling points

depending on the depth of the bedrock and patterns of erosion and sedimentation which will relate to the historical land use.

Access to the terrain, Road and Tracks

There is a regional road that provides access to the farm connecting Oyo to Iseyin. This road demarcates the northern boundary of the farm settlement and runs in the East -West direction. There are several dirt roads that nicely connects the different sections of the farm. Generally, accessibility of the farm settlement area is good and the accessibility of the various sections of the land is also good. The road network is mapped in Map 10.

Water resources and drainage network

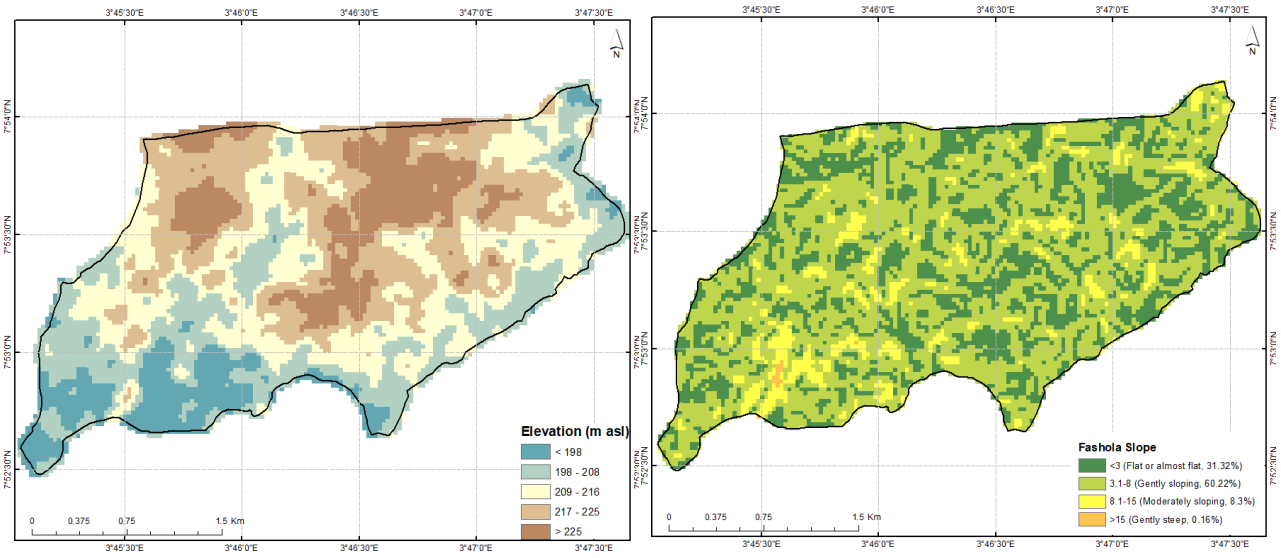
The main drainage channel runs along the eastern and southern border of the settlement area. This river is a third or fourth order permanent river. The river is called the Awon river which is actually a confluence of the Awon and Oloya river that join at the most extreme eastern point of the terrain. The catchments area is relatively small, meaning that, while there is plenty water during the rainy season, water will be little during the dry seasons (Map 10). The river is already dammed halfway along the southern boundary, creating a reservoir of not too big a size. The reservoir provides opportunities for irrigation, if it were for supplemental irrigation only. There seems to be an opportunity for creating an additional reservoir to increase the water available for irrigation. There are two seasonal streams within the western section that connect to the main drainage channel in the south. There is another stream that demarcates the western boundary of the farm settlement area. There is a borehole facility (with water tank) in working condition located in the centre of the land. In the past the tank was used to supply water to the water troughs to provide the cattle of water. That means there is some infrastructure that can be upgraded and used for irrigation purposes, maybe. This can be an asset for the further development of this land into a farm estate.

Topography

The elevation ranges from around 200 to 276 masl, with the highest elevation found in the north towards the centre of the land. The lowest elevation points are associated with the drainage networks within and at the fringe of the farm (see Map 11). In this landscape developed on the basement rock complex, the landform is characterised by hills with often rock outcrop on the top, giving rise to a gently undulating to undulating topography (Map 11). In this particular case, rock outcrops are limited to the fringe of land in the south of the AoI. The slope gradient class varies from ‘flat to almost flat’ to ‘sloping’ in some parts. Flat areas hardly occur and the whole area is sloping to varying degree.

The elevation profile of the land in the west to east transect shows an undulating terrain and the slope length varying from about 300 - 800 meters or more (Fig. 2). There are relatively long slopes in the western section of the transect.

The situation in the south – north transect is the same, with generally more gently sloping land. The landscape is level to nearly level particularly around the south while around the north the land is gently undulating with long slopes.



Map 11 Elevation and slope classes

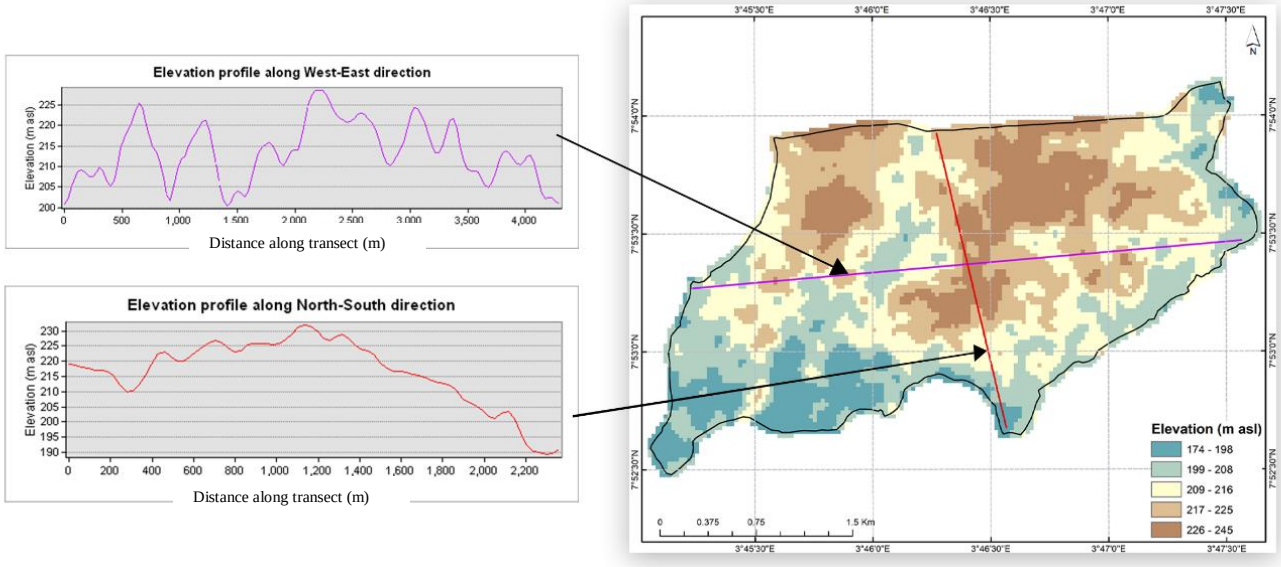
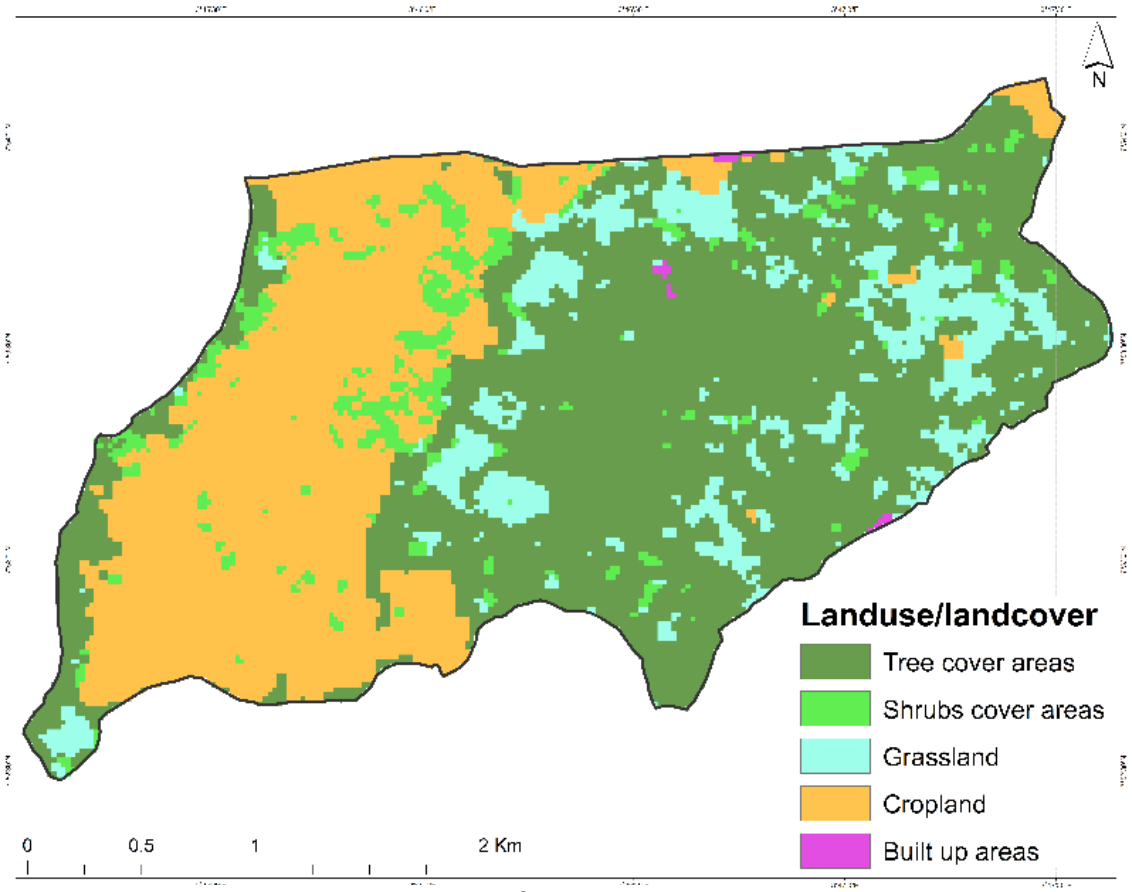


Figure 2 Elevation profiles of the sections of Fasola farm settlement

Land use and Land cover

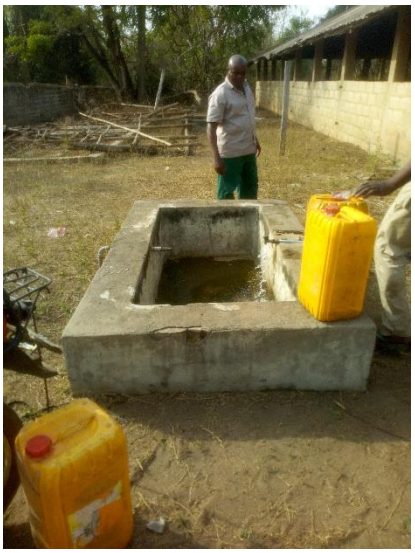
Map 12 is from a global database of land use and land cover data which does not relate the current state of the land. Most of the land has been cleared at some point in time and currently over 60% of the land is being used for cultivation. The entire western section is more intensively cultivated than the other parts of the land. There are Gliricidia plantations dispersed across the land but more prevalent in the eastern section of the farm. Crops grown are yam, cassava, maize and soybean. There are a number of staff residential quarters which are still in good condition. Also, there are several office buildings around the north section of the farm

some of which are a few meters from the main entrance but in dilapitated condition.



Map 12 Land use and land cover map of Fasola

Soil sample collection and field assessment at some of the sampling locations



Water facility at the cattle ranch

Water storage facility near the entrance of the settlement

Cassava field on gently undulating terrain

Cattle paddock at the centre of the settlement

Idle land not being used for cultivation

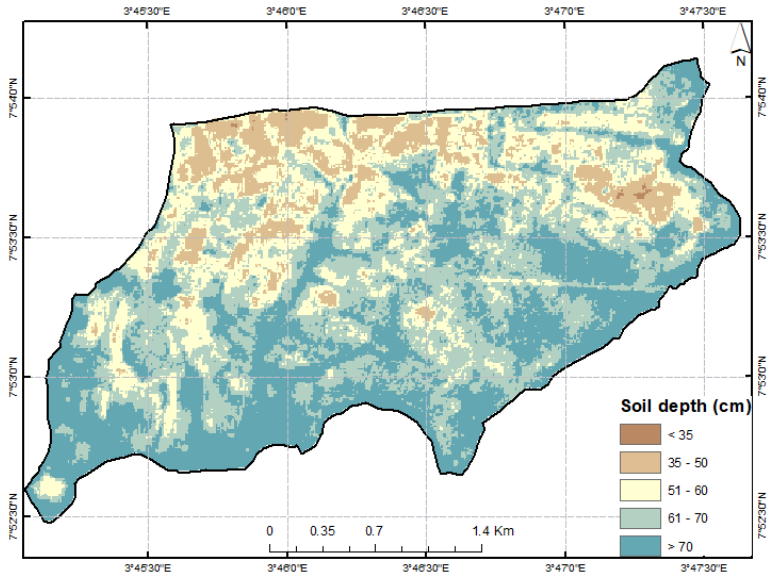
Grazing field at F45 point

Inland valley on which rice was recently harvested

Soil characteristics

Soil depth and texture

Soil depth restriction is measured by how deep one is able to dig with the soil auger. The depth restriction is indicated by the depth at which it is not possible to drill further down the soil profile. Depth restriction does not equate to rooting depth restriction but is a good indicator of effective soil depth. Restrictions generally occur because of the increasing gravel content with depth. Crop roots will have difficulties penetrating such soil layers. The soil depth varies from very shallow to moderately deep. The soils are generally moderately deep (>50 cm); 25% of the area is shallow (>25 cm<50 cm depth) and only about 3% of the area is very shallow (<25 cm). See Map 13 for the variation in soil depth across the farm settlement. Soil depth is associated with the areas of higher elevation (hilltops) and are found predominantly in the northwestern section and there is also a spot of shallow soils in the northeast. Gravel is present in the soil profile, and gravel content is generally associated with soil depth, in which the shallow soils have higher gravel content. The gravel content of the soil varies widely from 1 to 100% but generally the average gravel content is 17%. The very shallow soils are not suitable for agricultural production. The shallow soils do present a constraint specifically to mechanised operations. If claypans occur within shallow depth it will affect the drainage capacity of the soil.



Map 13. Soil depth variations across Fasola farm

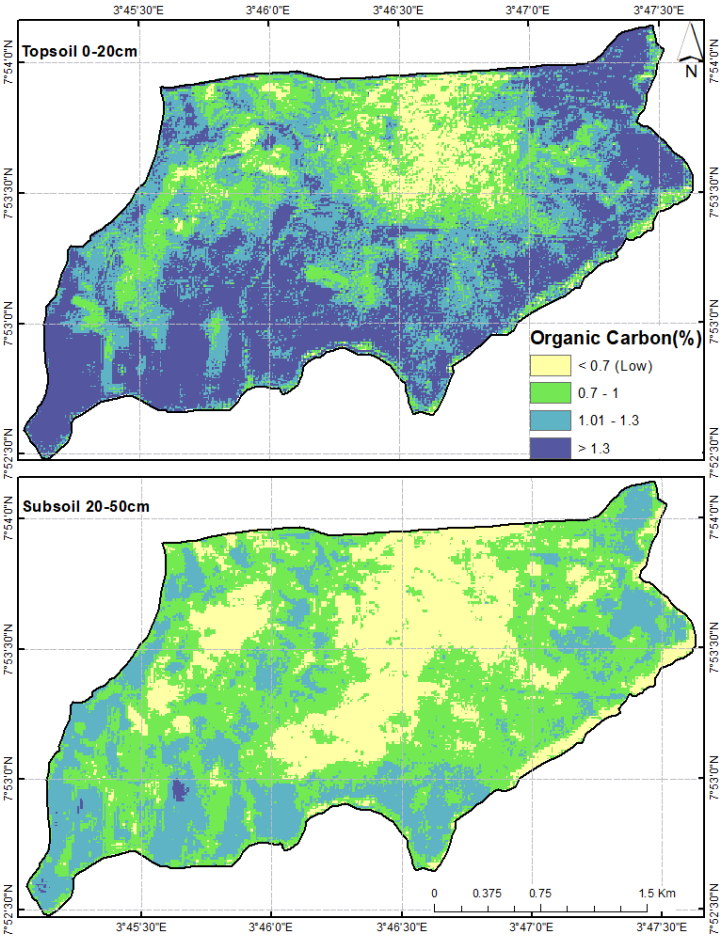
Soils in this area are derived from the Basement Rock Complex, which generally results in light textured soils. The soil textural class varies predominantly between loamy sand (44%) and sandy loam (45%) with few occurrences of sandy clay loam and loam. The sandy clay loam is found in the subsoil and these type of soils are located along the drainage channels. Based on the textural composition, and considering the gravel content, about 70% of the sampling points are categorized as belonging to soil type having either less or least desirable soil textural properties, implying a low moisture holding capacity and indicating low moisture availability for plant uptake at field capacity when the soils are well drained. The soils have been classified as well to extremely well drained, though we see some spots of poorly drained soils connected with the drainage channels.

Based on the aforementioned characteristics, there is a potential risk for shortage of water for plant uptake, even under condition of fairly regular rainfall. Moisture deficit may occur only after a few dry days and irrigation needs to be done quite regular to prevent it. Moisture deficit affects the availability of nutrients and impacts on the uptake of the nutrients by plants. The sandy and gravelly texture and little developed structure affect root development as well.

Soil amendments are needed to improve the soil physical characteristics and the only practical measure is to increase soil organic matter by adding manure, compost, or other organic resources.

Soil organic carbon (SOC)

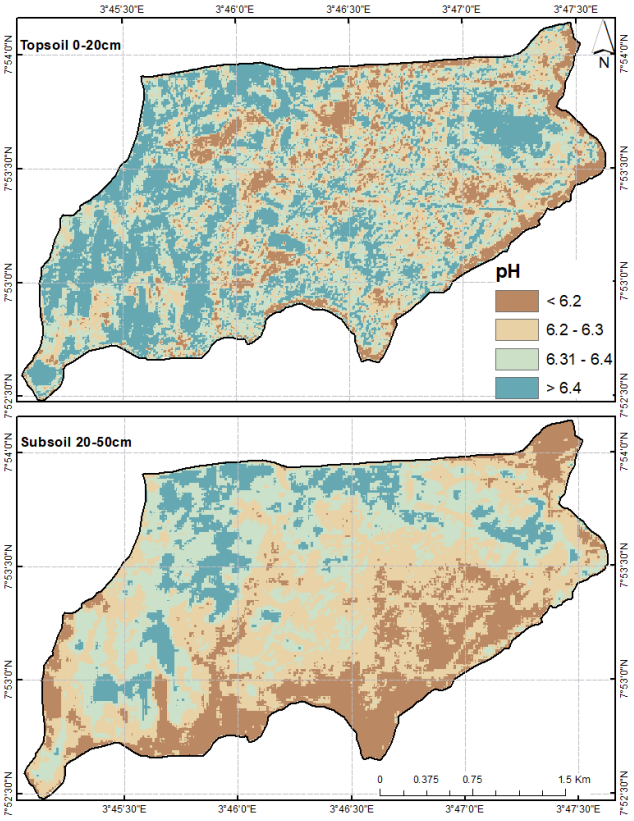
Soil organic carbon is an important quality indicator as it supplies many plant nutrients and regulates many other soil properties. The spatial distribution of SOC in the topsoil reflects the elevation pattern and soil depth distribution across the farm settlement (See Map 14). Soil organic carbon was very low in 26% of the sampling points, low in 43%, and 31% of the farm has SOC ranging from adequate to high levels. The regions of adequate to high level of SOC are in the southern and eastern sections of the land. There are relatively high SOC content in the direct vicinity of the drainage channels that are not cultivated. The SOC distribution is also connected with the land use history of the farm, in which the regions of very low and low SOC are associated with areas that have been more intensively used for cultivation and where most of the infrastructure and houses and buildings are situated. Soil organic carbon has a strong influence on other soil functional properties whether related to hydrologic properties, soil chemical properties or soil biological properties, and is of importance especially for sandy soils in which these properties are less suitable. The management of soil organic matter is, therefore, imperative in the management of soil water and water availability to crops, in the management of soil fertility and increase of nutrient availability to the crop, and in management of the soil biological quality and reduction in soil borne pests and diseases.



Map 14 Soil organic carbon distribution across Fasola farm

Soil pH

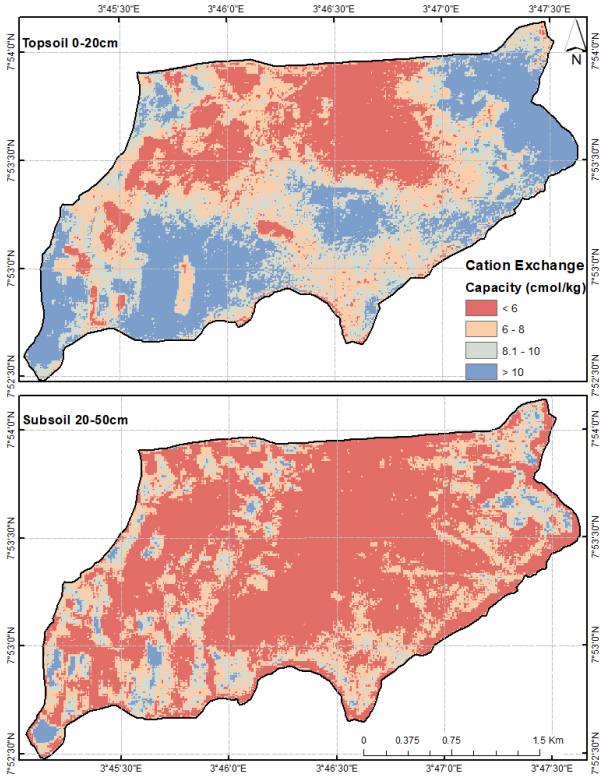
Soil pH is one of key soil functional properties and it affects nutrient availability in soils. At very low pH and very high pH nutrient limitations set in as soil nutrients become unavailable for plant uptake. As a result, soil and crop productivity is linked to soil pH value. Soil pH is at optimum level within the Fasola Farm settlement (Map 15) and there is hardly any variation. There are no management concerns with respect to the soil pH.



Map 15 Soil pH distribution on Fasola farm

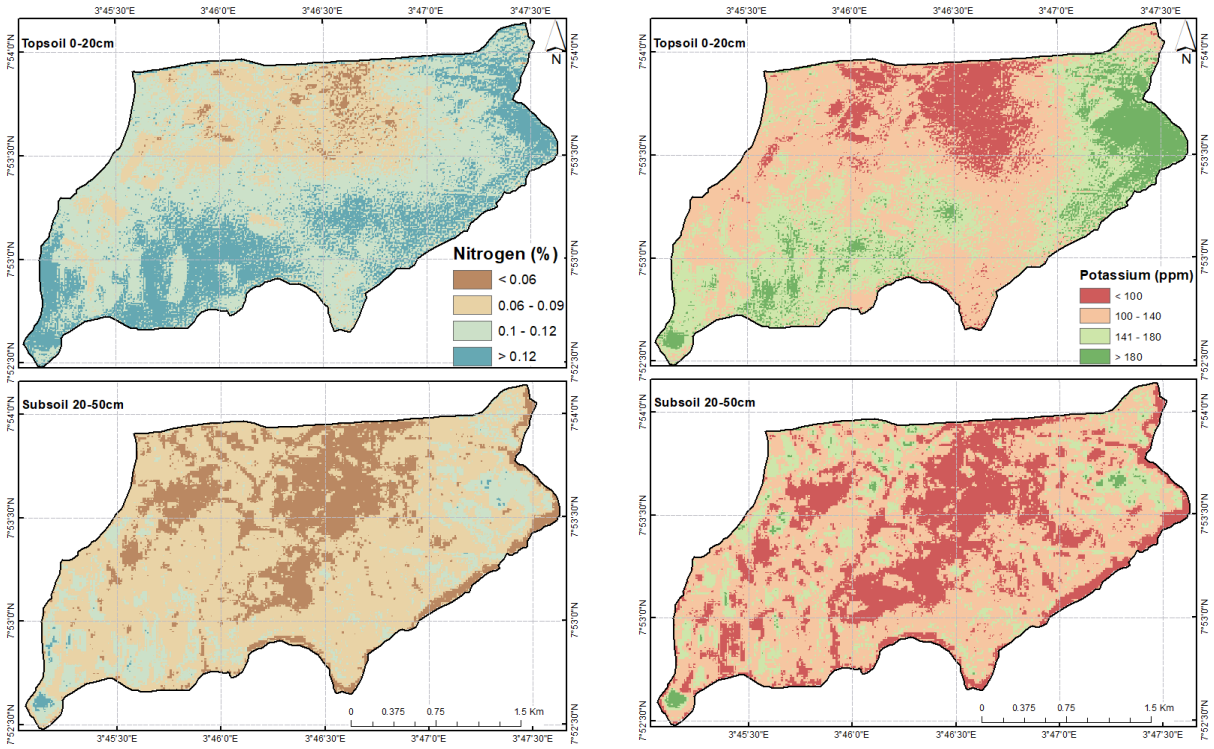
Soil nutrient

The capacity of the soil to hold nutrients other than N and P (that is Ca, Mg, K and Na, as reflected in the ECEC), is strongly related to the soil organic carbon content. The ECEC is considered critically low in 31% of the land, low in 52%, and adequate in 17% of the land (Map 16). The pattern of distribution follows the same trend as that of the SOC (Map 14). The central part towards the main entrance are areas that are critically low in SOC. This is an expected trend due to the high proportion of bare land, and more intensely cropped land within this region of the farm. The distribution pattern for nitrogen and potassium follows the same trend. The soils of the AoI are limiting in nitrogen with about 91% of the land being considered very low in soil nitrogen concentrations. Soil nitrogen is at adequate level in only 9% of the farm settlement area and these regions of adequate soil nitrogen are found in the fringes of the farm settlement area along the river (Map 17). Phosphorus is critically low in 49% and low in 46% of the AoI. Regions of adequate phosphorus content are about 5% of the total farm settlement area. Potassium is less limiting. In 53% of the Fasola farm settlement area the level of available potassium is adequate. This occurs mostly in the eastern section which is cropped less intensely. The soil is however low in available potassium in about 47% of the land and the pattern of



Map 16 Variations in effective cation exchange capacity of the soil at Fasola

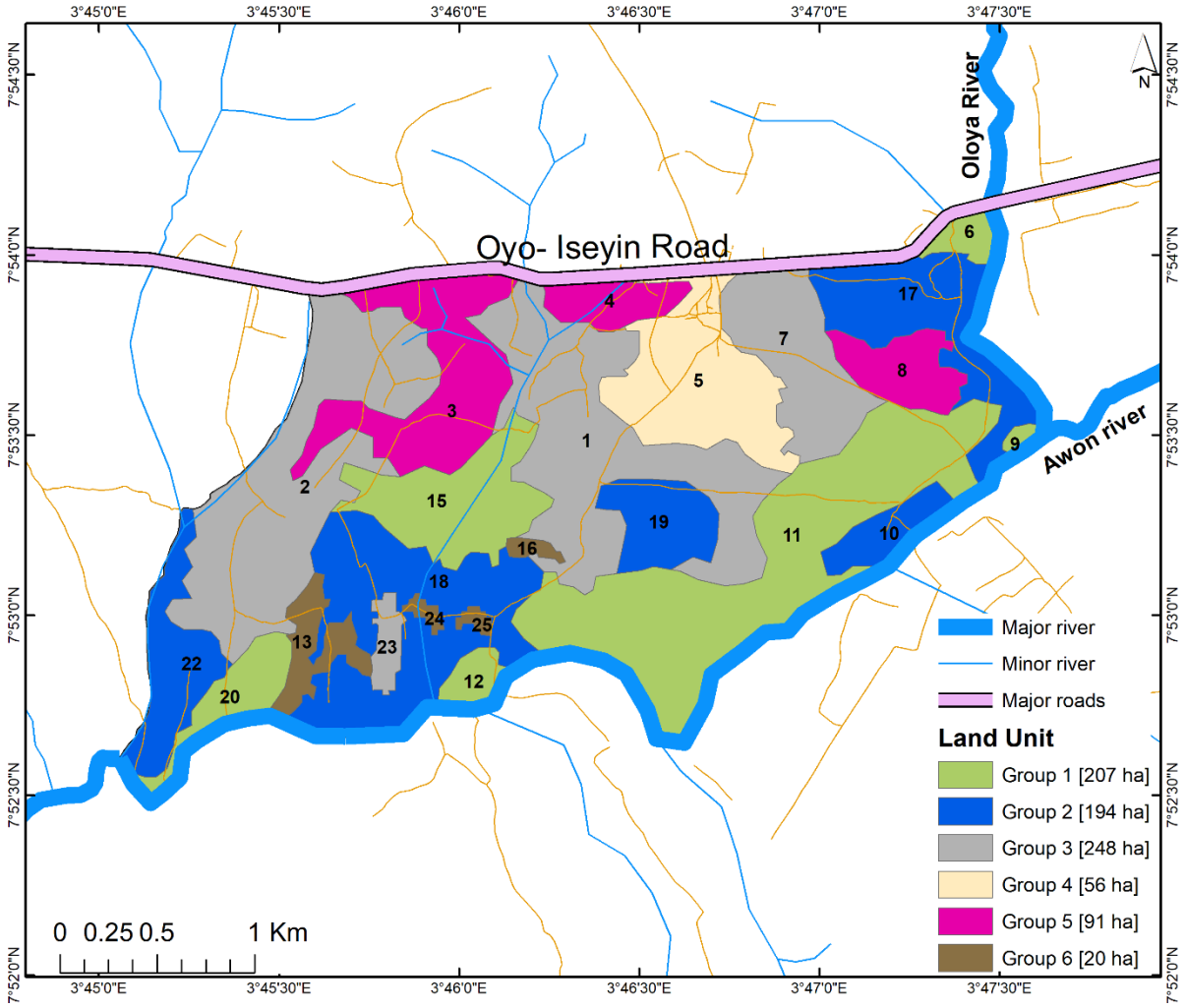
distribution is connected with the distribution pattern of SOC and CEC. Calcium is at adequate level in all portions of the farm; areas around the east border and the south-western corner are particularly high in calcium content. The distribution pattern of calcium follows the same pattern as those of SOC, ECEC and soil nitrogen. Magnesium is however low in about 69% of the land. The other portions of the land have adequate magnesium level. In terms of the micronutrient content, manganese, iron, copper and zinc are at adequate levels in over 95% of the land. Meanwhile boron is limiting in over 90% of the AoI (See Appendix). Generally, the soil fertility is rated moderate for this type of soil and therefore requires sound agronomic management and nutrient application in form of mineral fertilizer and manure for sustainable crop production. Tables and maps of soil nutrients characteristics are included in the Appendix.



Map 17 Variations in soil total nitrogen and exchangeable potassium across Fasola farm

Land use zoning and suitability assessment

Land units have been defined based on a combination of land and soil characteristics that are defined in terms of the soil type. These characteristics are: land use and land cover, soil depth, slope, soil organic carbon and cation exchange capacity (CEC). For land use focus is on the field patterns. The maps of these properties are overlain, and by looking at the spatial distribution patterns of these properties it is possible to delineate land units that are homogeneous in terms of the composite characteristics with clear difference between the units in terms of the property values. The units are subsequently characterized in terms of pH, fertility status, soil texture, soil depth, etc. Based on these characteristics an integrated evaluation of the suitability of the land for commercial agricultural use is made, which looks at suitability for mechanised operations, suitability for the different types of crops and soil fertility. All units are labelled and are grouped based on these characteristics the groups subsequently rates in terms of suitability. Map 18 presents the land units within the AoI.



Map 18. Fasola Land units' map

Group 1 (LU 6, 9, 11, 12, 15 & LU 20)

Group 1 comprises 6 land units with a total acreage of 206.8 ha and covers 25% of the entire AoI. LU 6 is located in the extreme northeast section and bounded in the east by the major drainage channel around the area. The unit is open and under continuous cropping. The unit has an undulating terrain with slopes varying from gently sloping to moderately sloping. LU 9 is small unit located in the extreme eastern section of the Aol, bounded in the east by the major drainage channel. LU 11 is a larger unit located in the eastern section of the land stretching towards the south of the land and bounded in the east and south by the major river that is also the boundary of the Aol. The river is dammed providing the land unit with good water resource for irrigation. LU 12 and LU 12 are again small units situated in the south and bounded in the south by the river. LU 15 is located in the centre-west part of the AoI; the elevation is relatively low with the main stream within the Aol passing through it. Irrigation water for this Group 1 is available will need to be pumped up. LU 6, LU 12, LU 20, and LU 15 are purely agricultural lands with extensive cropping activities presently on going while LU 11 is composed of a mix of cropland and woodland (old tree plantations). A major portion of LU 11 is poorly drained and may be considered suitable for rice or other crops that do not mind

wet feet. Generally, the land is moderately deep (>60 cm depth) with lower gravel content. The soil texture is mostly sandy loam and, in some cases, sandy clay loam with good water holding capacity are found. Group 1 comprised land units with the best agricultural potential in the entire AoI. The soil is optimum/adequate for a number of soil quality parameters such as pH, SOC, macro – and micronutrients. These make the soil fertility and highly suitable for agricultural activities. Caution should be taken however to prevent erosion and depletion of the soil fertility. LU 6 is 8.7 ha, LU 9 is 2.3 ha, LU 11 is 127.2 ha, LU 12 is 7.8 ha, LU 15 is 41.6 ha while LU 20 is 19.2 ha.

Group 2 (LU 10, 18, 17, 19 & LU 22)

The units of Group 2 are closely associated with the units of Group 1, and they share the same physiographic unit. All units of Group 2 are adjacent to units of Group 1 and they share many of the same characteristics. Apart from LU 19 all the land units in Group 2 are bounded by the river. LU 10 is located in the west-end of the Aol. LU 17 is located in the eastern part bounded by the Oloya river. LU 19 is sited more or less in the centre of the farm settlement while LU 13 is located in the southern section and LU 22 in the southwest section. The topography is gently undulating with long slopes without any major restrictions for mechanization. The soil is sandy loam, moderately well drained and moderately deep with no rooting restrictions. Group 2 has the highest effective cation exchange capacity with values greater than or equal to 10 cmol/kg, and which distinguishes this Group from Group 1. The soil pH is suitable for most arable crops. The soil organic carbon is at adequate levels with values greater than 1.2% in most cases. The macro- and micronutrients are at adequate levels with little or no concerns for nutrient limitations. The soil fertility level of Group 2 is good and the units should be considered as the priority areas for arable cropping. LU 10 measures 13.6 ha, LU 13 measures 79.3, LU 17 measures 50.3 ha, LU 19 measures 21.9 ha and LU 22 measures 28.4. In total, Group 2 measures 193.5 ha and occupies 24% of the farm settlement.

Group 3 (LU 1, 2, 7 & LU 23)

LU 1 is located at the middle of the Aol encapsulating LU 19. LU 2 is situated in the western section stretching from north to south. LU 7 is found around the northeast section while LU 23 is located around the southwest of the Aol. These units (Group 3) are sited on the high elevation area of the Aol though just not including the highest points. The slopes are long and straight and ranging in steepness from almost flat to gently undulating. Thus, from this point of view mechanisation is possible without major constraints. These are seasonal streams that run through some of these units, but they do not carry much water and do not provide a viable source of water. The land use is that of a continuous cropland (LU 2, 7 and 23), but the southern part of LU1 has tree cover that constitutes about 30% of the land area for this Group. The soils are moderately deep and well drained. The soil texture is sandy loam but with considerable amount of gravel. The soil pH is optimum for the growth of many arable crops and soil organic carbon is adequate (>1.2%). The soil nitrogen though within the low threshold but relatively high for this type of sandy soil. The ECEC ranges between 6 and 10 cmol/kg. The soil is well supplied with a range of micronutrients. The soil fertility for this Group is considered moderate and the units can be used for many arable crops. LU 1 measures an area of 99.7 ha. LU 2 measures 99.5 ha. LU 7 measures 42.6 ha while LU 23 measures 6.4 ha. Group 3 measures in

total an area of 248.2 ha and covers 31% of the AoI.

Group 4 (LU 5)

Group 4 consists of only LU 5 and is found in the area with highest elevation of the Aol. but with relatively flat land and very gently undulating terrain. This unit houses the major administrative and residential buildings within the settlement. There are no streams within this unit but there is an existing borehole facility that is fairly in good condition which may be explored for irrigation at small scale. In the past this facility has been used for watering the cattle. The land cover includes some croplands, buildings, some shrubland and tree cover (old Gliricidia plantation). The soil is gravelly with about 30% gravel content and the soil texture falls in transition between sandy loam and loamy sand textural class. However, if correction for gravel content is done, the texture will be loamy sand with less favourable hydrologic conditions (very limited water holding capacity) The soil pH is optimum, but the soil organic carbon is very low. The soil concentrations of nitrogen, phosphorus, potassium including the micronutrients are very low. The soil is poor in plant nutrients and other soil quality parameters indicate a poor quality. LU 5 measures an area of 56.2 ha, covering 7% of the enitre AoI.

Group 5 (LU 3, 4 & LU 8)

Land units in Group 5 covers 11% of the AoI and are basically located in the northern section of the land with LU 3 and 4 bordering the regional road (Oyo-Iseyin Road). LU 8 is in the northeast section. A small seasonal stream passes through LU 3 and LU 4 while there are no drainage channels within LU 8. LU 3 and 4 are solely croplands, apart from the areas directly bordering the streams, while in LU 8, some parts are cultivated while others are either on fallow or under tree cover. LU 4 houses some of the old buildings of the settlement. Soils within Group 5 are shallow with average depth of about 50 cm. The soils are gravelly and well drained. Group 5 has soils with are optimum in pH (6.3 – 6.8) for most crops. Soil organic carbon is very low (<0.7%) and the group represents units with the lowest soil organic carbon content within the entire settlement. Nitrogen and other macronutrients are also critically low. The soils have low concentrations of micronutrients (among the lowest soil micronutrients content within the Aol. The overall capacity of the soil to hold nutrients (ECEC) is also very low. The soil fertility level is low and the potential for crop production is limited. These soils require careful management to restore soil fertility and should be used for the cultivation of less demanding crops (e.g., tree crops).

Group 6 (LU 13, 16, 24, & LU 25)

Group 6 has four small land units all situated in the southwest section of the settlements. These land units are associated with terrain that has moderately steep slopes which distinguishes these units from the other land units of the Aol. The risk of erosion is highest in this Group. These areas are less suitable for mechanised operations though still possible and would requires measures for erosion control. The soils are under extensive cultivation. Soil fertility parameters such as soil organic carbon, total nitrogen, available phosphorus, exchangeable potassium, zinc, copper and ECEC among others are either very low or low. The soils of this units are therefore considered marginal for sustainable commercial agricultural crop production. LU 13 measures an area of 14.3 ha, LU 16 measures 2.3 ha, LU 24 measures

1.8 ha and LU 25 measures 1.7 ha. Group 6 measures a total area of 20.1 ha which is 2% of the enitre AoI.

Summary, Conclusions and Recommendations

There are no major constraints for the development of Fasola farm settlement in terms of its suitability for commercial agricultural use. The access to the farm settlement is good and within the settlement there are numerous road tracks that nicely connect to different sections of the farm, and that could be upgraded to make them trafficable also during the rainy season where and when needed. There are numerous tracks that have been created by the activities of farmers and the nomadic herdsmen in the area.

The topography provides opportunity for large scale mechanized crop production without any major constraints. The slope classes are 'flat to almost flat', 'gently sloping', but there is 'moderate sloping' land only in some few and small parts of the terrain. There are large stretches of land surfaces that are not dissected or fragmented, which is required for large scale mechanized operations.

A considerable part of the land (approximately 70%) is cleared and currently in use. A good portion of the Aol (by approximation 30%) has dense woody vegetation composing of either woody vegetation with a single structural layer or of multi-layered woody vegetation. The single-layered woody vegetation is mainly *Gliricidia septium* plantation. It consists of small trees (light vegetation) that could be cleared with relatively light machinery if needed. The dense multi-layered woody vegetation in most cases relates to secondary vegetation that has established on previously cultivated land, and it still does not represent a major obstacle for clearing of the land. There are large continuous stretches of land which are cultivated with yam, cassava, maize and cowpea. There are also parts where cropland is alternated with woodland or shrubland resulting in a patchy distribution pattern and this is prevalent in the eastern section of the farm. There are local depressions in the landscape where the conditions are more wet and that lend themselves very well to the growing of rice, maize or other demanding crops.

There are artificial and natural sources of water that could be explored for irrigation. The settlement is bounded by a small river in the west, and the Oloya and Awon river in the east and south. There are also some seasonal streams within the land particularly within the western section. During the late rainy season, the broad and shallow valleys associated with these streams serve as cropland for rice production and in some part as grazing land for cattle. Two borehole facilities were also observed within the farm premises and which are still in good condition and that might provide irrigation capacity for small scale intensive cultivation (e.g., production of vegetables in screen houses). In the extreme south, there is also an artificial lake which carries water all year through; not enough to ensure extensive irrigation for a larger part of the terrain, but probably enough for the strip of land bordering the river to the north. There may be an opportunity to construct a second dam and herewith a second reservoir to increase the water resrouce avaiable for irrigation. There is, therefore, no major water related constraint for further development of the farm.

In terms of soil condition distinction needs to be made between the land and soils of the higher elevation parts of in the centre of the AoI (Groups 3 and 5) and the land and soil on the middle and lower slopes of the terrain towards the outer boundary of the farm settlement area (Groups 1 and 2). The latter two Groups are the most suitable and covers 49% of the AoI. The

soil condition is good. The soils are moderately deep (greater than 60 cm depth). The soil texture is more favourable, soil organic carbon levels are adequate and soil fertility status is reasonable. This land has the highest production potential of the AoI

The land in the centre on the other hand (Groups 3 and 5) has a less favourable physical characteristics (high sand and gravel content), has low soil organic carbon levels and also has nutrient limitations. Careful management is required to restore soil fertility and physical characteristics and would still not result in a highly productive area. At the same time, because of the lower potential, it is not suitable for all types of crops and consideration should be given to growing less demanding crops and possibly tree crops when cultivation is done in the open field. Otherwise, cultivation in greenhouses or screenhouses can be considered for high value crops, but this will require a lot of investment that could possibly benefit from the existing infrastructure of boreholes and pipelines. The management of soil organic matter will play a crucial role to improve and maintain soil quality. But also, careful management of the water and nutrients for crop production is required to ensure efficient use of fertilizer and water resources. (The soils have low capacity to hold water and nutrients for crop uptake; fertilizers can be used to correct nutrient limitations but sound, adapted and integrated agronomic practices are required to make sure that there is sufficient response to fertilizer application). These soils are considered vulnerable because they are susceptible to loss of soil organic carbon.

Most of the land units are suitable, to varying degree for agricultural crop production. A few units are considered unsuitable and thus should be excluded from crop production. Land units that fall under Group 5 and 6 should be considered and possible alternative land uses assigned; Group 4 because of the poor soil conditions and Group 6 because of the terrain conditions. For the establihsment of facilities, like barns, storage and processing facities, offices and houses, the land units of Groups 4 and 5 could best be targeted. Group 6 should be maintained under permanent vegetation.

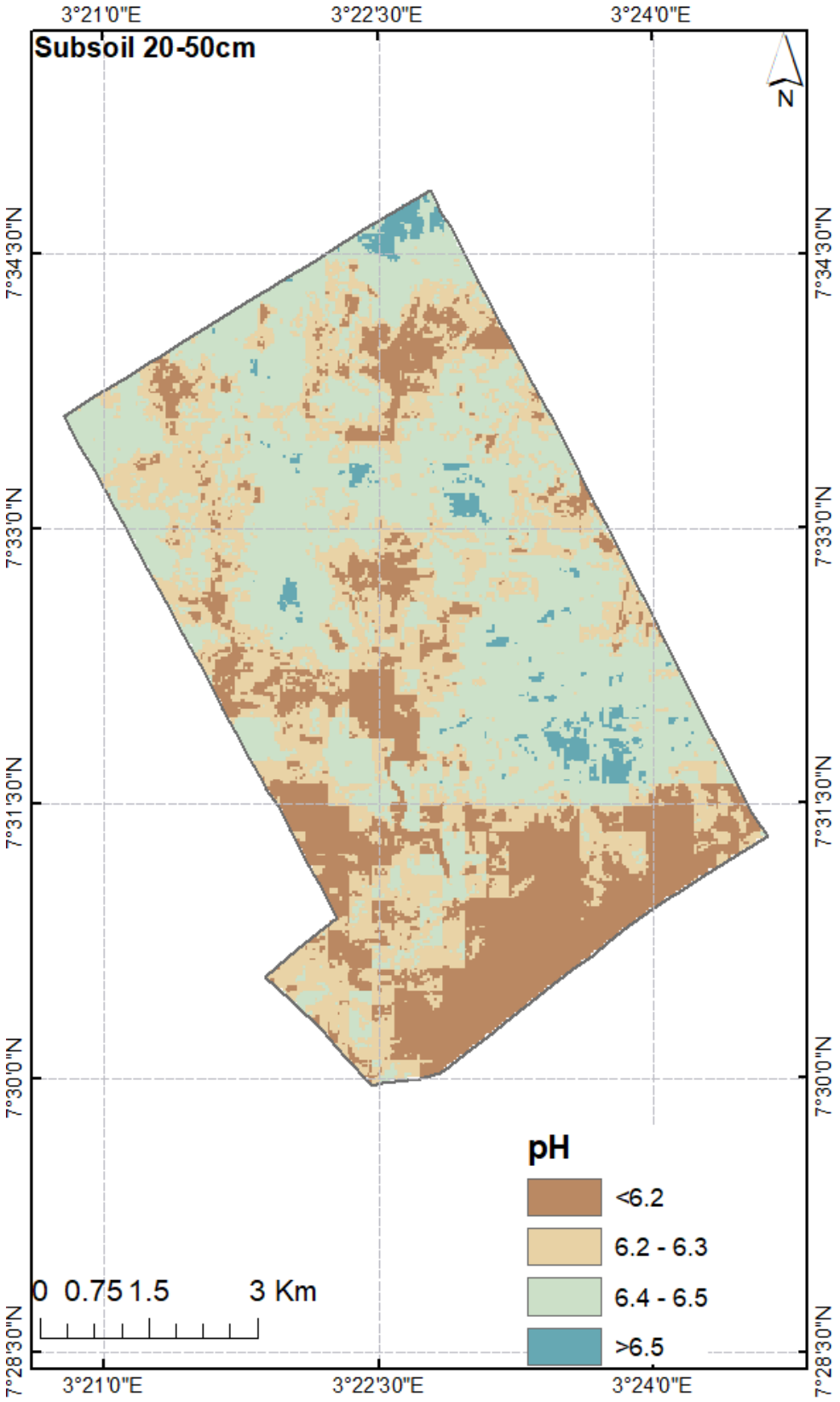
Appendix 1: Wet chemistry soil analysis results of some of points within the Eruwa Farm settlement

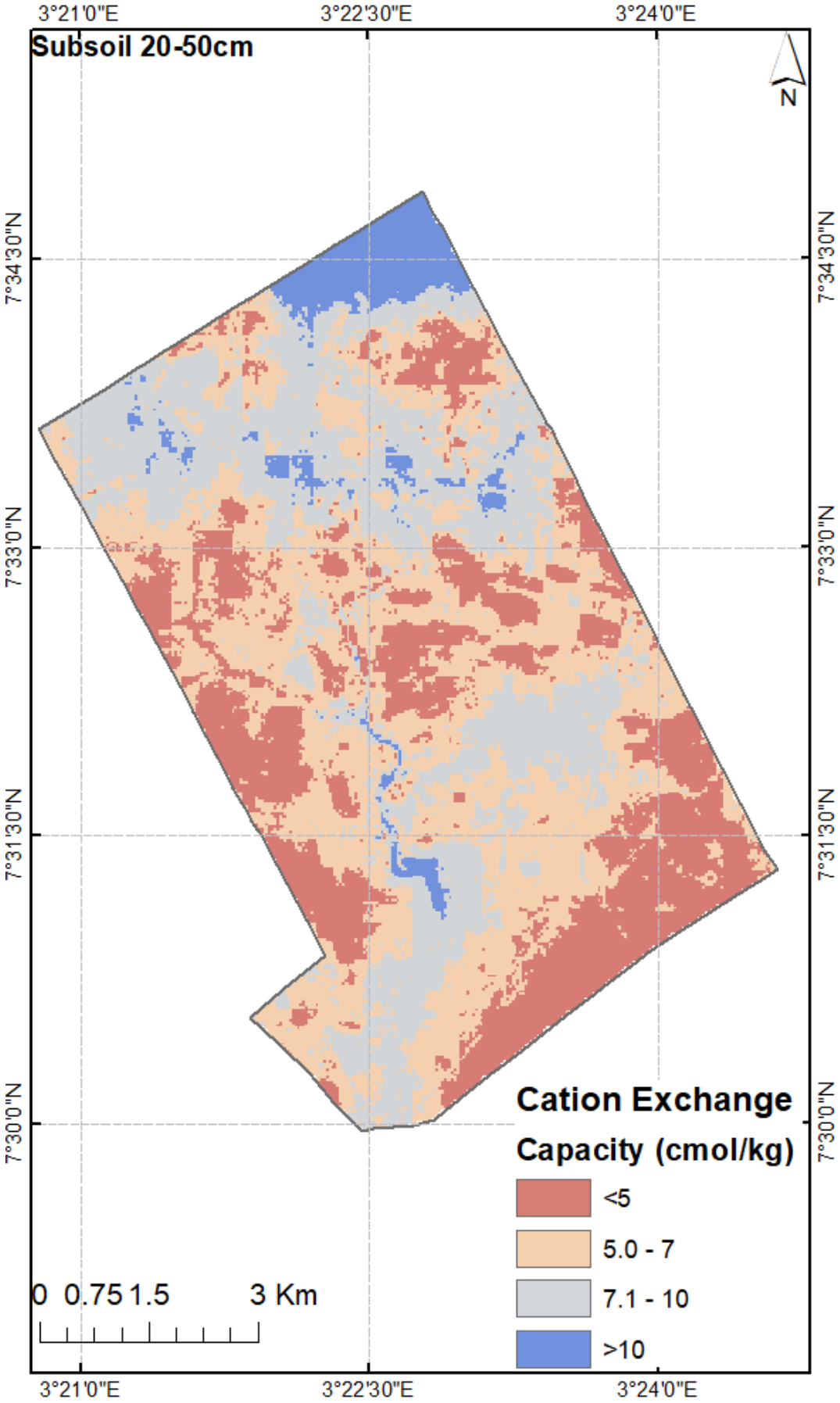
Lab	Sample	Your	pH(H20)	OC	N	Meh P	Particle size			Ca	Mg	K	Na	ECEC	Zn	Cu	Mn	Fe
ID	ID	ID	1:2.5	%	%	ppm	% SAND	% SILT	% CLAY	----------cmol+/kg----------					ppm	ppm	ppm	ppm
202100814	1	A1,0-20	5.7	0.80	0.069	3.67	70	13	17	4.12	1.11	0.14	0.09	5.45	204.05	7.67	34.91	405.86
202100815	2	A12,0-20	6.0	0.28	0.029	4.50	82	5	13	1.00	0.28	0.09	0.06	1.43	538.78	3.82	89.20	100.98
202100816	3	A24, 0-20	5.9	0.23	0.026	3.25	82	7	11	1.31	0.25	0.16	0.03	1.75	79.31	2.86	77.55	84.49
202100817	4	A24, 20-50	6.3	0.29	0.023	1.17	82	5	13	1.17	0.22	0.10	0.04	1.53	313.06	3.82	58.00	73.27
202100818	5	A29, 0-20	6.0	0.26	0.028	0.47	82	5	13	0.92	0.23	0.11	0.06	1.32	483.34	3.82	36.68	139.92
202100819	6	B22, 0-20	6.0	1.12	0.107	2.00	62	15	23	7.21	1.73	0.19	0.13	9.26	27.73	4.78	22.67	254.08
202100820	7	B22, 20-50	6.2	0.42	0.050	2.97	74	13	13	4.17	1.07	0.10	0.11	5.46	19.81	3.82	23.06	158.40
202100821	8	A21, 0-20	6.3	0.18	0.020	1.59	82	7	11	1.45	0.30	0.19	0.06	2.00	438.79	2.86	62.94	124.74
202100822	9	A14, 0-20	6.1	0.69	0.050	2.00	84	7	9	3.84	0.73	0.32	0.03	4.93	404.14	4.78	61.16	99.01
202100823	10	B14, 0-20	6.4	0.24	0.018	2.14	84	5	11	1.69	0.23	0.07	0.04	2.04	317.02	2.86	62.15	83.17
202100824	11	B6, 0-20	6.6	1.92	0.175	4.64	64	13	23	19.61	2.18	0.32	0.20	22.30	261.58	7.67	58.60	246.16
202100825	12	B14, 0-20	7.0	0.59	0.039	5.89	82	7	11	4.48	0.70	0.36	0.04	5.57	47.94	4.78	124.73	132.66
202100826	13	B34, 0-20	6.5	0.68	0.050	2.56	78	9	13	4.28	0.79	0.19	0.04	5.30	35.27	5.74	86.83	152.46
202100827	14	B12, 0-20	6.2	1.07	0.080	5.61	72	11	17	3.35	0.54	0.14	0.19	4.22	19.81	6.70	66.89	387.38
202100828	15	B20, 0-20	6.2	0.44	0.034	1.31	84	5	11	2.66	0.72	0.09	0.04	3.51	23.77	5.74	78.14	162.36
202100829	16	B27, 0-20	6.0	1.54	0.111	7.00	64	19	17	8.91	1.70	0.32	0.08	11.02	433.84	6.70	81.10	242.20
202100830	17	B41, 0-20	6.3	0.43	0.032	2.14	84	5	11	2.05	0.37	0.22	0.04	2.68	17.83	4.78	92.35	108.90
202100831	18	C6, 0-20	6.1	0.76	0.069	1.45	86	5	9	3.90	0.80	0.20	0.04	4.93	29.71	5.74	80.11	100.98
202100832	19	C6, 20-50	6.4	0.48	0.040	1.86	86	5	9	3.65	0.55	0.16	0.06	4.43	35.27	6.70	64.72	88.45
202100833	20	C24, 0-20	6.3	0.77	0.067	1.59	84	5	11	4.01	1.11	0.34	0.05	5.51	34.87	7.67	30.96	168.95
202100834	21	C39,0-20	6.3	0.66	0.047	2.14	84	7	9	2.08	0.63	0.30	0.05	3.06	30.32	5.74	86.23	120.12
202100835	22	C29, 0-20	7.4	0.72	0.058	6.45	86	5	9	6.13	0.84	0.40	0.06	7.43	36.85	6.70	84.46	116.82
202100836	23	C40, 0-20	5.9	0.95	0.080	3.25	73	11	16	1.47	0.17	0.19	0.06	1.90	36.45	4.78	43.79	401.24
202100837	24	C40, 20-50	5.6	0.54	0.048	1.45	75	9	16	1.22	0.12	0.16	0.08	1.59	21.79	7.67	29.18	310.17

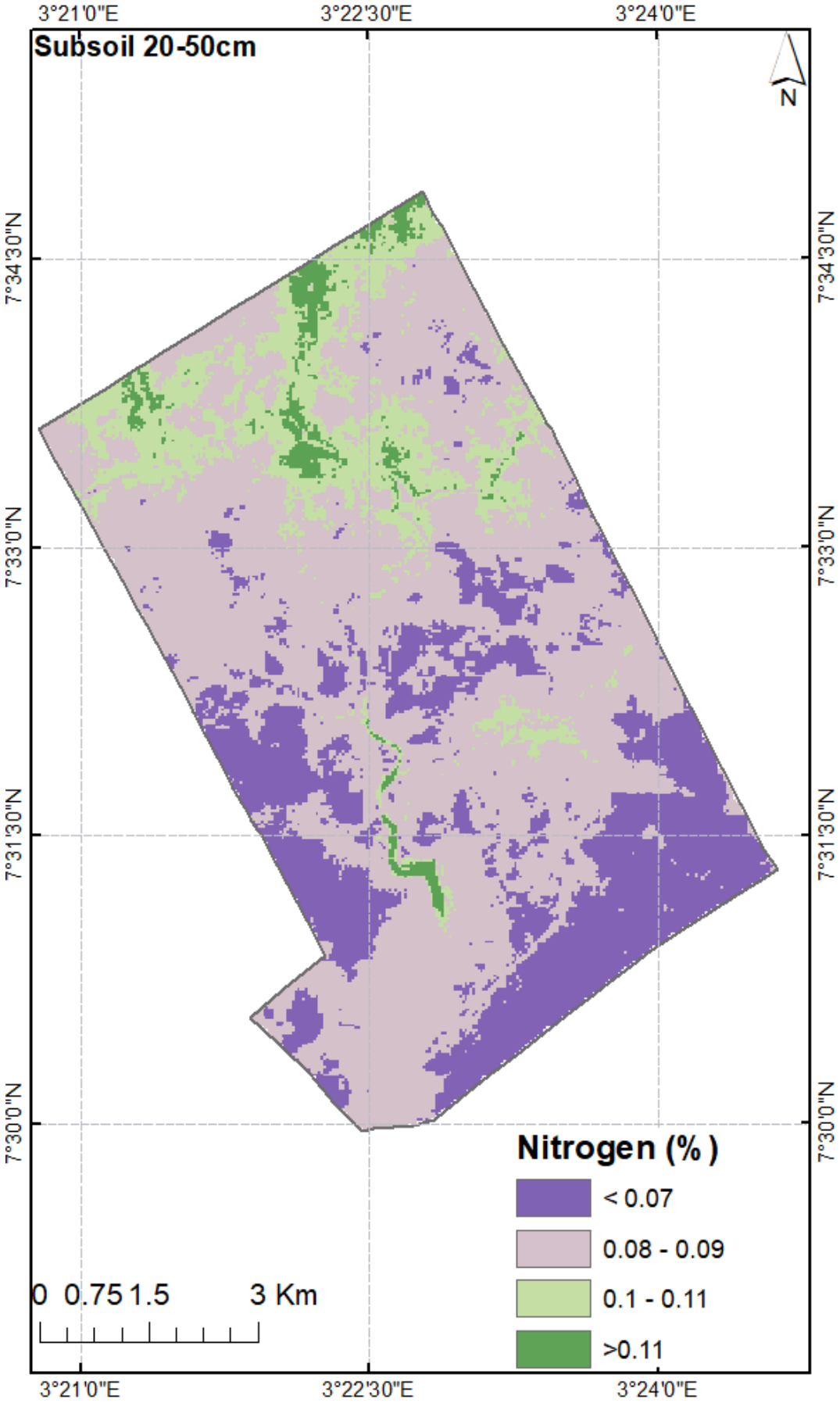
Appendix 2: Wet chemistry soil analysis results of some of points within the Fasola Farm settlement

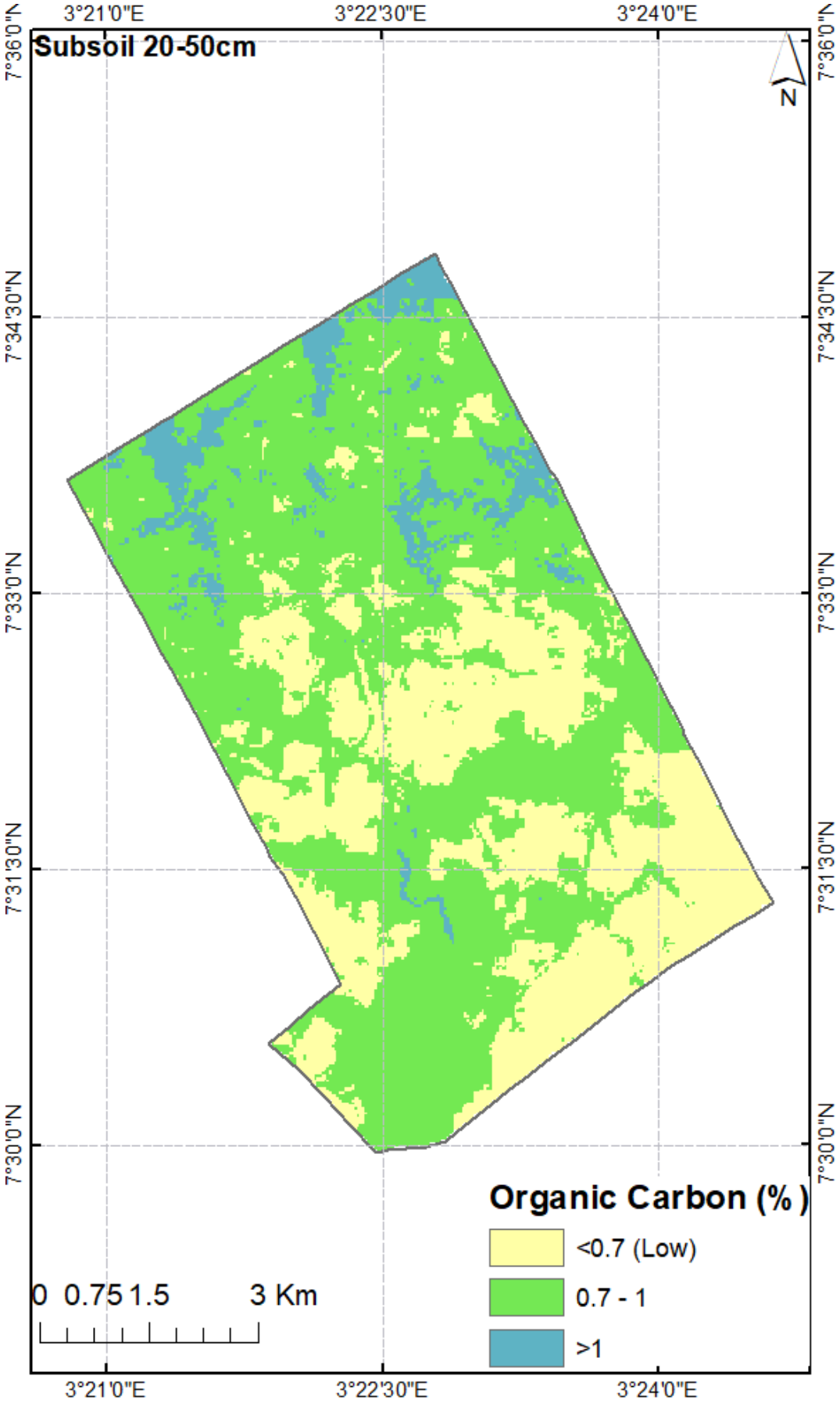
Lab	Sample	Your	pH(H20)	OC	N	Meh P	Particle size			Ca	Mg	K	Na	ECEC	Zn	Cu	Mn	Fe
ID	ID	ID	1:2.5	%	%	ppm	% SAND	% SILT	% CLAY	----------cmol+/kg----------					ppm	ppm	ppm	ppm
202100838	25	F15, 0-20	5.8	0.72	0.056	4.78	85	5	10	3.46	0.96	0.38	0.05	4.85	36.45	5.74	61.95	108.24
202100839	26	F15, 20-50	6.6	0.46	0.054	1.86	83	5	12	1.83	0.59	0.19	0.05	2.67	13.87	5.74	63.33	73.27
202100840	27	F9, 0-20	6.1	0.60	0.050	3.11	81	7	12	3.26	0.52	0.24	0.03	4.06	35.27	6.70	56.82	76.57
202100841	28	F26, 0-20	6.4	0.51	0.040	4.09	81	7	12	2.08	0.51	0.17	0.03	2.80	36.26	3.82	111.90	92.41
202100842	29	F28, 0-20	5.9	0.39	0.031	7.56	85	5	10	1.34	0.25	0.12	0.04	1.74	34.87	2.86	13.59	174.23
202100843	30	F30, 0-20	6.5	0.98	0.070	8.81	85	5	10	5.03	0.90	0.42	0.03	6.38	71.88	1.90	70.44	97.03
202100844	31	F30, 20-50	6.8	0.50	0.037	5.06	83	7	10	2.80	0.61	0.30	0.03	3.74	27.73	3.82	90.97	147.18
202100845	32	F51, 0-20	6.7	0.45	0.035	1.17	77	9	14	3.32	1.08	0.15	0.12	4.67	176.33	4.78	43.40	205.25
202100846	33	F42, 0-20	6.3	0.74	0.050	5.89	81	7	12	5.28	0.70	0.30	0.04	6.32	175.84	5.74	125.13	140.58
202100847	34	F22, 0-20	7.1	1.39	0.112	88.06	77	9	14	9.88	1.28	0.97	0.04	12.17	93.66	6.70	98.08	183.47
202100848	35	F18, 0-20	6.6	1.70	0.148	31.13	75	11	14	10.68	1.74	0.90	0.05	13.37	338.80	4.78	103.80	108.24
202100849	36	F18, 20-50	7.0	0.72	0.059	17.69	75	11	14	5.97	1.20	0.46	0.06	7.68	222.97	4.78	90.97	86.47

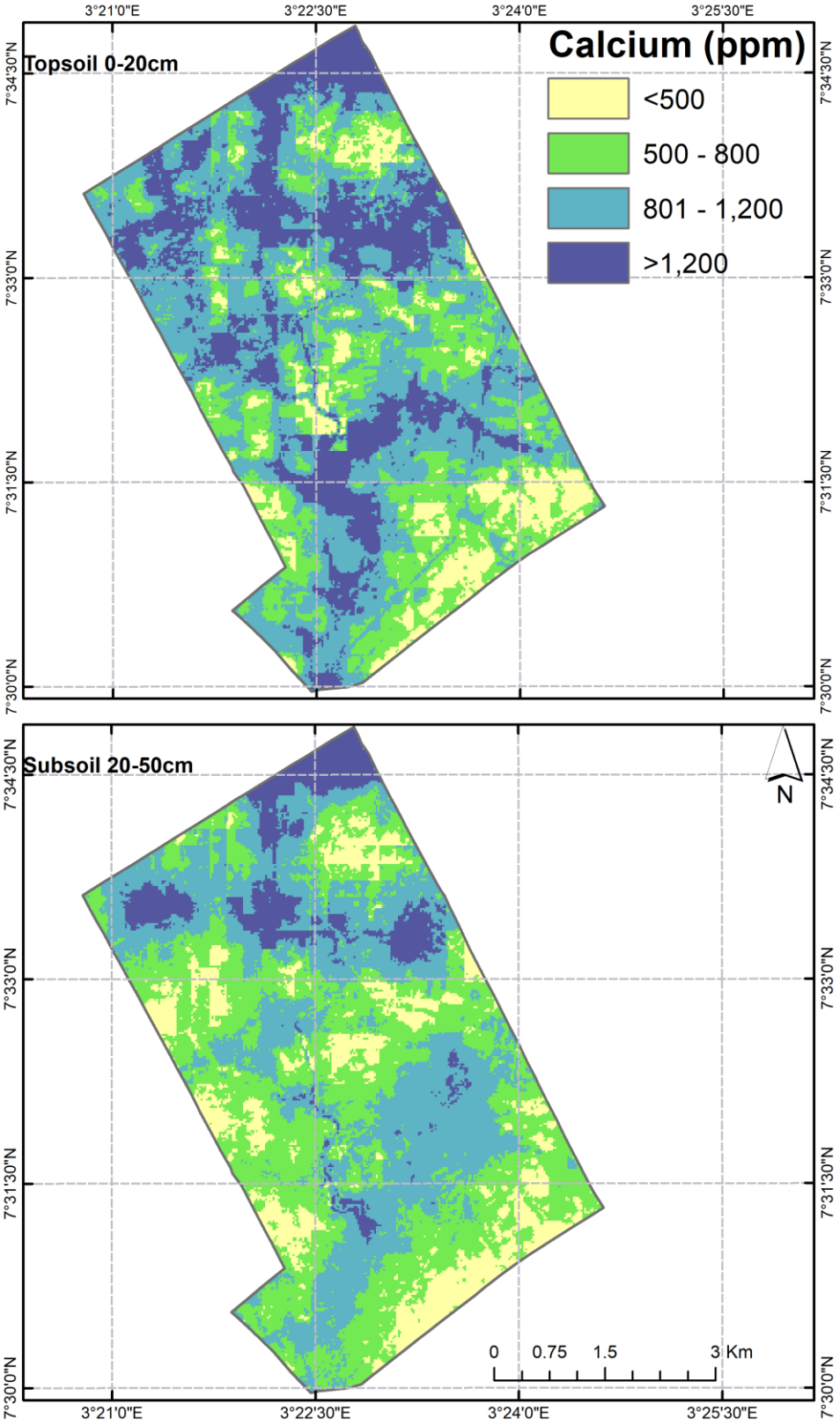
Appendix 3: Maps of macro and micronutrients distribution within the Eruwa Farm settlement

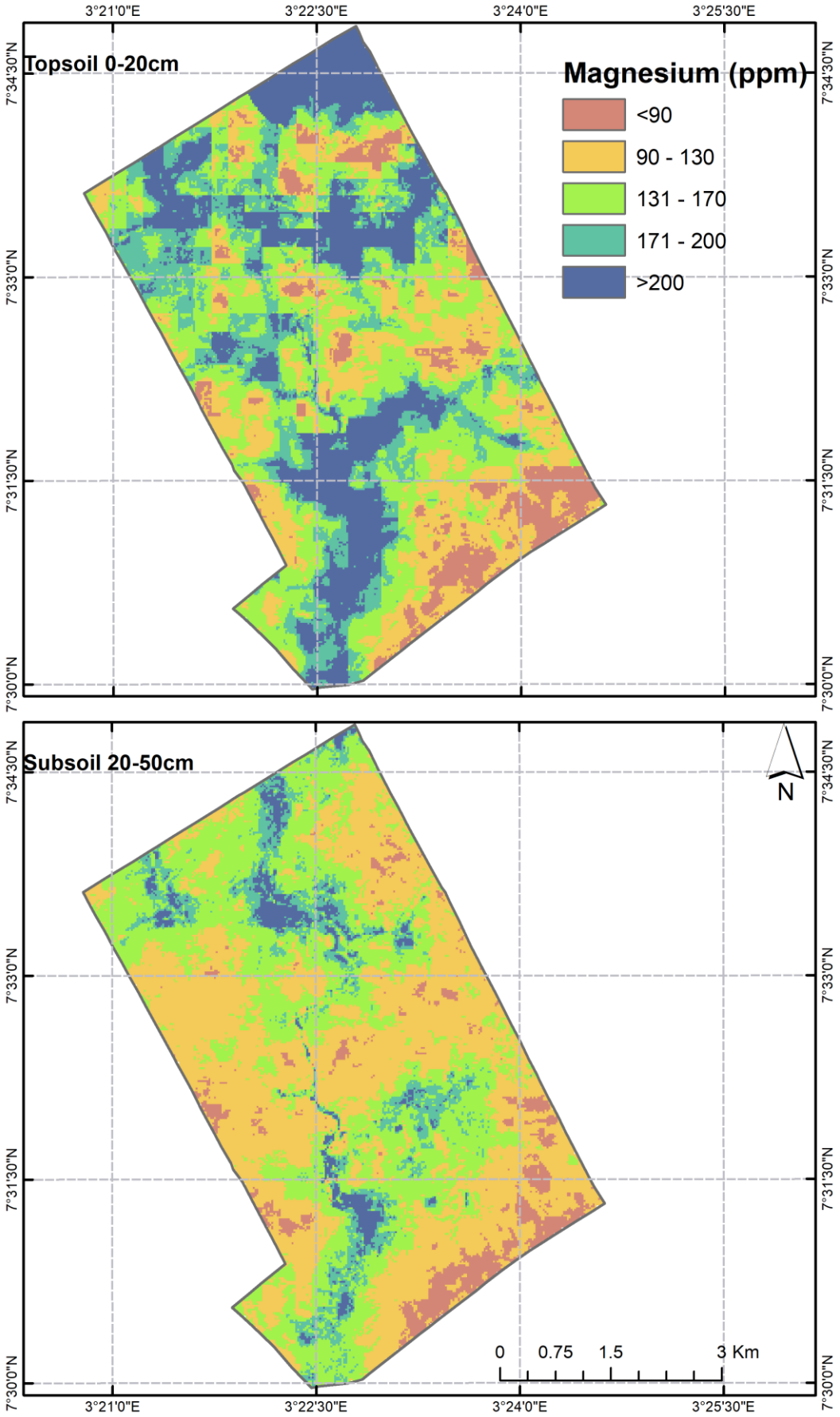


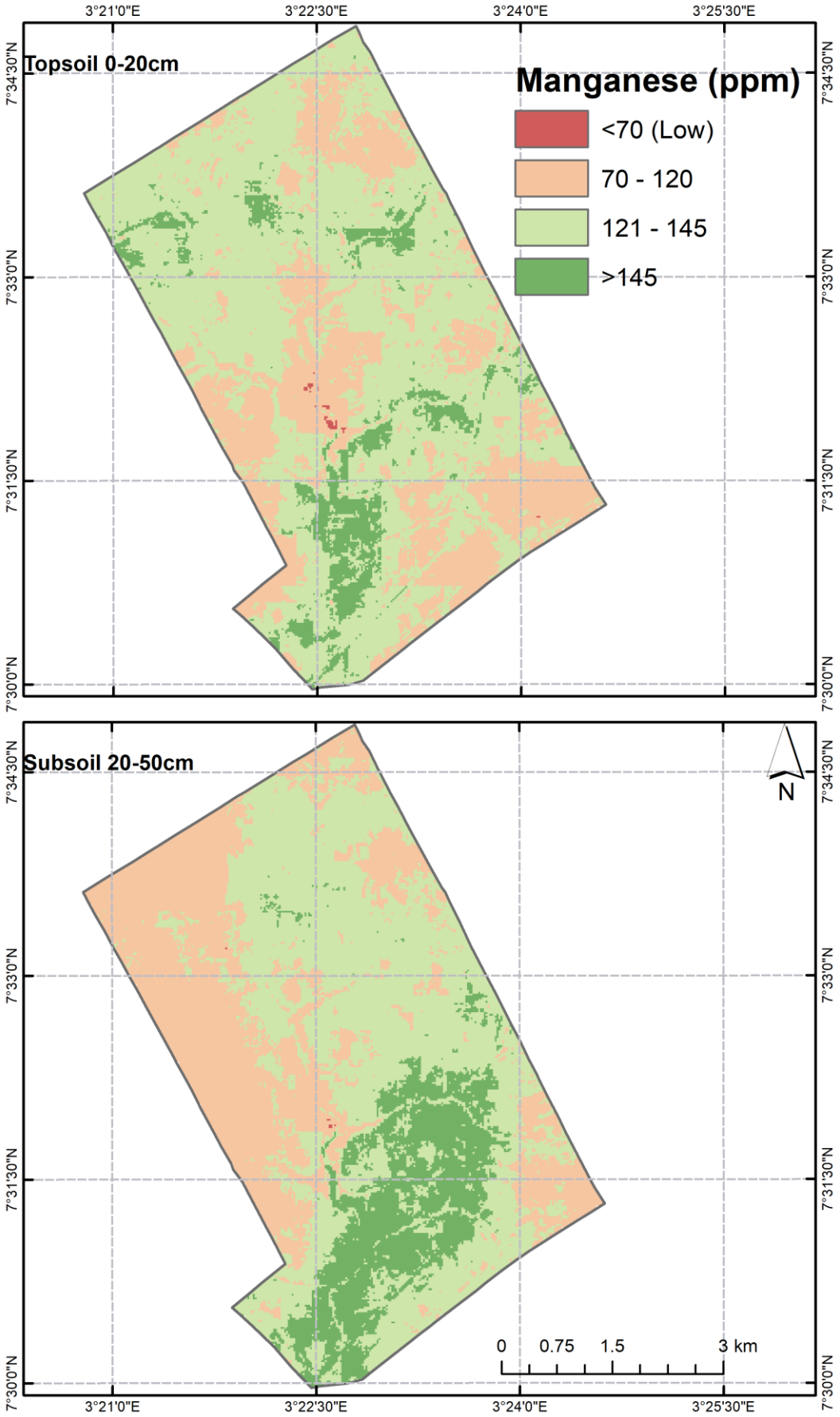

Subsoil 20-50cm
N
3°21'0"E
3°22'30"E
3°24'0"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N
Cation Exchange
Capacity (cmol/kg)
≤5
5.0 - 7
7.1 - 10
>10
0 0.75 1.5 3 Km

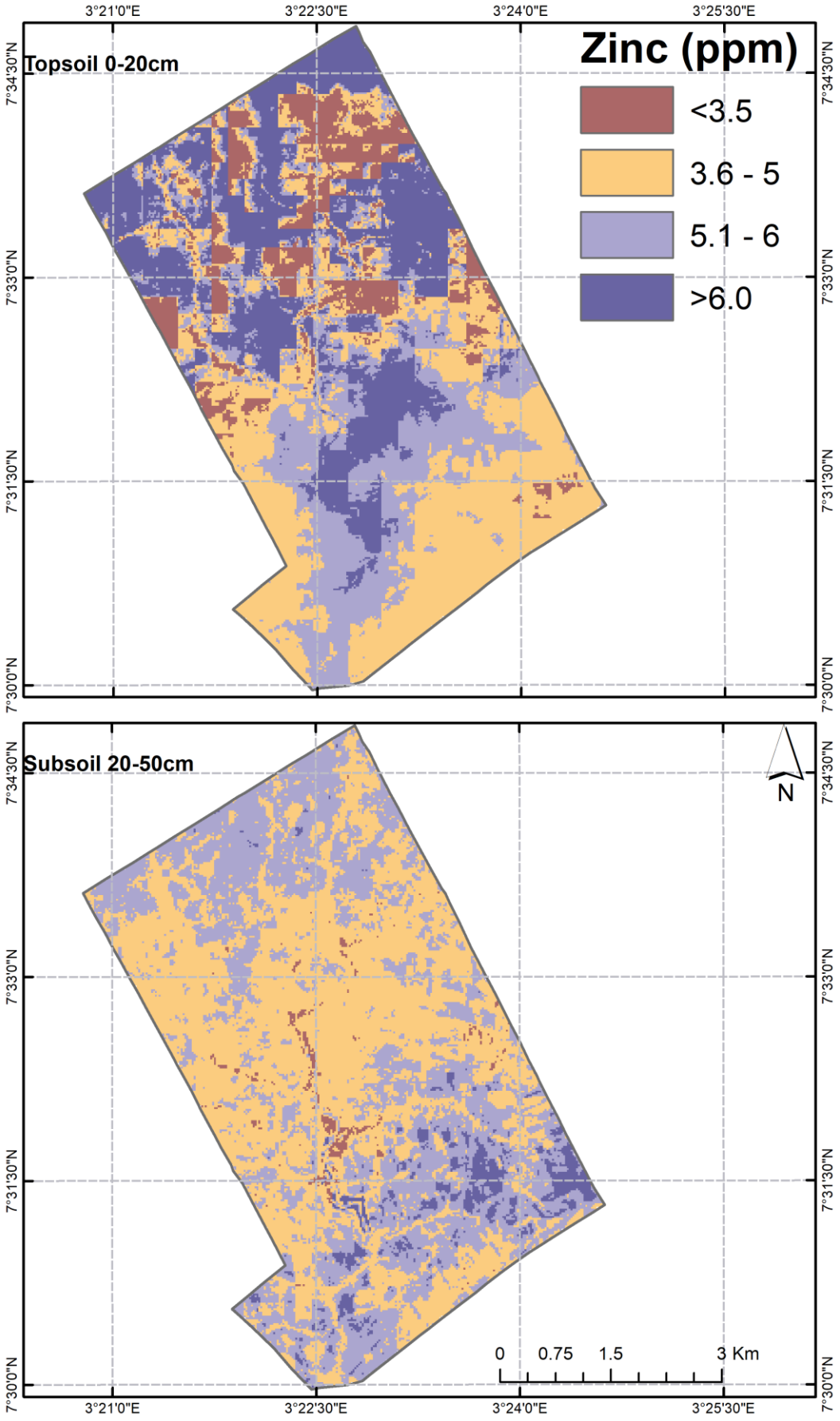

Subsoil 20-50cm
N
3°21'0"E
3°22'30"E
3°24'0"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N
Nitrogen (%)
< 0.07
0.08 - 0.09
0.1 - 0.11
>0.11
0 0.75 1.5 3 Km

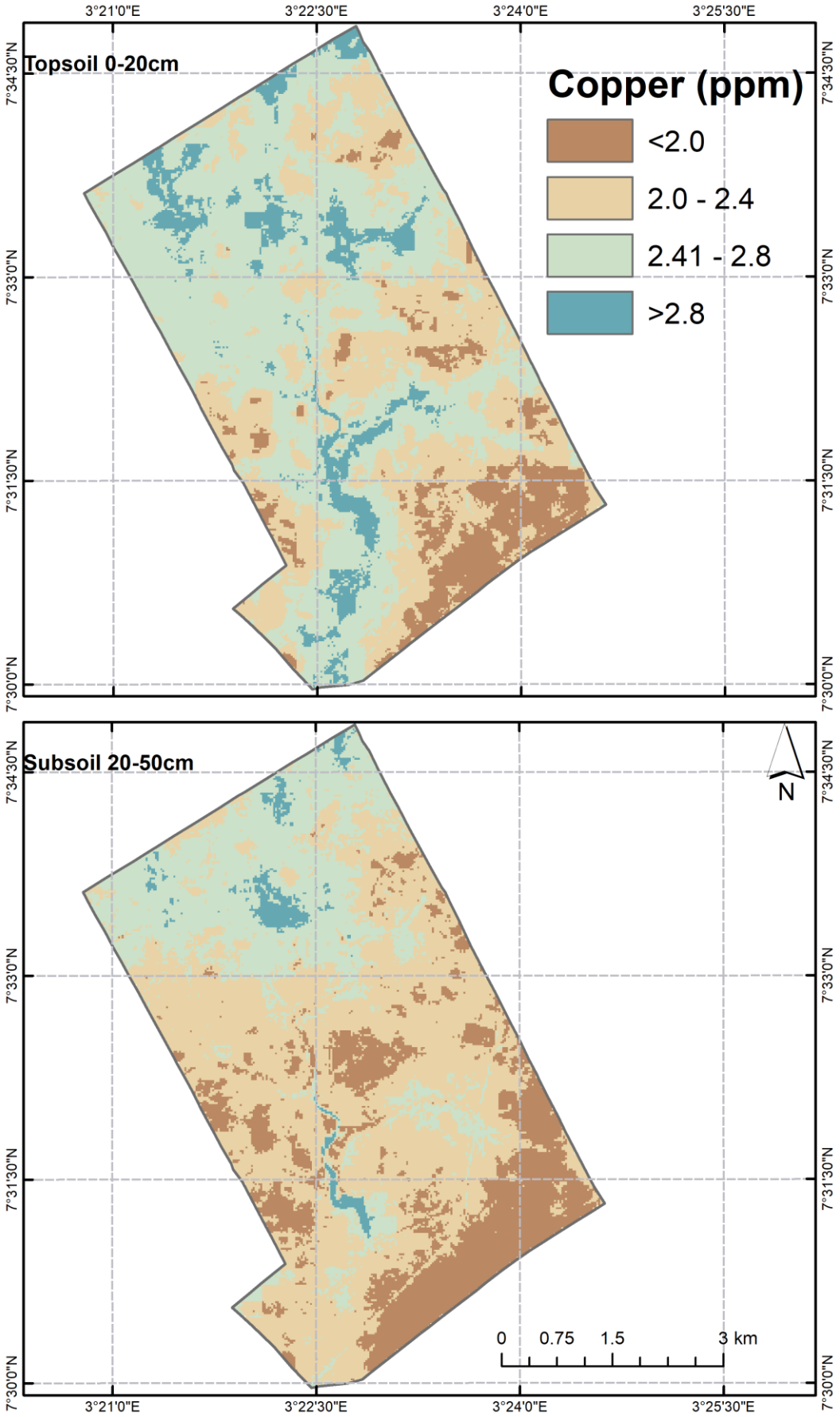

Subsoil 20-50cm
N
3°21'0"E
3°22'30"E
3°24'0"E
7°36'0"N
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N
Organic Carbon (%)
<0.7 (Low)
0.7 - 1
>1
0 0.75 1.5 3 Km


Topsoil 0-20cm
Calcium (ppm)
<500
500 - 800
801 - 1,200
>1,200
Subsoil 20-50cm
N
0 0.75 1.5 3 Km
3°21'0"E
3°22'30"E
3°24'0"E
3°25'30"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N

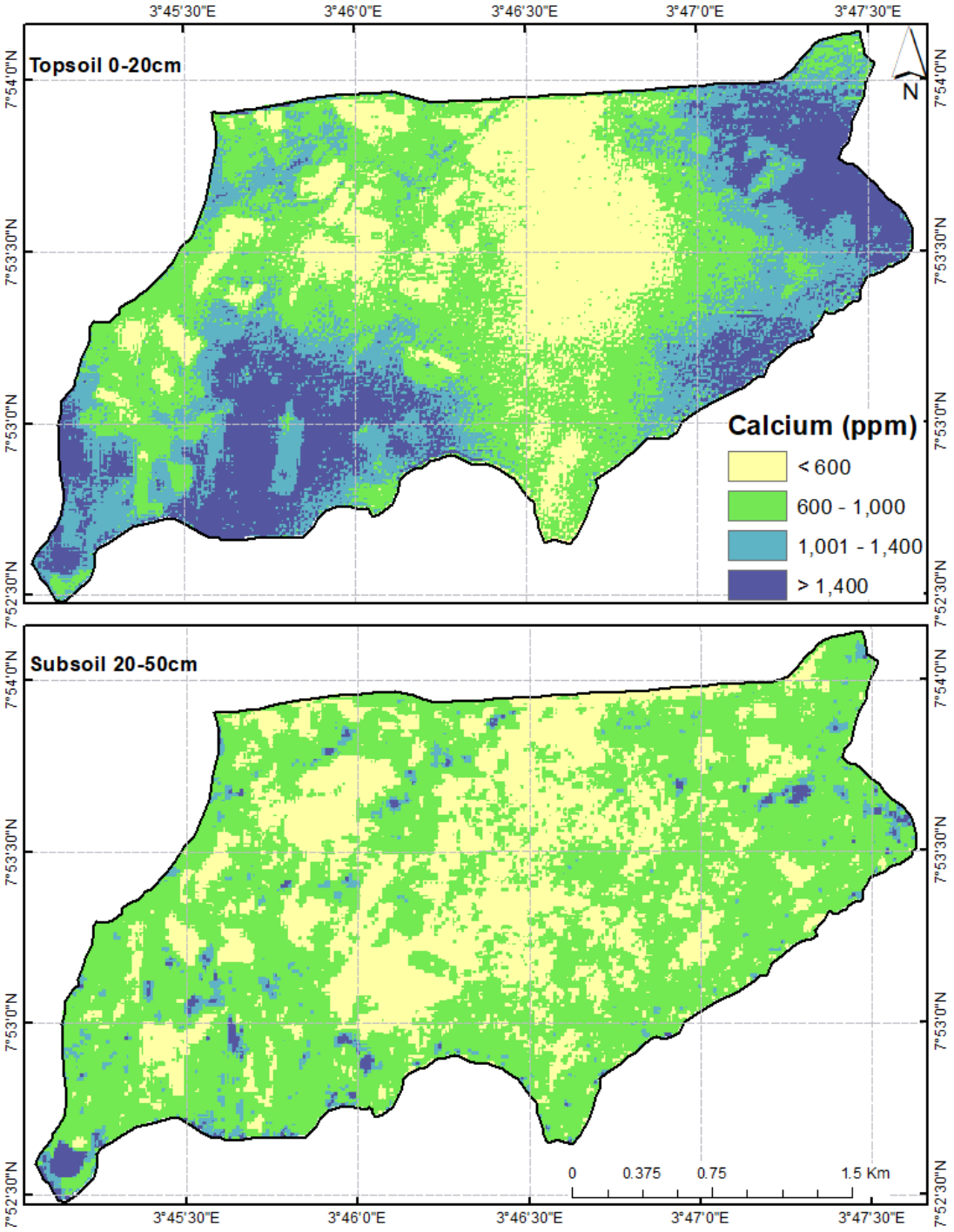

Topsoil 0-20cm
Magnesium (ppm)
<90
90 - 130
131 - 170
171 - 200
>200
Subsoil 20-50cm
N
0 0.75 1.5 3 Km
3°21'0"E
3°22'30"E
3°24'0"E
3°25'30"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N

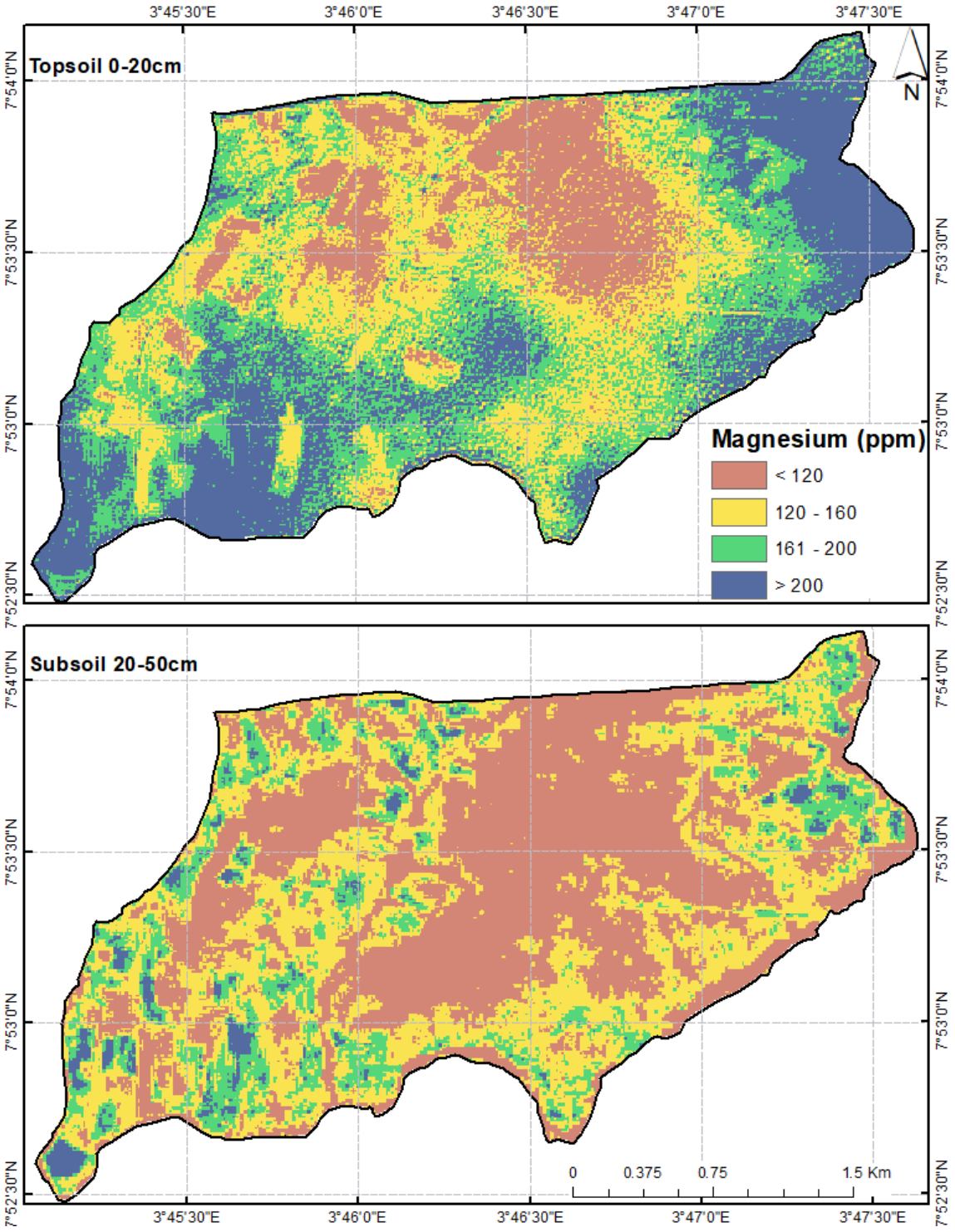

Topsoil 0-20cm
Manganese (ppm)
<70 (Low)
70 - 120
121 - 145
>145
Subsoil 20-50cm
N
0 0.75 1.5 3 km
3°21'0"E
3°22'30"E
3°24'0"E
3°25'30"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N

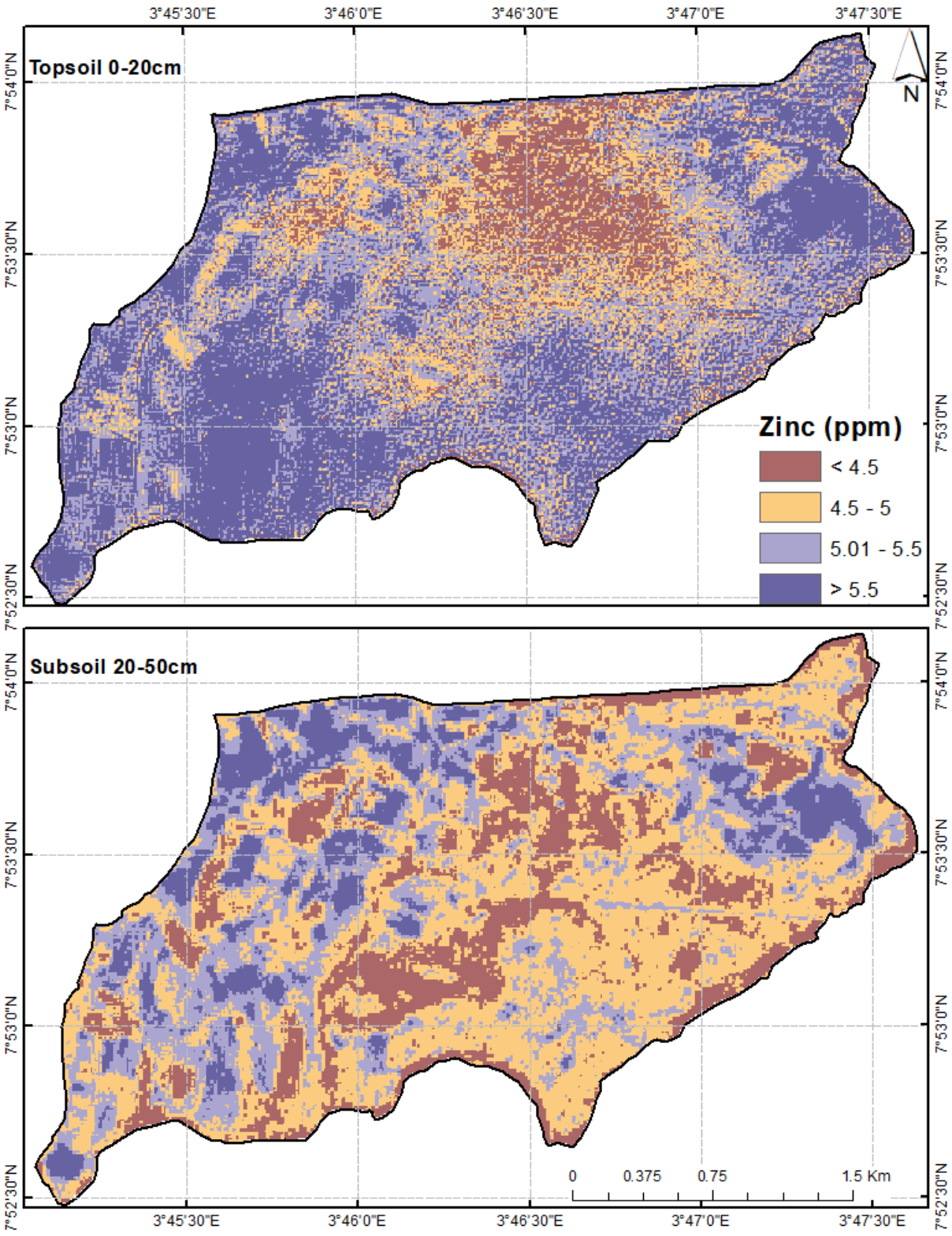

Topsoil 0-20cm
Zinc (ppm)
<3.5
3.6 - 5
5.1 - 6
>6.0
Subsoil 20-50cm
N
0 0.75 1.5 3 Km
3°21'0"E
3°22'30"E
3°24'0"E
3°25'30"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N

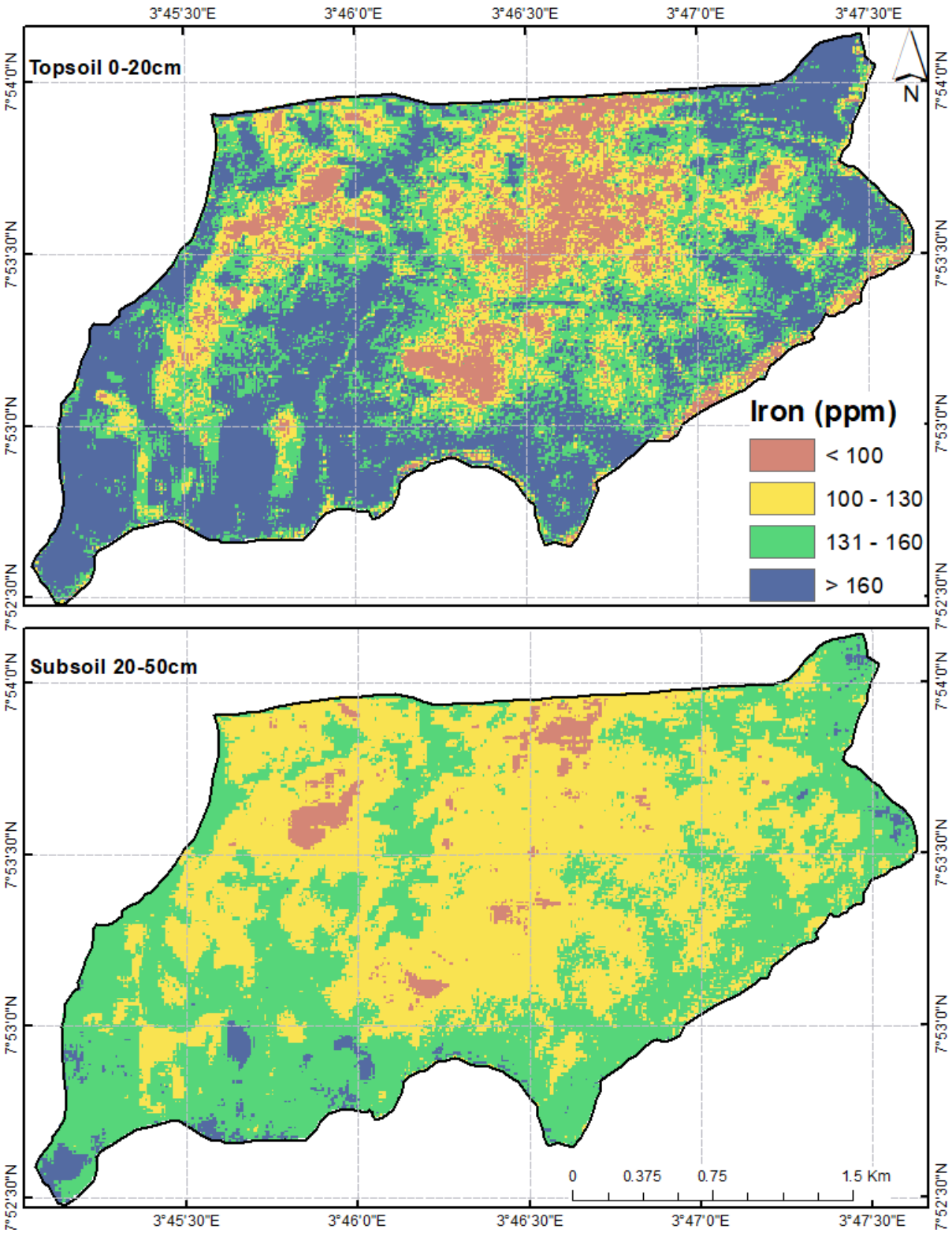

Topsoil 0-20cm
Copper (ppm)
<2.0
2.0 - 2.4
2.41 - 2.8
>2.8
Subsoil 20-50cm
N
0 0.75 1.5 3 km
3°21'0"E
3°22'30"E
3°24'0"E
3°25'30"E
7°34'30"N
7°33'0"N
7°31'30"N
7°30'0"N

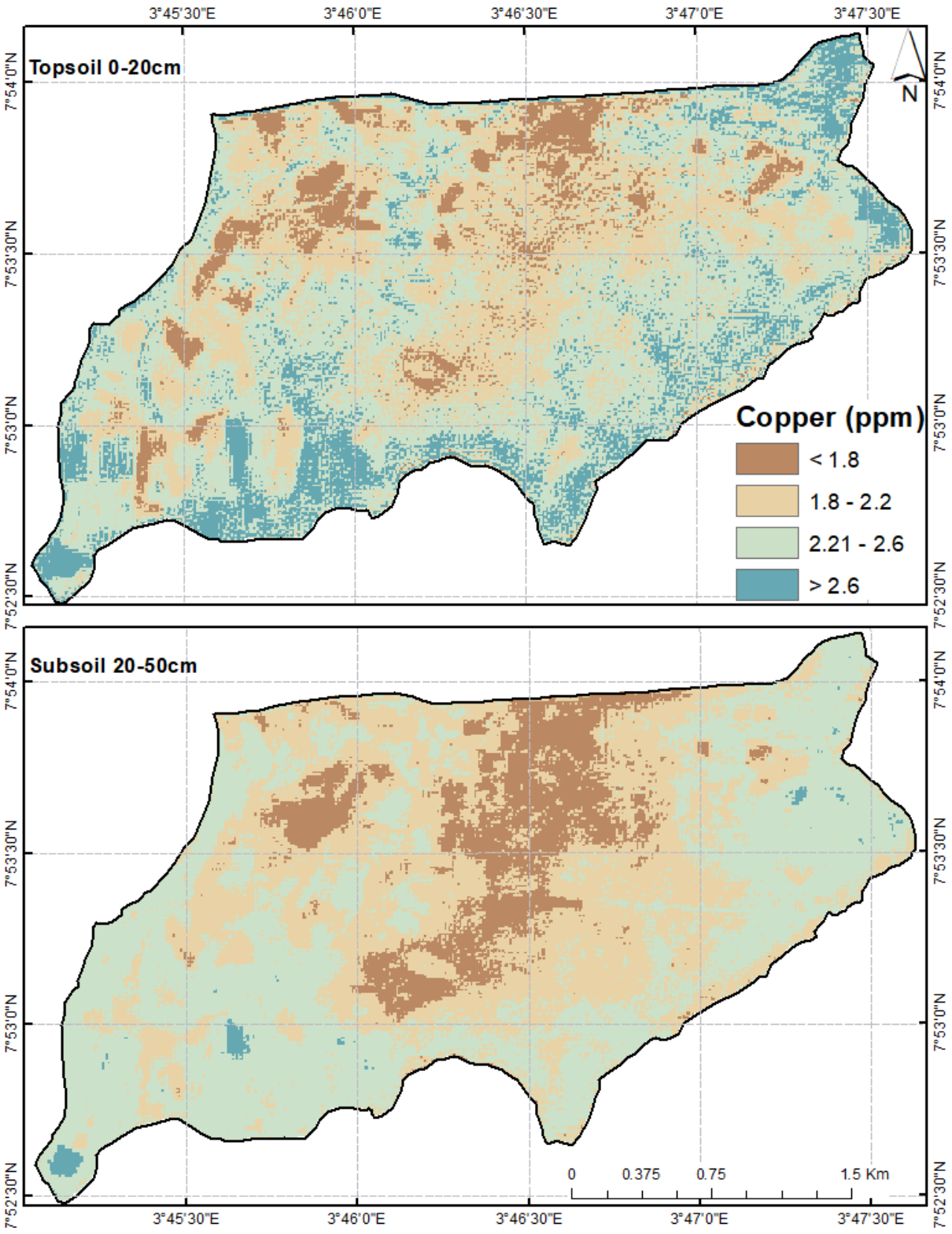
Appendix 4: Maps of macro and micronutrients distribution within the Fasola Farm settlement




Topsoil 0-20cm
Subsoil 20-50cm
Magnesium (ppm)
< 120
120 - 160
161 - 200
> 200
N
0
0.375
0.75
1.5 Km
3°45'30"E
3°46'0"E
3°46'30"E
3°47'0"E
3°47'30"E
7°54'0"N
7°53'30"N
7°53'0"N
7°52'30"N


Topsoil 0-20cm
Subsoil 20-50cm
N
Zinc (ppm)
< 4.5
4.5 - 5
5.01 - 5.5
> 5.5
0
0.375
0.75
1.5 Km
3°45'30"E
3°46'0"E
3°46'30"E
3°47'0"E
3°47'30"E
7°54'0"N
7°53'30"N
7°53'0"N
7°52'30"N


Topsoil 0-20cm
Subsoil 20-50cm
N
Iron (ppm)
< 100
100 - 130
131 - 160
> 160
0
0.375
0.75
1.5 Km
3°45'30"E
3°46'0"E
3°46'30"E
3°47'0"E
3°47'30"E
7°54'0"N
7°53'30"N
7°53'0"N
7°52'30"N


Topsoil 0-20cm
Subsoil 20-50cm
N
Copper (ppm)
< 1.8
1.8 - 2.2
2.21 - 2.6
> 2.6
0
0.375
0.75
1.5 Km
3°45'30"E
3°46'0"E
3°46'30"E
3°47'0"E
3°47'30"E
7°54'0"N
7°53'30"N
7°53'0"N
7°52'30"N

Appendix 5 Eruwa farm Observation data

Sample ID	*Lat*	*Lon*	*Topographic position*	*Soil depth (cm)*	*Topsoil Colour*	*Subsoil Colour*	*Remarks*
Eruwa B14	7.5305	3.3871	Midslope	50	10YR3/2	10YR3/2	Cassava maize farm. Maize has been harvested and there are stones on the surface and there are no trees.
Eruwa B13	7.5306	3.3825	Footslope	60	10YR2/1	10YR4/2	The land is dry but there is likelihood of stagnant water during rainy season. This is majorly a cassava farm at about 3months of growth
Eruwa B15	7.5306	3.3919	Upland	35	7.5YR2.5/2	7.5YR2.5/2	The land is in fallow land.
Eruwa D4	7.5388	3.8957	Ridge_Crest	100	Yr	Yt	No
Eruwa B40	7.5450	3.3967	Upland	60	7.5YR3/2	7.5YR4/3	Cassava farm with stony soil
Eruwa B39	7.5448	3.3920	Upland	45	7.5YR3/2	7.5YR4/4	Fallow land
Eruwa B32	7.5401	3.3873	Upland	70	7.5YR4/3	7.5YR3/4	Cassava farm about 2months growth
Eruwa B22	7.5352	3.3873	Footslope	100	10YR2/1	10YR3/1	Site will to be good for rice farming also likely to be flooded during rainy season and presently used as a grazing land.
Eruwa B10	7.5304	3.3680	Upland	55	10YR3/2 very dark grayish brown	10YR3/3 dark brown	Recently ploughed land with no crop on it
Eruwa B11	7.5305	3.3728	Upland	30	10YR2/1 Black	10YR2/2 very dark brown	Forest land.
Eruwa B12	7.5303	3.3758	Footslope	100	10YR2/1 Black	10YR2/1 Black	The main point is 118m directly inside the water, so sample was taken about 150m on a dry soil. Grazing land
Eruwa B28	7.5401	3.3679	Upland	20	10YR2/2	n/a	Stoney soil with 20cm depth. No Subsoil at this particular location. Forest land.
Eruwa B21	7.5353	3.3825	Upland	55	10YR2/1	10YR2/1	Cassava land about 3months old
Eruwa B20	7.5354	3.3777	Midslope	45	10YR2/2	10YR3/3	Partly a cassava farm with fallow land
Eruwa B31	7.5401	3.3824	Midslope	100	10YR3/3	10YR4/2	This is cassava field

Eruwa B30	7.5402	3.3776	Upland	60	10YR3/1 very dark gray	10YR3/2 very dark grayish brown	This is a cassava field recently planted. The soil is sandy and very stony
Eruwa B33	7.5401	3.3922	Upland	35	10YR3/3 dark brown	10YR3/4 dark yellowish brown	This is cassava field recently harvested
Eruwa B16	7.5303	3.3967	Upland	70	10YR3/1 very dark gray	10YR2/2 very dark brown	Fallow land with charcoal process points.
Eruwa B24	7.5346	3.3969	Upland	n/a	10YR3/6 Dark yellowish brown	7.5YR4/3 brown	Cassava harvested plot recently ploughed with some area newly cultivated with cassava about 3months old.
Eruwa B25	7.5354	3.4016	Upland	80	10YR3/2 very dark grayish brown	10YR3/2very dark grayish brown	Cassava farm of 3 months old couple cashew growth about 3years old, Maize harvested plot.
Eruwa B34	7.5401	3.3968	Bottomland	100	10YR3/1 very dark grey	10YR3/2 very dark grayish brown	Site will be good for rice farming, cassava grown partly one side and economic tress (cashew) only observed one part of the site that is not Prone to flood.
Eruwa B46	7.5488	3.3951	Upland	50	10YR3/3 dark brown	10YR3/4 dark yellowish brown	Fallow land
Eruwa B43	7.5497	3.3920	Upland	60	10YR3/3 dark brown	7.5YR3/3 dark brown	Fallow land with observation of grazing.
Eruwa B42	7.5496	3.3873	Upland	70	10YR3/3 dark brown	10YR3/4 dark yellowish brown	Cassava farm
	7.5239	3.4167	Ridge_Crest	n/a	n/a	n/a	n/a

ERUWA	7.5740	3.3817	Midslope	40	10yr 3/4	10yr 4/3	Cassava plantation with you g cashew; clean weeded; stony
ERUWA	7.5692	3.3673	Midslope	60	10yr 3/4	10yr 3/6	Cassava plantation without tree and shrub
ERUWA	7.5596	3.3626	Midslope	25	10yr 3/1	10yr 3/3	Woodland not used but over grazed
ERUWA	7.5548	3.3673	Midslope	25	10yr 3/4	10yr 3/6	Uncultivated woodland
ERUWA	7.5548	3.3625	Midslope	30	10yr 3/4	10yr 4/3	Cassava plantation without cashew
ERUWA	7.5500	3.3625	Midslope	65	10yr 3/4	10yr 3/6	Old cashew plantation
ERUWA	7.5500	3.3769	Midslope	30	10yr 3/4	10yr 4/3	Ploughed land with scattered trees and shrub
ERUWA	7.5500	3.3721	Midslope	80	10yr 3/4	10yr 4/4	Woody grazing land
ERUWA	7.5452	3.3674	Midslope	65	10yr 2/1	10yr 3/4	Packing from land clearing. Sampling at 12 m away because of decaying woods
ERUWA	7.5453	3.3625	Midslope	70	10yr 3/4	10yr 3/6	Cassava plantation
ERUWA	7.5500	3.3673	Midslope	30	10yr 3/4	10yr 3/6	Woodland
ERUWA	7.5644	3.3769	Midslope	40	10yr 3/4	10yr 3/6	Young cassava plantation
ERUWA	7.5596	3.3769	Midslope	25	10yr 3/2	10yr 3/4	Wood land
ERUWA	7.5596	3.3674	Midslope	25	10yr 2/1	10yr 3/2	Cashew plantation
ERUWA	7.5500	3.3577	Midslope	65	10yr 2/1	10yr 3/4	Wood land
ERUWA	7.5500	3.3529	Midslope	35	10yr 2/2	10yr 3/4	Wood land
ERUWA	7.5597	3.3722	Midslope	90	10yr 3/1	10yr 3/1	Wood land
ERUWA	7.5548	3.3721	Midslope	30	10yr 3/4	10yr 3/6	Ploughed land
Eruwa B41	7.5498	3.3825	Upland	50	10YR4/3 brown	10UR4/3 brown	Cassava farm
Eruwa B38	7.5448	3.3872	Upland	35	10YR4/3 brown	10YR4/3 brown	Recently cultivated cassava farm about a month with recently harvested cassava plot.
Eruwa B37	7.5449	3.3824	Upland	35	10YR3/2 very dark grayish brown	10YR3/3 dark brown	Cassava farm of different ages
Eruwa B36	7.5449	3.3778	Upland	45	10YR3/1 very dark grey	10YR3/2 very dark grayish brown	Partly fallow land and partly cassava cultivated.

Eruwa B44	7.5544	3.3921	Upland	70	10YR3/2 very dark grayish brown	10YR3/3 dark brown	Harvested maize farm.
Eruwa B9	7.5311	3.3641	Upland	35	10YR3/1 very dark grey	10YR2/2 very dark brown	Stoney plot with Cashew plantation about 3years old.
Eruwa B17	7.5351	3.3631	Midslope	75	10YR3/2 very dark grayish brown	10YR4/1 dark grey	Land presently not in use
Eruwa B18	7.5351	3.3680	Upland	40	7.5YR2.5/2 very dark brown	7.5YR3/2 dark brown	Cassava farm about 3months old
Eruwa 26	7.5402	3.3584	Upland	20	7.5YR3/2 dark brown	n/a	Stoney soil, Auger can not go above 20cm. No subsoil for this particular location.
Eruwa B27	7.5401	3.3632	Bottomland	70	10YR2/1 Black	10YR2/1 Black	Forest land.
Eruwa C1	7.5450	3.3585	Midslope	45	10YR2/2 very dark brown	10YR2/2 very dark brown	Idle land surrounded with rock.
Eruwa C11	7.5545	3.3584	Upland	55	10YR2/1 Black	10YR4/2 dark grayish brown	Forest area which will be good yam farming.
Eruwa C10	7.5545	3.3536	Upland	10	10YR3/1 very dark grey	n/a	Idle forest land full of stones. No subsoil at this location.
Eruwa B29	7.5401	3.3728	Upland	45	10YR3/2 very dark grayish brown	10YR3/2 very dark grayish brown	Cassava cultivated land of about 3months old. Harvested maize plot Stoney soil.
Eruwa B19	7.5359	3.3724	Midslope	60	10YR2/1 Black	10YR2/1 Black	B19 point fall directly inside the river therefore samples ware collected at 70m to the point. Forest land

Eruwa B35	7.5455	3.3726	Bottomland	100	10YR3/1 very dark grey	10YR2/2 very dark brown	B35 is directly inside river, therefore the samples was collected 70M to the point. Forest land
Eruwa B23	7.5354	3.3921	Midslope	60	10YR4/1 Dark grey	10YR4/1 Dark grey	Swamping area.
Eruwa A20	7.5208	3.3824	Upland	35	7 5YR4/2 dark brown	10YR4/4 dark yellowish brown	partly cultivated with cassava, cashew and the other part in fallow
Eruwa A17	7.5163	3.3873	Upland	25	7.5YR4/2 dark brown	n/a	This plot is a mix between cropland; fallow land and a teak plantation. Very shallow and stony. Trees being used for firewoood and tumber
Eruwa A16	7.5161	3.3824	Footslope	80	10YR4/3 dark brown	10YR3/3 dark brown	Close to the dam. few dispersed oil palm trees.
Eruwa A25	7.5212	3.4062	Ridge_Crest	20	10YR 4/4	10YR 5/6	This plot fell on road and we have to move 15meters away from the road.
Eruwa A29	7.5257	3.4064	Upland	25	10yr 5/4	7.try 4/4	The plot is near a big rock.
Eruwa A24	7.5209	3.4016	Ridge_Crest	30	10yr 3/3	7.5yr 4/4	Nil
Eruwa A28	7.5257	3.4016	Upland	40	10yr 3/2	7.5yr 4/4	Tick plantation
Eruwa A12	7.5113	3.3873	Upland	60	7.5YR3/4 strong brown	7.5YR4/6 strong brown	Recently burned teak plantation. fiat land and moderately deep soil
Eruwa A27	7.5258	3.3969	Midslope	15	10yr 4/4	7.5yr 4/3	None
Eruwa A11	7.5114	3.3824	Upland	50	10YR3 /3 dark brown	10YR4/4 dark yellowish brown	This is a Gmelina plantation
Eruwa A10	7.5112	3.3776	Footslope	60	10YR2/2 very dark brown	7.5YR4/2 dark brown	The land is inbetween a teak plantation and a river/dam. suitable for agric but not in use
Eruwa A23	7.5210	3.3968	Upland	30	10yr 5/4	7.5yr 4/4	None
Eruwa A19	7.5161	3.3968	Upland	35	10yr 4/3	7.5yr 3/3	None

Eruwa A18	7.5161	3.3920	Upland	35	7.5YR3/4 dark brown	5YR3/3 dark reddish brown	This is a cassava and the soil very stony
Eruwa B6	7.5257	3.3781	Footslope	40	19YR2/1 black	10Yr3/1 very dark gray	This point is on the dam. So we few metres from the point and took sample
Eruwa B8	7.5257	3.3872	Upland	40	10YR3/2 Very dark grayish brown	10YR4/3 Brown	This is a fallow land
Eruwa A22	7.5210	3.3920	Footslope	50	10YR4/2	7.5YR 4	This a a cashew fel
Eruwa A26	7.5257	3.3920	Upland	40	10yr 3/2	7.5yr 4/4	Burnt bush
Eruwa B45	7.5283	3.3707	Midslope	25	10YR3/1 black	n/a	No subsoil very stony
Eruwa A1	7.5018	3.3740	Midslope	35	10YR3/1 Very dark gray	10YR4/1	This is teak and Gmelina plantation. Sited Down along a flood path
Eruwa A31	7.5032	3.3826	Upland	35	5yr 4/3	5yr 4/4	Cultivated cassava plot
Eruwa A30	7.5306	3.4017	Ridge_Crest	0	10yr 3/2	10yr 4/4	Cassava cashew intercrop
Eruwa A21	7.5209	3.3872	Midslope	40	10YR4/3 dark brown	7 5YR/4 dark brown	Stony soils cassava farm recently ploughed/prepare for planting
Eruwa B7	7.5257	3.3825	Midslope	50	7.5YR4/2 dark brown	7 5YR4/4 dark brown	This is a cashew plantation
Eruwa A2	7.5020	3.3774	Footslope	50	10YR3/1 Very dark gray	10YR3/2 very dark grayish brown	This point is on the river course samples taken 30m away.
Eruwa B1	7.5220	3.3688	Upland	45	10yr 3/3	7.5yr 4/2	Cashew plantation
Eruwa B2	7.5209	3.3728	Upland	35	10yr 3/1	10yr 5/2	Idle land
Eruwa A13	7.5113	3.3920	Upland	35	7.5yr 4/2	7.5yr 3/2	Cassava plot
Eruwa A7	7.5065	3.3872	Upland	35	10yr 3/4	7.5yr r/4	Harvested cassava plot
Eruwa A6	7.5065	3.3824	Upland	35	10yr 3/3	10yr 3/6	Tick plantation burnt by fire
Eruwa A5	7.5069	3.3776	Upland	60	10yr 3/2	10yr 5/3	It fell inside a water body therefore it was taken at 35 meters away from it.

Reyes A4	7.5068	3.3729	Bottomland	40	10yr 4/2	10yr 5/2	It falls into a gully and had to be taking 23meters away from it.
Eruwa A3	7.5065	3.3697	Ridge_Crest	55	10yr 3/1	10yr 3/2	Banna cashew and cassava under cropped
Eruwa A9	7.5114	3.3728	Midslope	40	7.5YR3/2 dark brown	10YR3/3 dark brown	Cassava field stony soils no trees
Eruwa A14	7.5160	3.3728	Upland	40	10YR2/2 very dark brown	10YR4/3 Brown	This is a recently harvested cassava field
Eruwa A15	7.5161	3.3776	Upland	35	10YR3/4 dark yellowish brown	10YR3/4 dark yellowish brown	This is a young cashew plantation. Shallow and stony soils
Eruwa B3	7.5210	3.3776	Footslope	35	10YR3/2 dark grayish Brown	10YR5/2 Brown	Cassava field owned by Mr Olawale Adegoke. Close to dam
Eruwa B5	7.5255	3.3721	Bottomland	100	2.5YR3/2 very dark gray	7.5YR5/0 Gray	Lowland along the dam. Land being used for grazing
Eruwa A8	7.5108	3.3688	Midslope	35	10YR4/2 brown	7.5YR3/2 dark brown	Cashew plantation. Gravelly and stony shallow soils
Eruwa B4	7.5257	3.3679	Upland	40	10yr3/1	10yr 3/2	Is an idle land

Appendix 6 Fasola field ovservation data

Sample ID	lat	long	Topographic position	Soil depth (cm)	Topsoil Colour	Subsoil Colour	Remarks
FASOLA	7.883927	3.777414	Midslope	40	10yr 3/4	10yr 4/4	Wood land
FASOLA	7.883896	3.781033	Midslope	90	10yr 2/1	10yr 3/4	Wood land
FASOLA	7.880235	3.777356	Midslope	90	10yr 2/1	10yr 3/4	Wood land
FASOLA	7.879465	3.775447	Footslope	90	10yr 4/3	10yr 4/4	Sampling point fell inside a river. Sampling done 50 m away
FASOLA	7.881406	3.773788	Bottomland	90	10yr 3/1	10yr 4/1	Close to the river.
FASOLA	7.883918	3.770106	Midslope	90	10yr 3/1	10yr 3/3	Wood land
FASOLA	7.883963	3.766555	Midslope	45	10yr 3/2	10yr 3/4	Following farmland
FASOLA	7.884003	3.762914	Midslope	90	10yr 3/4	10yr 4/4	Wood land
FASOLA	7.883946	3.755634	Midslope	90	10yr 4/2	10yr 4/4	Intensively managed cassava farm
FASOLA	7.880331	3.755653	Midslope	90	10yr 4/1	10yr 4/3	Fallowing farm land
FASOLA	7.880366	3.751991	Footslope	90	10yr 3/1	10yr 3/2	Sampling point is outside the boundary by 65 m. Sampling done at the boundary beside the river
FASOLA	7.876761	3.752009	Midslope	90	10yr 2/1	10yr 2/1	Intensively managed maize /cassava intercrop
FASOLA	7.880306	3.759218	Footslope	90	10yr 3/4	10yr 3/6	Cassava plantation
FASOLA	7.883948	3.759217	Midslope	90	10yr 3/4	10yr 4/4	Cassava plantation

FASOLA	7.884007	3.751978	Footslope	90	10yr 3/1	10yr 3/2	River bank
FASOLA	7.887532	3.755601	Midslope	45	10yr 3/4	10yr 3/6	Cassava plantation
FASOLA	7.880354	3.762883	Midslope	45	10yr 3/2	10yr 3/3	Harvested cassava farm
FASOLA	7.880343	3.766534	Midslope	90	10yr 3/4	10yr 3/6	Newly cleared farm land
FASOLA	7.883917	3.773731	Midslope	35	10yr 3/4	10yr 3/6	Wood land
Fashola F32	7.89084	3.781777	Upland	60	10YR2/2 very dark brown	10YR3/3 dark brown	Forest land which will be good for yam farming.
Fashola F24	7.887298	3.781771	Upland	100	10YR2/2 Very Black Brown	10YR3/2 very dark grayish brown	Idle land.
Fashola F25	7.887238	3.785464	Upland	55	10YR2/2 very dark brown	10YR3/2 very dark grayish brown	Idle land with larger percentage of tick trees
Fashola F33	7.891015	3.785635	Upland	100	10YR2/1 Black	10YR3/1 very dark grey	Forest/Grazing land Land will be good for yam farming.
Fashola F34	7.89087	3.788979	Upland	100	10YR3/2 very dark grayish brown	10YR4/2 dark grayish brown	Land clearing in process for yam farming.
Fashola F54	7.89138	3.792355	Bottomland	100	7.5YR3/1 very dark grey	7.5YR3/1 very dark grey	Swapping area couple with grazing land.
Fashola F31	7.891006	3.77809	Footslope	80	7.5YR3/1 very dark grey	10YR4/2 dark grayish brown	Swapping/Grazing land. Land will be good for rice cultivation.

Fashola F30	7.891054	3.77436	Upland	50	10YR3/2 very dark grayish brown	10YR4/2 dark grayish brown	Idle land Good for yam farming.
Fashola F22	7.88728	3.774345	Upland	60	10YR2/2 very dark brown	10YR3/2 very dark grayish brown	Open grazing land. Most trees has been fell in this location.
Fashola F23	7.887235	3.778047	Upland	60	10YR2/1 Dark	10YR3/2 very dark grayish brown	Idle land / Grazing land.
Fashola F21	7.887236	3.770717	Upland	100	10YR2/2 very dark brown	10YR4/3 brown	Forest land.
Fashola F20	7.887317	3.767237	Midslope	65	10YR2/2 very dark brown	10YR4/2 dark grayish brown	Swapping area and major part way for cattle grazing.
Fashola F29	7.890931	3.770868	Upland	70	10YR3/2 very dark grayish brown	10YR3/3 dark brown	Cassava land about 3 months old cultivated on the land. The land is good for tubers crops.
Fashola F28	7.890862	3.767174	Upland	100	10YR3/3 dark brown	10YR4/3 brown	Cassava cultivated land about 4months old.
Fashola F27	7.890903	3.763676	Upland	50	7.5YR3/3 dark brown	7.5YR3/4 dark brown	Cassava cultivated land about 3months old.
Fashola F19	7.887228	3.763557	Upland	55	10YR2/2 very dark brown	10YR3/2 very dark grayish brown	Idle forest land.
Fashola F18	7.887262	3.759915	Upland	60	10YR2/1 Black	10YR3/2 very dark grayish brown	Harvested pepper land with recently cultivated cassava about 3months old.

Fashola F26	7.890899	3.759877	Upland	60	10YR3/2very dark grayish brown	10YR3/3 dark brown	Cassava harvested farm.
Fasola F49	7.898067	3.778156	Upland	60	7.5yr 3/2	7.5yr 5/2	Is a cassava plot
Fasole F41	7.894476	3.781764	Upland	40	10yr 4/2	7.5yr 4/4	Cassava plot
Fasola F42	7.894478	3.785404	Midslope	40	10YR3/2 very dark grayish brown	7.5YR3/2 dark brown	Cassava field. Gravel at 40cm.
Fasola F50	7.898132	3.781777	Bottomland	60	10YR3/1 Very dark gray	10YR3/2 very dark grayish Brown	Lowland rice field.
Fasola F51	7.897961	3.785412	Footslope	60	10YR3/1 very dark gray	10YR3/2 very dark grayish Brown	Yam field. Lowland area
Fasola F55	7.901291	3.790372	Upland	60	10yr 3/2 very dark grayish brown	10yr 4/3 dark brown	Is an idle land
Fasola F38	7.894517	3.770911	Midslope	45	10YR3/3 dark brown	10YR4/6 dark yellowish brown	Cassava field. A part is recently harvested and the other parts have young growing cassava field. No trees
Fasola F45	7.89809	3.763631	Upland	45	7.5YR4/2 dark brown	10YR4/3 dark brown	Yam and cassava field recently harvested
Fasola F44	7.898061	3.760026	Footslope	60	10YR3/1 very dark gray	10YR4/2 dark grayish Brown	Lowland area Close to a paddy
Fasola F47	7.898182	3.770992	Midslope	48	7.5YR4/2 dark brown	7.5YR4/4 Brown	Cassava field gravel at 35cm. There are beehives

Fasola F37	7.894498	3.767259	Midslope	55	7.5YR4/2 dark brown	7.5YR3/4 dark brown	Cassava field
Fasola F35	7.89458	3.759968	Bottomland	60	2.5Y2/0 black	10YR5/1 gray	Lowland not in use
Fashola F40	7.894509	3.778221	Upland	62	7.5yr 4/2	7.5yr 4/2	Is an idle land
Fasola F52	7.898126	3.789071	Midslope	60	10YR3/1 very dark gray	10YR3/2 very dark grayish brown	Land on fallow. Adjacent is a yam field
Fasola F48	7.89809	3.774475	Footslope	65	7.5YR4/2 dark brown	7.5YR5/8 strong brown	Cassava field. Moderately deep soil. Adjacent to rice field extensive lowland in the NE direction
Fasola F39	7.89444	3.774484	Bottomland	45	10YR3/1 very dark gray	' 10YR4/1 dark gray	Yam field presently on fallow. Lowland valley bottom
Fasola F46	7.898073	3.767261	Midslope	25	7.5YR3/4 strong brown	n/a	Freshly harrow land bounded by a cassava field and a lowland in the SE
Fasola F36	7.894483	3.763568	Midslope	55	10YR4/4 dark yellowish brown	5YR4/4 reddish brown	Cassava field slopes towards a rice field in the N. The lowland rice field was visited by jeroen and Sam during the orientation visit
Fasola F43	7.894504	3.788953	Midslope	30	10YR3/3 dark brown	10YR3/4 dark yellowish brown	Harvested cassava field.
Fasola F53	7.894238	3.791949	Footslope	70	10YR2/1 black	10YR5/3 brown	Land not in active use except for grazing

Soil survey members and delegates from OYSADA at the Eruwa Farm Settlement

Some of the soil survey teams and some staff members at the Fasola farm settlement