Nigerian Journal of Soil Science
Journal homepage:www.soilsjournalnigeria.com

AN ASSESSMENT OF LAND USE/COVER USING CONVENTIONAL AND SATELLITE DATA IN TOMAS IRRIGTION SCHEME, KANO, NORTH-WESTERN NIGERIA.

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ABSTRACT

Soil is a life supporting system upon which human beings have been dependent from the dawn of civilization. Hence comprehensive information on soil resources, its potentials, limitations and capabilities are required for a variety of purpose, which includes sustainable agriculture, reclamation of degraded lands among others. Data from SPOT 5 (2005), a satellite image and ERDAS; a geographic Information System were used to assess the current and potential land use in Tomas irrigation scheme. Soil map of Tomas at the scale of 1: 25,000 produced by Ministry of Agriculture and Natural Resources (MANR, 1987) was digitized and used to obtain the current and potential land use maps. Supervised image classification system was employed in the classification. Three major land use types (LUT) were identified viz; rainfed which accounted for 70.42 % of the total area, irrigated 12.6 % and “others” covering 16.94 %. The land capability classification of the soils revealed “marginal”capability class (IIIfs) with major limitations of inherent low fertility and soil texture. The extent of land utilization indicated that 86.2 % of the land in the study area was over utilized; these are marginal lands subjected to intensive and moderately intensive use. This is where severe environmental problems are expected. Only 12.81 % of the land was properly managed, where current land use fits potential capability.

Key Words: Land capability, Land use/cover and Satellite data.

INTRODUCTION

The terms “land cover” (LC) and “land use” (LU) are sometimes used interchangeably, but they are actually different. Simply put, land cover is what covers the surface of the earth, such as water, snow, grassland, deciduous forest, bare soil, and land use describes how the land is used, such as wildlife management, agricultural land, irrigated land, urban and recreation (Seshasai *et al.,* 2007). A given land use may take place on one or more than one pieces of land and several land uses may occur on the same piece of land (Kebede, 2010). Land cover change is the complete replacement of one cover type by another, while land use changes also include the modification of land cover types, such as intensification of agricultural use like irrigation with-out changing its overall classification (Turner *et al.* 1993). In areas where land is scarce, the need to maintain food production with growing demand is achieved via technological changes in land use accomplishing higher returns per area of land. Where land is abundant, land conservation remains the main strategy. A better understanding of land use changes is essential to asses and predicts its effects on ecosystem and society (Dolmans *et al.* 2002). Land use capability classification (LUCC) is the viable option to be employed in predicting and allocating land correctly to the uses that provide the greatest sustainable benefits (Raji, 2004). This will ultimately lead to sustainable land use that will conserve land, water, plant and animal genetic resources, that are environmentally none degrading, technologically appropriate, economically viable and socially acceptable.

The use of remotely sensed data in form of satellites as a source of authentic information for surveying, classification, mapping and monitoring has been emphasized. Many researchers have demonstrated the relevance of land capability classification in allocating land uses that aid in sustainability using GIS and remote sensing (Raji, 2004; Ali Mahmoud *et al.,* 2009; Ali and Kotb, 2010 and FDALR, 2013). Land use/cover mapping is one of the most important and typical application of remotely sensed data (Lillesand, 2006). This has been extensively used in supervised image classification where a prior knowledge of all the cover types to be mapped within the classified scene is assumed (Sesha *et al.* 2007).This knowledge is used to define signatures of the classes of interest to be applied to the entire scene. SPOT (*Systeme Pour l observation de la Terre*), is one of the most popular earth observation satellites in the world. It was designed and launched by CNES (*Centre National d Etudes Spatiales*) of France, with support from Sweden and Belgium. SPOT 5 (2005) satellite image with 3 bands (1, 2 and 3) and spatial resolution of 5.0 m multispectral and 2.5m panchromatic were used for land cover and land use classification of the Tomas irrigation scheme.

This work therefore intended to:

- Use the information acquired from SPOT 5 to map and delineate the different land uses/cover in Tomas irrigation scheme
- Generate a potential land capability classification and assess the extent of land utilization in the scheme.

MATERIALS AND METHODS

Description of the study area.

The study area is located within old Dambatta and new Makoda Local Government Areas, in the western part of Kano State, east of Kano-Daura road. It is situated approximately between latitudes 12^0 18` and $12^0$ 25`N, longitude 8^0 32` and $8^0$ 38`E (Figure 1). The Babbaruga Dam across Tomas River is just upstream of the existing road and bridge, while the potential area for irrigation stretches on either bank of the Tomas River. (MANR, 1978).The scheme covers an area of 12,441ha.

The study area is located in sub humid tropical zone with a distinct rainy season lasting from May to September. Rainfall is characterized by heavy storms with a mean yearly precipitation of 833 m between 1950 and 1965 (Daniels, 1985). The area has a seasonal climate which is largely determined by inter tropical discontinuity zone (IDZ). The geology of the area lies within the basement complex formation, which consists of the Precambrian igneous and metamorphic rocks, overlain by a mantle of Aeolian deposits varying in thickness from 3.048m to 15.24 m. Physiographically, the project area can be described as consisting of gentle plain of low relief, with the ground on either side of the river gently sloping towards the fadama.The soils of the project area have developed under tropical climatic conditions, with yearly cycles of a short wet season followed by a long dry season. In general, the soils are weakly developed with little horizon differentiation (MANR 1978). They are classified into: Lower terrace (Fadama), higher terraces and transitional belt.

The natural vegetation is of Sudan sub humid (FDLAR, 2013). There are two types of land use in the study area, rain fed and irrigated. Sometimes, irrigation is used to supplement the rain fed farming. The major type of land used in the study area includes arable farming, livestock farming, and fire wood and timber exploitation. Arable farming consists of subsistence and irrigation which is characterized by intensive and continuous cultivation (Yaro, 2005), with no case of land tenure conflict reported. The main crops grown under rain fed are sorghum, millet, groundnut, cassava, cowpea, and sometimes rice, maize and water melon. Rice and maize are being supplemented with irrigation.

Methodology

Data acquisition involves sourcing of ancillary data on climate, soil, vegetation, soil maps and satellite images. SPOT 5 (2005) satellite image with 3 bands (1, 2 and 3) and spatial resolution of 5.0 m multispectral and 2.5 m panchromatic were used for land cover and land use classification of the Tomas irrigation scheme. The softwares used for data preparation and analysis incude: the Integrated Land and Water Management Systems (ILWIS) for digitization of land use and land cover, and most of GIS analysis. Arc view and Arc GIS were used for map creation; layout and finalizaton, while ERDAS image was used for land use and land cover classification. GPS reading was used in locating geographic coordinates values in UTM, latitude-longitude. The GPS reading was used in locating positions of different land uses and land covers for image classifications.

Image classification

Land cover and land use classification was carried out using SPOT 5 (2005) satellite images for identifying land cover and land use types. For the study of current land use, supervised signature extraction classification method was used in classifying the image. The land use and land cover themes were generated through manual interaction and field experience. Based on literature, initial classification was erected as irrigated crops, non irrigated crops, fallow, settlement, bare soil and rock out crop, forest reserve and water bodies. The acquired images were processed using ERDAS IMAGINE 9.1 and Arc GIS 9 software. On the acquired images, water bodies appeared deep blue, vegetation (plantations and cropped areas) were red, while settlements and roads showed up in shades of cyan. The classification system used by Raji (2004) in Kadawa irrigation scheme using Nig.Sat 1 was employed in this study.

Detailed Field Work

The field work was carried out to investigate the land resource across the study area. This has helped in identifying the major land use and land cover types especially for the various crop types within the irrigated crop class and to confirm for areas of uncertainty, which was made possible with the aid of GARMIN GPS (hand held), software version 4.52 (GARMIN, 1999). Coordinates of one hundred and ten points (110) were identified and their land use noted. The ca-

Table 1: Land use/cover, before and after field work

Before			After	
Description	**Area (Ha)**	**(%)**	**Area (Ha)**	**(%)**
Irrigated	1,356.25	10.90	1,544.40	12.64
Rainfed	8,793.71	70.68	8,605.50	70.42
Others	2,291.51	18.42	2,069.50	16.94
Total	12,291.51	100.00	12,219.4	100.00

The difference in areas (Table 1) above was due to the field check with the classified image for adoption and refining of the training samples

pability classification used was based on rating of a set of permanent soil characteristics as regards to risks of soil damage. The United States Department of Agriculture (USDA) version by Killingibiel and Montgomery (1961) was adopted for this study. The procedure used involves, the digitization of the soil map of the study area, to form a homogeneous soil unit in form of permanent soil limitations of soil depth, drainage, soil texture and nutrient holding capacity. Electrical conductivity (EC) and exchangeable sodium percentage (ESP) were also considered. These limitations were used to form a simple capability classification with rankings in accordance with the main limiting factors.

Extent of land utilization

The current land use was reduced to three legends (i.e. irrigated, rainfed and "others"). These were classified based on land use intensities, with irrigated land use as "highly intensive", rainfed land use as "moderately intensive" and others as "low intensive". The supervised land use map produced was compared with the potential land capability map using a cross tabulation algorithm, leading to the production of a new map and a new table, indicating the extent of land utilization in the area. This provided an idea about areas that are underutilized, over utilized or well managed.

RESULTS AND DISCUSSION

Current Land Use/cover

From SPOT 5 image classification, three major land use and cover types were identified by relying heavily on the differences of spectral characteristics of the landscape for separation into meaningful land use and land cover classes. These classes included; irrigated land use type 1,544.4 ha (12.6 %), rainfed 8,605 ha (70.42 %) and others 2,069.5 ha (16.94 %). Table 1 and Figure 1, present the area and extent of the different land use and land covers in the irrigation scheme.

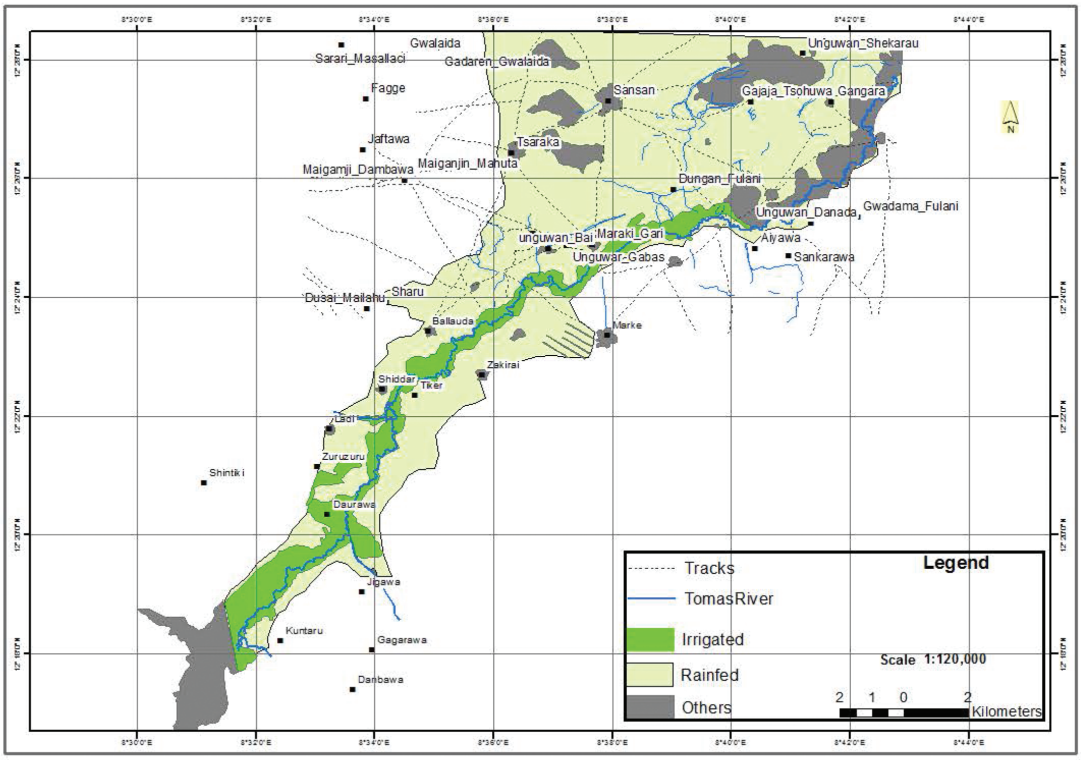

Figure 1: Map of Tomas irrigation scheme showing landuse types

Irrigated landuse type

Irrigated landuse type covers an area of 1,544.4 ha (12.6 %). These are areas mostly around the river banks and tributaries within the scheme. The low percentage of the irrigation activity in the area was due to the lack of irrigation channels for water conveyance from the dam to the farmer's field, and or poor maintenance of the existing ones. This necessitates farmers to use tube wells in their farms for the irrigation activity. Crops grown for irrigation purposes included; maize, rice and water melon. About

Table 2: Current land capability class

Capability class	Mapping unit	Area (Ha)
III	Sn	1,681.19
III	Ba	6,406.96
III	To	2,264.98
III	La	1,386.78

Table3: Actual vs potential land use (in ha)

Capability class	highly intensive	moderately intensive	low intensive
marginal	1,538.4ha	8,587.38ha	1,487.3ha

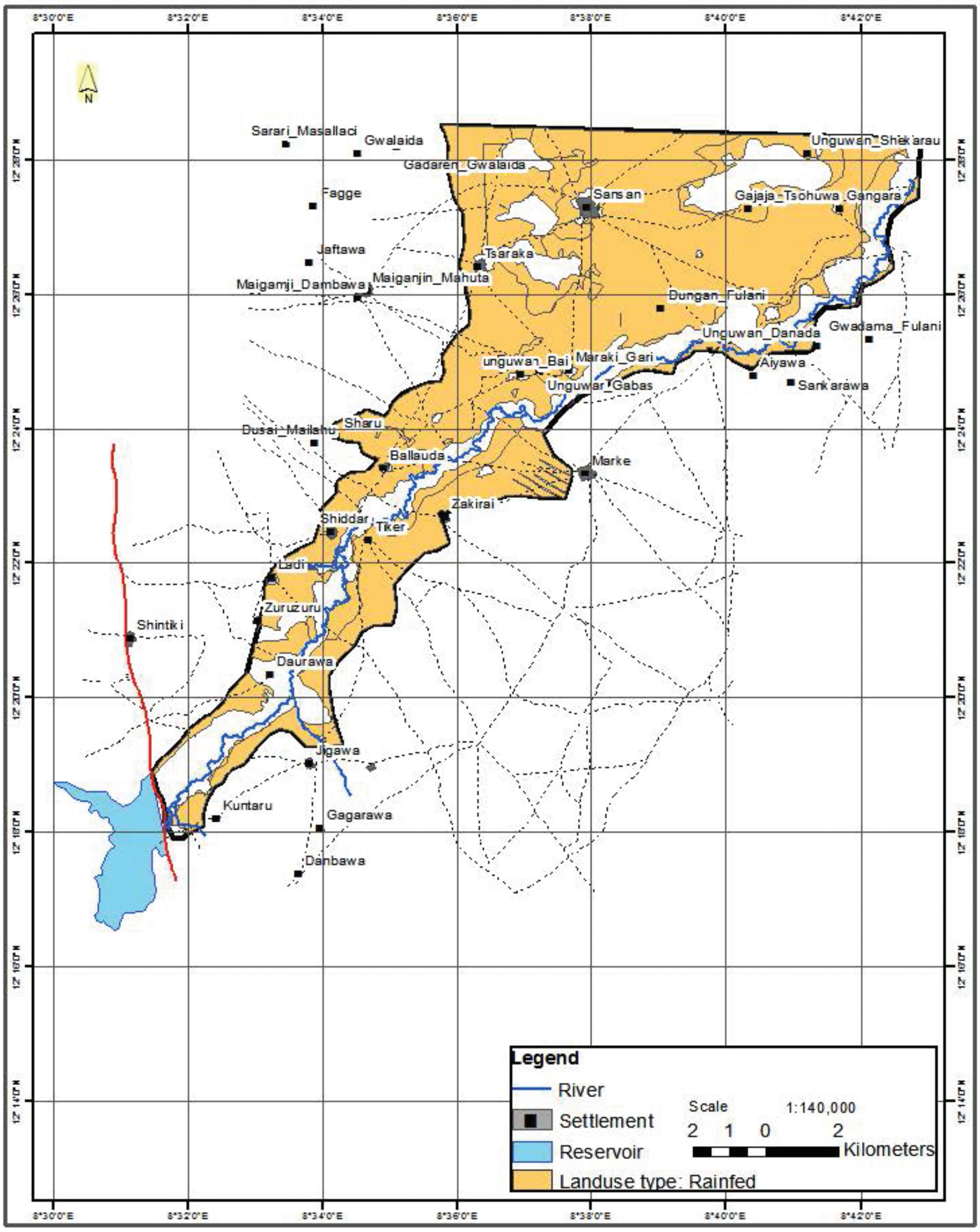

Figure 2: Map of Tomas irrigation scheme showing extent of rainfed land use type on marginal capability class

70 % of the irrigated fields have been cultivated for vegetables which included; tomatoes, onion, pepper and water melon.

Rainfed land use type

This was identified as the most dorminant land use type in the area, accounting for about 8,605ha (70.42 %) of the total area. Sorghum-millet-cowpea and maize-millet-cowpea were the major crop rotation in the area. Maize and water melon were also cultivated under rainfed crops on monocropping basis. Rice was also cultivated with supplementary irrigation.

Other land use and land cover types

The third land use and land cover type was classified as “others” and includes water body, forest plantation, settlements, bare soil, sugar

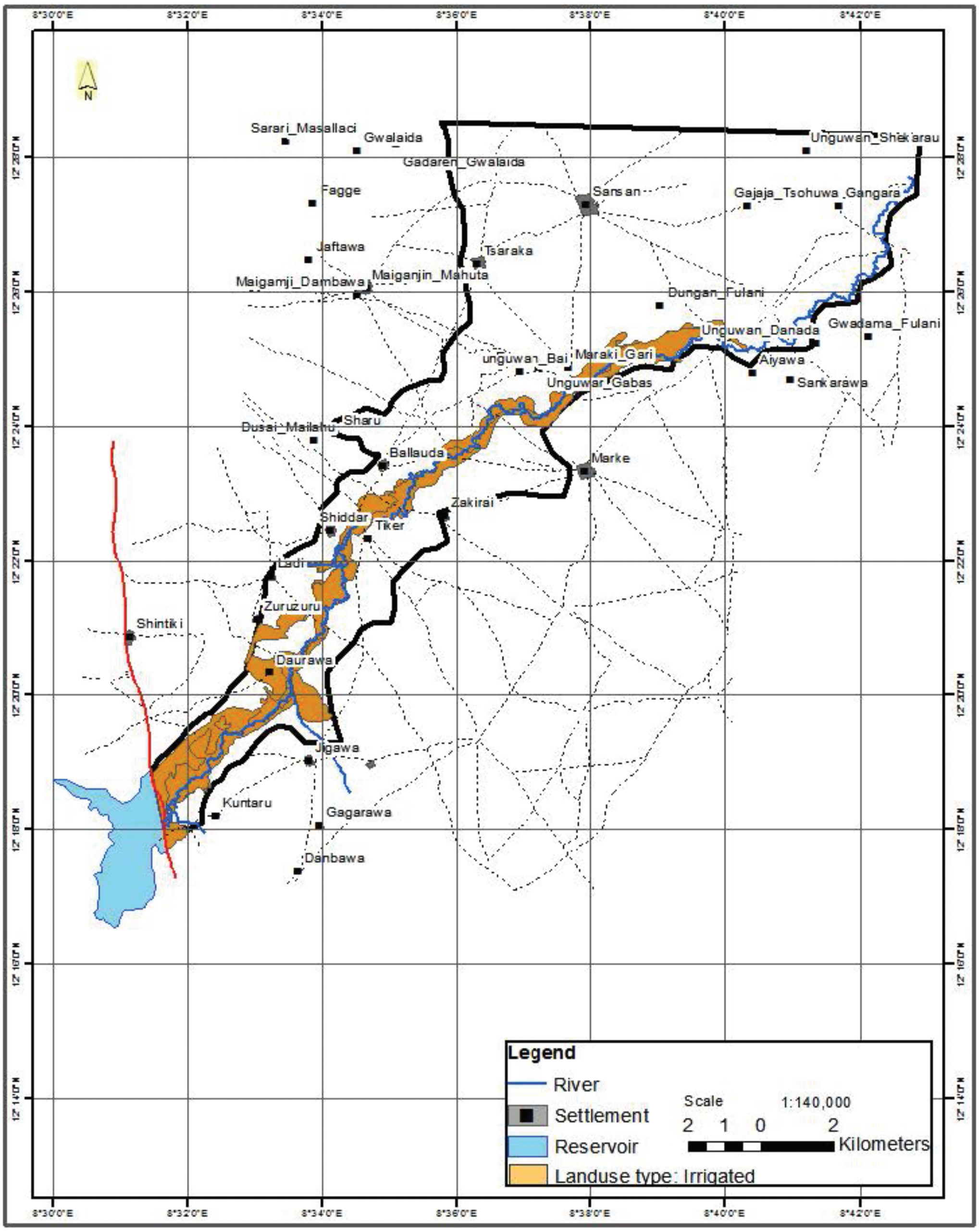

Figure 3: Map of Tomas irrigation scheme showing extent of irrigated land use type on marginal capability class

cane and mango plantations located along river side. This land use/cover type extends to about 2,069.5 ha (16.94 %).

Current capability

All the soil mapping units of Tomas irrigation scheme (Ballauda, Sansan, Ladi and Tomas series) were classified as IIIfs (Table 2). These are soils that are deep, well drained with good condition for easy root development and mechanization, that could rate the soil in to class I. However, due to inherent low soil fertility (Low CEC, OC, total N and available P), coarse texture in addition to climatic limitation, these soils were classified in to class III. The coarse texture facilitates the poor moisture retention ability of the soils, while the low inherent fertility makes the soils to have poor nutrient holding capacity.

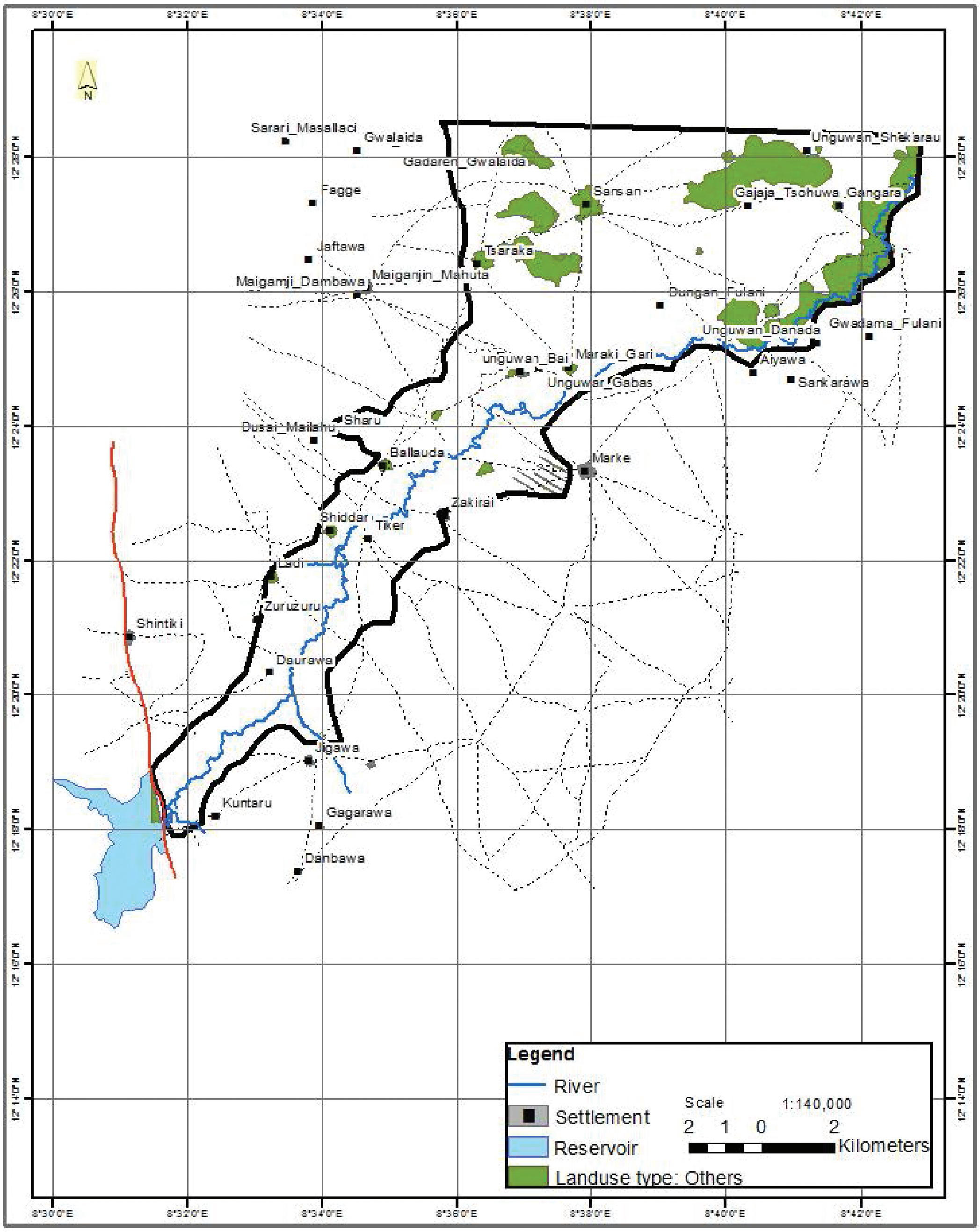

Figure 4: Map of Tomas irrigation scheme showing extent of "others" land use type on marginal capability class

Current land capability class of these soils is rated as class IIIfs (marginal). This indicates that, these soils (Ballauda, Sansan, Ladi and Tomas) have severe limitations that reduce the choice of crop; they require very intensive conservation measures or both (Killingebiel and Montgomery, 1962).

Potential capability

Majority of these limitations can be corrected (except texture), with little management or conservation measures. Climatic limitation, low inherent soil fertility and drainage were all found to be correctable limitations. While climatic limitation may be corrected with irrigation, nutrient availability and CEC should be corrected by incorporation of crop residues, cover cropping in a good rotation farming system and inorganic fertilizer application will upgrade the capability class of these soils from marginally capable class (IIIfs) to moderately capable class (IIs) (Ali *et al.*, 2009). ESP, EC, salinity and alkalinity were found to pose no threat in the scheme.

Extent of land utilization

Identification and accurate description of current and potential production areas were essential for research and agricultural development (Corbett, 1996), which will help in knowing the extent of land utilization in an area. This was made possible by comparing the differences and similarities between the present/current land use in the area and the potential land use (Perveen *et al.,* 2007), which will finally give an insight into areas affected by under or over utilization for proper assessment, in order to avoid land degradation, and improve on crop yields (Raji, 2004).

From the result of this study (Figures 2,3 and 4), marginally capable land subjected to intensive cultivation (irrigation), accounted for 1,538.4 ha (13.25 %)(Table 3), and also marginal lands subjected to moderately intensive use (rainfed), accounted for 8,587.51 (73.95 %). These are areas identified with over utilization, which may lead to land degradation and impaired drainage, leading to soil salinity in the future. The remaining 1, 487.3 ha (12.81%), are areas of marginal capability class been subjected to low intensive use “others” (Figures 2,3 and 4). This is an area that is properly managed; where current use fits the potential capability or suitability (Raji, 2004). Therefore, there is no threat to sustainability in terms of land degradation or otherwise in this area.

SUMMARY AND CONCLUSION

From the results of this study, it can be seen that, integration of satellite data, GPS, GIS and field work will help in speeding up land resource inventory exercise in such a way that land use planners and policy makers will guide the land users, so that current land use problems are reduced, and that specified social, economic or environmental goals (e.g. sustainability, food self-sufficiency, income, environmental conservation) will be achieved. Therefore, repetitive and comprehensive coverage is required in monitoring the land use/cover of Tomas irrigation scheme through satellite imagery to review its soil inventory as early warning for food security.

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