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A Review of the Techniques for Monitoring Soil Salinity in Irrigated Fields

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ABSTRACT

Soil salinity is a major form of environmental degradation in agricultural areas which has great impact on soil fertility and agricultural productivity. This degradation takes place so fast that many countries may not be able to achieve sustainable agriculture in future. In arid and semi-arid regions, nearly 20% of all irrigated land is salt affected, and this percentage tends to increase in spite of the considerable effort dedicated to land reclamation. The excessive application of herbicides and fertilizers, poor drainage system and improper irrigation practice are considered as major sources of soil salinity. Salinization affects both the physical and chemical properties of soil leading to decrease in quality of agricultural soil and loss of crop yield. For the amelioration of salt affected soils, to keep track of changes in salinity level and predict further degradation, monitoring of salinity is essential for proper and timely decision to be made. Experimental methods for monitoring soil salinity are very demanding of time and resources, also very limited in terms of spatial coverage. This paper review is to assessing soil salinity using Remote Sensing (RS) and Geographical Information system (GIS) technique for effective and accurate monitoring of soil salinity.

Keywords: Remote sensing, GIS, soil salinity, Irrigation.

Aims Research Journal Reference Format:
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1. INTRODUCTION

In most developing and developed countries, soil salinity is one of the problems that affect irrigated lands. Salt affected soils are majorly found in arid and semi-arid regions; areas affected by salt can be found globally under almost all climatic conditions. Nearly 20% of all irrigated land is salt affected, and this percentage tends to increase in spite of the considerable effort dedicated to land reclamation. High levels of soil salinity negatively affect crop growth and productivity leading land degradation ultimately (Allbed and Kumar, 2013). Major causes of soil salinity includes; deforestation of the past, poor drainage system, improper irrigation practices, excessive application of fertilizer, herbicides and use of other agrochemicals. Detection of salinization, assessment of the degree of severity and the extent, particularly in its early stage is vital in terms of sustainable agricultural management (Farifteh, 2007). Various techniques have been employed by researchers to analyze and monitor soil salinity.

2.0 METHODS OF MONITORING SOIL SALINITY

The following forms of soil salinity monitoring exist

i. Traditional method (Conventional method)
ii. Electromagnetic Induction (EMI) method
iii. Remote Sensing (RS) and Geographical Information System (GIS) method

What follows is a discussion on each of this methods.

2.1 The traditional methods

Customarily, soil salinity has been defined and assessed in terms of laboratory measurements of the electrical conductivity of the extract of a saturated soil-paste sample (ECe) (Rhoades *et al.,* 1999). The traditional methods used for examining soil properties include ground-based geophysics and laboratory analysis (Robbins and Wiegand, 1990). In this method, soil salinity has been measured by collecting in situ soil samples and analyzing those samples in the laboratory using physicochemical analysis to determine their solute concentrations or electrical conductivities.

2.1.1 Procedure for traditional or conventional ground method

Soil samples are taken from a scheme at certain number of sampling points located in the field using soil auger. Sampling points are located in the field. Soil profiles are morphologically described according to SSS, (1993) and FAO, (2006). The collected soil samples is air-dried, crushed and passed throughout a 2 mm sieve. The fine earth (< 2mm) was taken for analysis. Electrical conductivity is determined by laboratory using chemical analysis of 1:2.5 soil–water suspensions (EC2.5) according to (Page, *et al*, 1982)

The disadvantages of traditional method includes; time consuming, costly since dense sampling is required to adequately characterize the spatial variability of an area and demanding when considering large areas (Brunner 2007; Nanni, *et al.,* 2006)

2.2 Remote sensing and GIS method

The application of Satellite Remote Sensing (SRS) and GIS has been proved useful and successful in many fields such as natural resources management, agriculture, and environmental resources. Remote sensing techniques are potentially very useful for detecting, monitoring and controlling soil salinity. With the launching of Land satellite in 1972, many researchers have used GIS and RS techniques to model, assessed, and investigate land use and land cover pattern, detect, map, monitor and forecast soil salinity on an irrigation scheme (Ibrahim,*et al.,* 2013). The use satellite imagery for mapping and monitoring soil salinity has been in practice over the years, mostly with multispectral sensors. These include Landsat Thematic Mapper (TM), Landsat Multispectral Scanner System (MSS), Landsat Enhanced Thematic Mapper Plus (ETM+), SPOT, Advanced Spaceborne Thermal Emission and Reflection Radiometer (Terra-ASTER), linear imaging self-scanning sensor (LISS-III) and IKONOS (Verma, *et al.,* 1994). Some vegetation and soil indices have been used as an indirect indicator to predict and map soil salinity.

Accordingly, numerous researchers have conducted studies on the mapping and delineation of soil salinity using different Spectral Vegetation Indices (SVI). Among the vegetation indices, Natural Differential Vegetation Index (NDVI), Natural differential Salinity Index (NDSI), Ratio Vegetation Index (RVI) and Tasseled Cap Transformation consist of Soil Brightness Index (SBI), the Green Vegetation Index (GVI), and the Wetness Index (WI) have been used in soil salinity studies (Matinfar, 2013). According to Ojo, *et al.,* (2011)**,** advantages of remote sensing and GIS method includes; time saving, wide range of coverage**,** facilitation of faster and long term monitoring.

2.2.1 Procedure for RS and GIS method

Landsat image is acquired with Landsat Thematic Mapper (TM-5) as shown in figure 1.0. Radiometric and atmospheric corrections is applied to image for elimination of errors in sensor malfunction and atmospheric effect. The spectra indices of soil salinity NDVI and the principal component of the corrected image is calculated using either supervised classification or unsupervised classification. Derived data is compared with the field measurement of soil EC to extract an EC estimation model allowing soil salinity mapping.

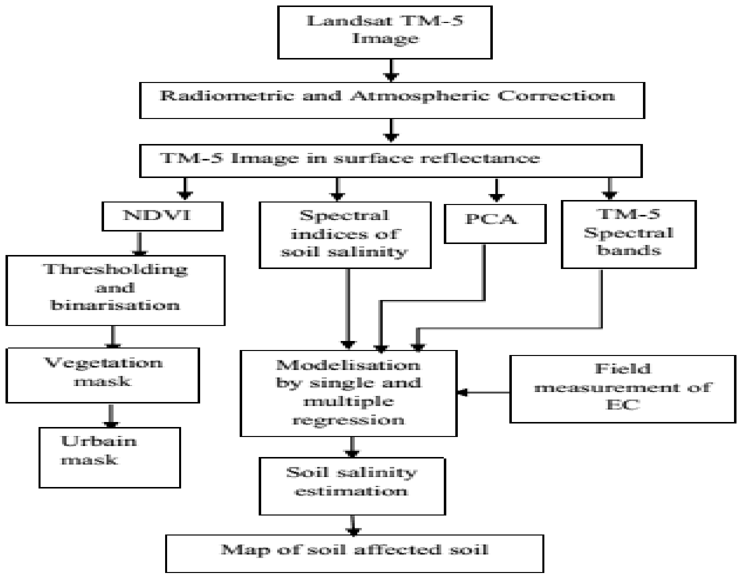

Figure 1.0 Procedure Flow Chart
Source: Lhissou *et al.,* (2014)

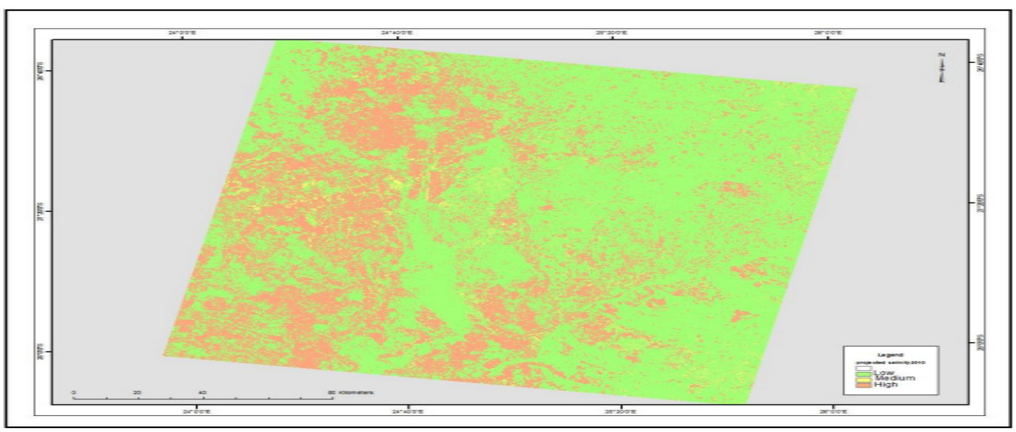

Figure 2.0 Salinity mapindicating the salinity classifications (2010)
Source: Ojo, (2013)

The salinity map of Vaal-Harts Irrigation Scheme in South Africa is shown in figure 2.0. The area in grey indicates lack of salinity, the green portions signifies area of low salinity, area in yellow indicates medium salinity areas and the portion in red indicates high salinity areas

2.3 Electromagnetic Induction (EMI) Method.
The first use of EMI in Agriculture was the assessment of soil salinity (van der Lelij, 1983). Soil salinity can be measured using electromagnetic induction method, which uses a transmitting coil to create a magnetic field that penetrates into the soil. The magnetic field creates an electrical current that in turn creates a secondary magnetic field which is received by the meters receiver coil (McNeilll, 1980) . The ratio of the secondary to primary magnetic field is in linear proportion to the soil's apparent electric conductivity (EC). Electromagnetic approaches are one of the reliable means used for rapid determination of soil salinity(Williams and Baker, 1982).

In top soils and within the crop root zone, EC is usually determined by EM 38 which operates to a maximum depth of approximately 1.5 m, whilst the subsoil EC is usually measured by EM 31, which may be operated manually or mounted to a vehicle with precision GPS to enable rapid paddock or farm scale mapping. Interpretation of soil salinity from EC maps requires the calibration of EC values to laboratory determined measurements of electric conductivity (EC 1:5, EC sp) from multiple locations and soil depths. over standard EM surveys due to its lower cost per hectare, rapid survey of large areas, and the ability to resolve spatial variations in EC a at discrete depth intervals. The use of EMI is to quickly and easily identify, characterize and map spatially varying soil types and properties. It offers distinct advantages over traditional methods.

3. CONCLUSION

It is important to assess the extent and severity of soil salinity at early stage as it has been a fundamental environmental problem facing irrigated soil. Therefore of all three prevalent techniques discussed in this paper review, it is cleared that the use of remote sensing and geographical information system is more suitable for monitoring and detecting salinity in irrigated soils.

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