Chapter 4

Geospatial Analysis for Irrigated Land Assessment, Modeling and Mapping

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Additional information is available at the end of the chapter

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Abstract

Assessment of irrigated lands by conventional means of survey requires a great deal of time, but the application of geospatial analysis using remote sensing data and GIS techniques minimize time consuming and offer the possibility rapid production of maps and models. This paper gave an overview of the techniques and methods in use at different scales. The presence of salt in the soils and its variation may be because of rise in water table and the difference in elevation in irrigated lands. The combined application of conventional methods with remote sensing and geographical information system techniques in detecting these problems in irrigated lands were examined. Different salinity indexes coupled with ground truthing with the proven results in assessing such problems were also examined thereby depicting indexes as good indicator of soil salinity and water logging, which may influence decision on reclamation of degraded land for proper agricultural land management. Irrigation and drainage managers, planners, farmers, and government agencies for smart agriculture can use models and maps generated through geospatial analysis.

Keywords: assessment, modeling, mapping, GIS, RS, irrigated land

1. Introduction

Irrigated agriculture is important to the national economy of a country as it contributes significantly to the production of food. The main objective of irrigated agriculture is to enhance crop production for food sufficiency, particularly in semi-arid and arid zones [1]. It has contributed positively to food security, poverty alleviation, and rural development. In addition, it protects plant against frost, suppresses growing of weeds in grain fields, and prevents soil consolidation. Most irrigation schemes are faced with problem of soil deterioration resulting from increased level of soil salinity and rise in water table. Soil salinity affects soil chemical, physical, and biological characteristics of the soil, fertility, and sustainable productivity unless it is properly monitored. Geo-informatics involves a combination of special techniques, technologies and tools for the acquisition, processing, management, analysis, and presentation of geospatial data [2]. It is a combined method to GIS and remote sensing. Remote sensing and GIS are well established information tools, since they give reasonable pictures of the entire process in spatial and temporal terms. They both provide a cost effective and adequate understanding of landscape dynamics, detect, identify, map, and monitor differences in land use and land cover pattern over long period of time [3]. 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 issues and water resources. Remote sensing approaches are very effective for detecting, monitoring and control of soil salinity. Remotely sensed data are used to assess soil salinity either on bare soils with salt crust or through biophysical properties of vegetation as these are affected by salinity [4].

1.1. General background

Replace environmental land degradation has recently become a global, urgent issue, and is now being considered with high priority, especially in the developing countries in order to meet the food and fiber demands of accelerated population pressure with limited available resources. One of the goals of irrigation is to boost food production in a sustainable technique so that a fast growing global population could be fed. Sustainable irrigation scheme can only be achieved effectively by taking into consideration the environmental effectiveness and availability of funds to maintain the implemented project. The function of irrigation is to apply water to maintain crop evapotranspiration, the total amount of available water essential for economy, health, and welfare of a very large part of the world [5]. Analyses of information from Asia have also shown that yields per area, for most crops have increased between 100 and 400% because of irrigation [6]. Based on the management system of irrigation scheme, it can provide both positive as well as negative effects on vegetation cover. Well-planned irrigation scheme have good natural vegetation conservation and management plans. Several factors could influence the salinity levels of irrigated land. One of the factors is the irrigation method [7].

1.2. Importance of irrigation

Irrigation is undertaken to provide insurance against droughts, cooling of the soil and atmosphere and provide more favorable environment for plant growth. It can also wash out or dilute salts in the soil, reduce the hazards of piping, and soften tillage pans [8]. Generally, the goal is to supply the entire field uniformly with water, so that each plant has the amount of water it needs. In arid and semi-arid areas where there are less rainfall, irrigation is often used to grow cash crops, develop landscapes and vegetate disturbed soils. This is expected of the increase in world population and the need to expand agricultural land under the threat of climate change. It has contributed immensely in the production of food in industries.

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1.3. Impact of irrigation on vegetation and soil

The practice of irrigation sometimes has an adverse effect on environmental condition otherwise properly monitored, planned and managed. Past record claims that human activities have a strong effect on the natural environment and becoming the main cause of environmental degradation [9]. The expansion of irrigation project has many advantages. However, large-scale irrigation projects changes natural ecosystem. To undertake large irrigation projects, vegetation cover needs to be cleared and different construction activities needs to be done. Natural vegetation is an eminent parts of the ecosystem negatively affected with large-scale irrigation projects [10]. Soil being a vital natural resources, it has been assisting the increasing number of life on earth. As regards to increase in population, food demand also increased. This in turn put-size pressure on land/soil resource, areas of land that are formerly considered as marginal are now being cultivated [11].

2. Characterization of soil salinity

Mougenot et al. [12] argues that visible reflectance of leaves from plants growing on non-salt affected leaves before plant maturation is higher than after maturity. In addition, visible reflectance of leaves from plants growing on salt affected soil is lower than the visible reflectance of plants growing on non-salt affected soils. Near-infrared reflectance increases without water stress due to a succulent (cell thickening) effect and increases in other cases. Spatial information on soil moisture can be accessed through bands in the near- and middle-infrared spectral bands; this is confirmed by [13]. The study showed that near- to middle-infrared indices are indicators for chlorosis in stressed crops normalized difference for TM bands 4 and 5. This new ratio is however dull to color variations and provides an indication of leaf water potential. In addition [14] showed that chlorotic canopies could be distinguished from healthy canopies, as biophysical response to a salinity can be seen in low fractional vegetation cover, low leaf-area index (LAI), high albedo, low surface roughness and high surface resistance compared with healthy crops. This is because healthy vegetation absorbs most of the visible light hitting it and reflects a large portion of the near infrared light. However, sparse vegetation (right) reflects more visible light and less near infrared light [15]. Traditionally, electrical conductivity (EC) measured in dS/m is used to determine the soil salinity on a small field with the aid of hand-held conductivity meter, while on a large scale it is measured and mapped using electromagnetic (EM) conductivity meter [15]. These approaches (traditional and geospatial) are used to quantify the density of plant growth on the earth visible radiation minus near-infrared radiation divided by near-infrared radiation plus visible radiation resulting into vegetation indices [16]. **Table 1** gave the criteria for classifying soil salinity.

2.1. Geographical information system in soil salinity modeling

During the last decade, there has been a proliferation of geospatial data in natural resource management including in the disciplines of forestry, fishery management, geology, geomorphology,

Degree of salinity	Salinity ECe (dS/m)
Slight	4–8
Moderate	8.25
Strong	>25
Source: [15].	

Table 1. Soil salinity classification.

hydrology, wildfire, and climate change [17]. Geographic Information System (GIS) enables the measurement and representation of geographic phenomena and thereafter transform this spatial information into various forms while interacting with social structures [18]. GIS has the benefit of its ability to interrelate spatially multiple types of information and data obtained from a range of sources. In addition based on the findings of [19], GIS technique has the capacity as an effective tool for spatial analyses and modeling of concentrations of air pollutants. GIS also has three basic key functions, which include database management, spatial analysis and visualization. Thus with these three components, this system (GIS) provides the capabilities of linking the concentration of the air pollutants with their geographic location [19]. From their study, it was also discovered that GIS technology could effectively represent the spatial relationships between sources and receptors as it can integrate with satellite remote sensing data in order to spatially analyze the relationship between the geographic location of air pollutants and the land use/land cover classes of the area. Models are representation of reality and they are created as a simplified, manageable view of reality, due to the inherent complexity of the earth and the diverse interactions in it. Models help to understand, describe, or predict how things work in the real world. Models are broadly classified into two namely representation and process models. Representation models are those that represent the objects in the landscape while those that attempt to simulate processes in the landscape are process models [20]. Representation models describe the objects in the landscape, such as buildings, streams, or forest while process models describe the interaction of the objects that are modeled in the representation model. There are different types of process models including suitability modeling, distance modeling and hydrological modeling [21].

2.2. Remote sensing for soil salinity mapping

The essence of remote sensing is the measuring and recording of the electromagnetic radiation emitted or reflected by the earth's surface [22]. For soil salinity investigation, this may be useful where salty soil, salt-affected vegetation, saline water, pond water and high water table area give contrasting reflectance with other landscape features so that they can be unambiguously distinguished. Remote Sensing (RS) is the art and science of obtaining information about an object, area or phenomenon through analysis of the data acquired by such device that is not in contact with the object, area or phenomenon under consideration. It is the measurement of object properties on Earth's surface using data acquired from aircraft and satellites. Rather than in situ, RS attempts to measure something at a distance. It involves measuring, recording and transmission of electromagnetic energy by the sensors mounted on aircraft or satellite reflected from or emitted by object from vantage point above the surface and relating

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of such measurements to the nature and distribution of surface materials and atmospheric conditions. Remote sensing system operation involves the detection, collection and interpretation of data from distance by mean of sensors. The reflectance of electromagnetic radiations from the features at the earth surface is measured with the aid of a sensor, while the radiated energy is transmitted through space in waveform. For land resources survey using remote sensing, wavelengths between 0.4 and 2.4 nm are commonly used. Generally, the electromagnetic spectrum ranges from gamma rays, with wavelength of less than 0.03 nm, to radio energy with a wavelength of more than 30 cm. According to [12], the presence of salts at the terrain surface can be detected from remotely sensed data either directly on bare soils, with salt efflorescence and crust, or indirectly through vegetation type and growth as these are controlled or affected by salinity. Better understanding of the relationship can advance the use of remote sensing for soil studies between soil properties and surface reflectance. Salt affected soils in arid regions, especially when a salt crust whitish color is formed show a high reflectance. Effective application of remote sensing data requires one to have the technical expertise and understand the spectra characteristics of the particular features to be studied. In addition, an understanding of the behavior of different wavelength regions on different soil materials and surface conditions may increase the efficiency of the study of soil salinity based on remote sensing [23].

2.3. Mapping of waterlogging

The change in soil color and the change in soil reflectance properties caused excess soil moisture, which can be easily detected by remote sensing. Plant response is one means of detecting poorly drained soils in California mainly because of a build-up of the water table. On the other hand, Salman [24] reported that as result of excess organic matter, soil color is generally darker in poorly drained areas than well-drained soils. The visible bands in Landsat-MSS data can be used to classify this color. According to [25] as cited in [26] pointed out that color infrared photography could indicate drainage problems by soil moisture saturation or plant stress. Shallow water tables exhibit a rise in surface moisture, which can be detected from visible reflectance and microwave emissivity. The information about drainage basin area and drainage pattern can be obtained from satellite imagery. Water logging and problems associated with drainage can be examined through GIS by identifying the drainage network and its characteristics in a basin, besides the report on the presence of high water table, high morphology, soil color, plant stress and drainage water collection in lower spots [27].

2.4. Application to large areas

For relatively large areas, remote sensing is an essential tool for mapping and surveying salt-affected and waterlogged soils [28]. The understanding of the actual conditions at the earth surface makes it feasible to interpret the satellite images. However, because of lack of specific absorption bands and spectral confusion, it is complex to distinguish the degree of salinity through remote sensing approach [29] that separated different soil salinity level using Landsat imagery. Most authors are capable to differentiate only 2–3 classes (strong and medium) of salinity levels with errors between moderately saline and normal soils.

2.5. Techniques in monitoring soil salinity

The classification of salt affected soils, assessment of the percentage of severity particularly in its early stage is important in terms of sustainable agricultural management [30]. Various approaches have been employed by researchers to analyze and monitor soil salinity. The three major techniques commonly used in soil salinity determination include traditional method, Electromagnetic Induction method and Remote Sensing and GIS method. The traditional or conventional methods used for detecting soil properties include ground-based geophysics and laboratory analysis methods [31]. Adeniran et al. [5] used this method to determine electrical conductivity of soil in Omi irrigation scheme by carrying out chemical analysis of the soil samples. 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 [32, 33]. Remote sensing methods are suitable for detecting, monitoring and controlling soil salinity. 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 [34]. Ojo et al. [15] stated the advantages of remote sensing and GIS method includes; time saving, wide range of coverage, facilitation of faster and long term monitoring. Electromagnetic Induction (EMI) was first employed in agriculture to detect saline soils by measuring its electrical conductivity [35]. Electromagnetic approaches are reliable means used for rapid determination of soil salinity [36]. Spatially varying soil types and properties are identified easily and map out quickly with the application of EMI as it offers unique benefit over traditional methods.

2.6. Soil mapping

There are varieties of methods to identify and map surface features using remotely sensed imagery. Techniques for mapping soil surface conditions, such as salinity and waterlogging are based on the presence or absence of spectral absorption features. Soil mapping include locating and identifying the various soils that occur, nature and properties, collecting information about soil location and recording this information on maps and in supporting documents to show their spatial distribution. Seghal et al. [37] applied Landsat MSS data for mapping salt affected soils in the frame of the reconnaissance soil map of Indian. Dwivedi [38] used Landsat MSS and TM data for more detailed mapping and monitoring of salt affected soils in the Indo-Gangetic alluvial plain. Landsat TM data have proved useful for mapping depositional environments on playas Tunisia [39]. Crowley [40] reported that gypsum and halite were likely to be the only evaporate phases detected and mapped on the Chott el Dyerid using TM data. Mehrjardi et al. [41] used Landsat TM+ taken in 2002 to map soil salinity in Ardakane Yazd by using an exponential model. They used band 3 of the images and soil salinity parameter in a regression analysis (R2 = 0.58) and reported a map accuracy of 0.87% and K coefficient equal to 0.47%. Various remote sensing data such as aerial photos, video, images, infrared thermography, visible and infrared multispectral, microwave and airborne geophysical data, is available for monitoring, classification and mapping out of saline soil [42]. According to [43] several authors have dealt with the study of soil salinization using satellite data, among them [12, 44–51]. In China, Peng [52] integrate

Landsat TM data with the depth and mineralization rate of groundwater to create soil salinity map. In Israel, hyper-spectral airborne sensor data were processed to yield quantitative maps of soil salinity [53].

2.7. Landsat image

Landsat image consists of three separate instrument subsystem, each operating in a different spectral region, using a separate optical system [54]. These subsystems are the Visible and Near Infrared (VNIR), the Short Wave Infrared (SWIR), and the Thermal Infrared (TIR), respectively. Landsat data has 14 bands allocated in three spectral regions as VNIR (band 1, 2, 3) with 15 m resolution, SWIR (bands 4–9) with 30 m resolution and TIR (bands 10–14) with 90 m resolution [55].

2.8. Landsat platform characteristics

With the launching of the Landsat satellite in 1972, researchers began to use satellite data for monitoring environmental activities in different parts of the world [56]. Landsat provides basic tools for working with satellite imagery as automated geo-referencing and cloud detection. Landsat consist of functions for radiometric normalization and various approaches to atmospheric correction. It also includes useful functions such as bare soil line and tasseled cap calculations [57]. The physiological condition of a crop is shown best at TM 5 and TM7. Landsat 5 (TM) that was launched on 01/03/1984 and Landsat 7 (ETM+) on 15/04/1999, each revisit a location every 16 days, and the two orbits are staggered for images to be taken every 8 days. Due to a hardware failure on 31/05/2003, Landsat 7 scenes are now missing 22% of the pixels also severe problem occurs toward the edges of an image. Band attributes are largely coherent, but ETM+ added an additional band. Landsat images haves been converted to integer digital numbers (DN) before distribution to facilitates storage and display. Atmospheric correction, topographic correction and conversion to radiance or reflectance may be required. Minimal processing may be needed if a single image or images widely separated in time are used to examine gross changes. However, careful correction is needed to examine detailed comparison of vegetation indices from multiple images. The most accurate atmospheric corrections need ground data collected during the satellite image capturing. For retrospective studies, this is impossible to obtain, and less-accurate image-based correction method must be used [58]. Band Wavelength and resolution for Landsat 5 Thematic Mapper (TM) and Landsat 7 Thematic Mapper (TM) is shown in **Tables 2** and **3** respectively. Panah and Goossens [23] claimed that thermal band of Landsat (TM) imagery is a good source of information that may have a vital role in soil salinity studies and in detecting gypsiferous soils in arid region. The reflective bands 1, 3, 4 and 7 are the best band composition for preparing the color composite images [59].

2.9. Land use and land cover (LU/LC)

Land-use and land-cover change being one of the major driving forces of global ecological change, is vital to the sustainable development discussion. One of the most accurate methods

	PW	AW	R
Band 1: Blue	0.45–0.52	0.452–0.518	30
Band 2: Green	0.52–0.60	0.528–0.609	30
Band 3: Red	0.63–0.69	0.626–0.693	30
Band 4: Near Infrared (NIR)	0.76–0.90	0.776–0.94	30
Band 5: Middle Infrared (MIR)	1.55–1.75	1.567–1.784	30
Band 6: Thermal Infrared (TIR)	10.40–12.50	10.45–12.42	120
Band 7: Middle Infrared (SWIR)	2.08–2.35	2.097–2.349	30

Source: [57]. Planned wavelength (PW), Actual wavelength (AW), Resolution (R).

Table 2. Band Wavelength (urn) and resolution (m) for Landsat 5.

to comprehend how land was used in the past, the types of changes to be expected in future, and also the forces and processes behind the changes is LU/LC analysis [45]. Increase in population, which lead people to clear forest for agricultural purposes in conjunction with anthropogenic activities accounts for the changes in LU/LC [60]. Messay [61] used sequential satellite images and GIS technologies, in combination with field observations, to investigate the LU/LC changes in the district of Nonno. The author stated that the overall consequence of conversion and modification processes of the LU/LC is the severe decrease in quality of the natural environment in the area. Changes in land use and land-cover provide a wide range of effect on environmental and landscape qualities including quality water, land and air resources, processes of ecosystem and functions, and the climate system itself through greenhouse gas fluxes [62]. Land cover is a significant element in change studies, affecting many aspects of the environmental system. Accurate and updated change in land cover information is necessary to understand the main factor causing changes and its environmental consequences [3]. Significant land-cover and land-use variation occurred in areas where irrigation is being practice in response to the increase of saline soils from time to time affecting crop cultivation leading to change in land-use [63]. The baseline data required for adequate and good understanding on the land-use patterns of previous years and its impacts can be extracted from Land-cover analysis. It also helps to figure out the percentage of the past land-cover changes and the physical factors behind [64]. Changes in land-use that occurs especially through deforestation and improper cultivation practice may rapidly degrade the quality of soil, as ecologically sensitive constituents of the habitats are not able to buffer the adverse effects. As a result, severe deterioration of the soil quality may result, leading to a permanent degradation of land productivity, and land degradation increases agricultural costs to maintain soil [65]. One of the major impacts of Land-use and Land-cover changes in arid and semi-arid region is soil salinization, this occur mostly wherever irrigation is being practiced. The decrease in soil quality due to accumulation of salts and sodicity keeps increasing at an alarming rate of endangering agricultural ecosystem and its environment [66].

	PW	AW	R
Band 1: Blue	0.45–0.52	0.452–0.514	30
Band 2: Green	0.52–0.60	0.519–0.601	30
Band 3: Red	0.63–0.69	0.631–0.692	30
Band 4: Near Infrared (NIR)	0.77–0.90	0.772–0.898	30
Band 5: Middle Infrared (MIR)	1.55–1.75	1.547–1.748	30
Band 6: Thermal Infrared (TIR)	10.40–12.50	10.31–12.36	60
Band 7: Middle Infrared (SWIR)	2.09–2.35	2.097–2.346	30
Band 8: Panchromatic	0.52–0.90	0.515–0.896	15

Source: [57]. Band 8 (ETM+ only) is higher resolution visible light data.
Planned wavelength (PW), Actual wavelength (AW), Resolution (R).

Table 3. Band Wavelength (urn) and resolution (m) for Landsat 7.

2.10. Landsat index

Soil and green vegetation have different methods of reflectance characteristics. The mixture of soil, green vegetation and shade in the pixels make remote sensing of land cover a challenge. Stewar and Rogerson [67] used vegetation indices to minimize the impacts of soil background and biological aging materials. Vegetation indices such as salinity index (SI), Soil Adjusted Vegetation Index (SAVI), Enhanced Vegetation Index (EVI), Green Vegetation Index (GVI), Transformed Soil Adjusted Vegetation Index (TSAVI), Simple Ratio (SR), Normalized Salinity Differential Index (NSDI), and Normalized Differential Vegetation Index (NDVI) are used to classified salt affected land to give better results [68].

2.10.1. Salinity index (SI)

Salinity index is the fraction of red band to near infrared band (NIR). The equation below describes salinity index equation [69].

$$SI = \frac{Band\ 3}{Band\ 4} \tag{1}$$

Lhissou et al. [70] cited that Al-khaier [71] reported the usefulness of the salinity index using ASTER (Advance Space borne Thermal Emission and Reflection Radiometer) sensor data in mapping salinity of irrigated farmland in Syria. Salinity Index (SI), and Normalized Differential Salinity Index (NDSI) give good results in detecting salt-affected lands; the spectral reflectance of NIR, which radioed with red hand, gives very spectral values for vegetation [72].

2.10.2. Normalized differential salinity index (NDSI)

NDSI is the ratio of the difference between the red band and NIR to the summation of the red band and NIR. Chandana et al. [73] used NDSI for identification of salt affected soils in assessment of soil salinity level of Pambantota district, Southern Sri Lanka, based on remote sensing information of TM sensor of Landsat 7 satellite. The equation for calculating NDSI is given in Eq. (2) [74].

$$\text{NDSI} = \frac{Band\ 3 - Band\ 4}{Band\ 3 + Band\ 4} \quad (2)$$

2.10.3. Normalized different vegetation index (NDVI)

The vegetation cover of a place can be examined using Normalized different vegetation index (NDVI) method [75]. NDVI is expressed as the fractional difference between NIR and red band to the addition of the two. It may be calculated from reflectance measured in the visible and near infrared channels from satellite based remote sensing. According to [75] NDVI shows spatial and temporal change of vegetation cover. The use of NDVI helps to create better and visual interpretation of healthy vegetation in contrast to other features [73]. The amount of salt present in the soil can be measured using NDVI through stressed vegetation; Aldakheel et al. [73, 76] gave the mathematical expression of NDVI as:

$$\text{NDVI} = \frac{Band\ 4 - Band\ 3}{Band\ 3 + Band\ 4} \quad (3)$$

NDVI has been used many researches to work mask vegetation from non-vegetation, and to detect the spatio-temporal change in vegetation biomass. Panah and Goossens [23] used TM based NDVI as an indicator of vegetation cover to separate bare soil from vegetation cover 1990 and the MSS based NDVI was taken to separate bare soil from vegetation cover in 1975. In Egypt, Masoud and Koike [77] used vegetation indices to examine and monitored salinization from changes in surface characteristics and radiometric thermal temperature for specific years. Darvishsefat et al. [78] classified salt affected soils based on ETM+ images acquired for Hoze Soltan Ghom area using image proportional and principal component analysis method. They claimed that the methods used were not suitable for image classification of saline soils. Saha et al. [47] employed band 3, 4, 5, and 7 of TM images to classifying salt affected land of moorland in India with an accuracy of 95%. Landsat ETM+ was applied in preparation soil salinity assessment for Texaco in Mexico [79]. Combined spectral response index (COSRI) and an exponential model was used to derive a high correlation coefficient between soil characteristics and spectral values of the multiband index. They reported values between −0.885 and 0.857 for EC and sodium adsorption ratio SAR as a correlation coefficient respectively with derived variance of 82.6 and 75.1% for EC and SAR as respectively. Unsupervised image classification technique is largely automated while supervised classification method requires considerable human input in the classification process [80]. Classification of soil using different Band Combination is presented in **Table 4**.

2.10.4. Pixel purity index (PPI)

Pixel Purity Index (PPI) is a way of finding the most spectrally pure pixels in hyper-spectral and multispectral images [81]. The most spectrally pure pixels typically correspond to mixing

Band Combination	Classification	Total Accuracy	Total Accuracy (Medium and High Salinity)
1,2,3,4,5,7	Supervised (Maximum likelihood Classification)	57%	66.20%
1,3,7	Supervised (Maximum likelihood Classification)	51%	56.50%
1,3,4,7	Supervised (Maximum likelihood Classification)	54%	71.3%
1,3,4,7	Hybrid	50%	80.5%
1,2,3	Supervised (Maximum likelihood Classification)	40%	***
1,3,4,7	Hybrid (No salinity and High salinity)	62%	***

Source: [59].
*** No figure.

Table 4. Total Accuracy of soil classification based on different Band Combination.

end-members. The PPI values are calculated by projecting n-dimensional scatterplots onto a random unit vector repeatedly. The pure pixels in each projection are recorded and the total number of period at which each pure pixel was marked is noted [71]. The digital number (DN) of each PPI generated corresponds to the number of pixel occurrence, which is recorded as extreme. The PPI normally run on a Minimum Noise Fraction (MNF) transform result apart from the noise bands. Results of the unmixing model and conventional classification technique are then compared for identification of land quality reduction in region [82]. Number of iterations with different threshold limit is carried out interactively to separate the position of most pure pixels in the image. A threshold of two are fixed for the identification of pure pixels in the image which will be explained as, all the pixels having 2 DN values (maximum limit) greater than the extreme pixel is thought to be pure. Two different sets of iterations 1000 and 5000 is carried out on the data set while keeping the threshold at two. The more the number of iterations, the more the number of extreme pixels found with more variability in the data set [40]. The value in the PPI image indicates the number of times each pixel as extreme in some projection while PPI image with higher values indicate pixels that are closer "corners" to the n-dimensional data cloud, and are hence relatively purer than the pixels with lower value. Lastly, Region of interest (ROI) is generated for the PPI image keeping the minimum threshold limit at 50, after comparing the PPI image with calibrated image to get a better idea about the position of the pure pixels [83].

2.10.5. Digital analysis using surface vegetation index

Vegetation index is a spectral index that detects the presence of chlorophyll [84]. Various crop indices have been derived using the fact that chlorophyll strongly absorbs the light energy in the red part and highly reflects in the near-infrared part [85]. Several researches for specific analyses have proposed a number of vegetation indices. Many papers have explained the detection of salinity through its effect on the vegetation. Richardson et al. [86] specified that an inverse relationship is observed between reflectance and salinity, as salt content induces less plant cover (decreasing of density, LAI and height) and sometimes slight salt deposition on surface associated with vegetation have similar reflectance as that of normal cropped area. Salt tolerant plants are good references of salinity level on salt marshes but necessitate good calibration [30]. Contrasted associations of vegetation and bare soils can be more useful for salinity detection than individual surface types. Remotely sensed imagery cannot be used to classify and assess soil profile. Spectral characteristics of the earth surface features that are indicative of subsurface conditions can be analyzed. Satellite multi-spectral data denote changes that aid in locating mapping units; they hold great promise for soil surveys and land-use planning [87]. Some relationships have been established to relate soil properties and spectral data while most of these properties have been from the surface soil, subsurface properties that influence some surface characteristics were considered. Satellite sensors observe only the ground surface, actually both subsurface and surface soil conditions are influenced by common genetic factors [88]. Both subsurface conditions and surface conditions are plant canopy. Therefore, when satellite imagery depicts a pattern based on a different spectral response, it is not unreasonable to attempt some inferences about subsurface soil patterns [70].

2.10.6. Image classification

There are many procedures commonly used for the classification of remote sensing images and this depends on the radiometric information in the image bands. The traditionally used classification method is a pixel-based approach and is one of the procedures based on conventional statistical techniques and it performs well. Pixel based approach is based on conventional statistical techniques, such as parallelepiped, maximum likelihood and minimum distance procedures [57]. In pixel-based classification, two kinds of traditional classification methods-unsupervised classification and supervised classification are used. Ideally, pixels are expected to be to a degree, more or less grouped in the multispectral space in clusters corresponding to different land cover types [89]. It is a classic classification approach that classifies an image pixel by pixel and one pixel can only be classified into one class, thus produces is a hard classification [67].

2.10.7. Classification of digital satellite data

The basic characteristics of digital image acquired by remote sensing method are composed of pixels. According to [24], the intensity of each pixel corresponds to the mean radiance measured electrically over the ground area corresponding to each pixel. Each pixel has digital number (DN) corresponding to the average radiance measured in this pixel. This number from quantizing the original electrical signal from the sensor result into positive integer values using a process termed analogue-to-digital signal conversion [90]. The DNs comprising of a digital image are recorded over numerical ranges as 0–255, 0–511, or higher. These ranges correspond to the set of integers that were recorded using 8-, 9-, and 10-bit binary computer coding scales, respectively. In such numerical formats, the image can be analyzed with the aid of computer [91]. A digital image is a 2-dimension array of elements; the corresponding

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area on the earth's surface was stored in each element emitted from the energy. The spatial arrangement of the measurements defines the image or image space, depending on the sensor; data are recorded in n bands.

3. Conclusion

The chapter demonstrates possibility of use of high technology in particular remote sensing and GIS technology in land cover/land use and soil salinity monitoring with demonstration of advantages of use such technology in similar problem solving. Detection of soil salinity by conventional means of soil survey requires a great deal of time, but the application of geospatial analysis using remote sensing and GIS techniques minimize time consuming and offer the possibility assessment, modeling and mapping of irrigated land. The chapter also worked on general subjects with reflection of the cycle of satellite data use with a variety of application, indexes for registration and data processing stage. The fact is that the use of space technology advances in land classification are commonly used instrument for soil monitoring which is one of the suitable and flexible instrument from a wide point of view. The instrument makes it possible to perform results conveniently for users. In addition, the application of these indexes is a good indicator of soil salinity in irrigated lands, which may influence decision on reclamation of soil salinity and used as an input for agricultural land management. Irrigation managers, planners, farmers and government agencies for smart agriculture can use models and maps generated through geospatial analysis.

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