International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

ORIGINAL RESEARCH PAPER

Application of remote sensing and geographical information system in mapping land cover of the national park

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ARTICLE INFO

Article History:
Received 15 December 2019
Revised 11 February 2020
Accepted 20 March 2020

Keywords:
Geographic Information System (GIS)
Land cover
Nechisar National Park (NNP)
Remote Sensing
Satellite images

ABSTRACT

The study was conducted with the objective of mapping landscape cover of Nechsar National park in Ethiopia to produce spatially accurate and timely information on land use and changing pattern. Monitoring provides the planners and decision-makers with required information about the current state of its development and the nature of changes that have occurred. Remote sensing and Geographical Information System have gained importance as powerful and efficient tools for land cover mapping of inaccessible area. Digital image classification is generally performed to produce land cover maps from remote sensing data, particularly for large areas. In this project, LANDSAT 7 ETM+ 2000 data was prepared for producing land cover map of study area, Nechisar National Park. Digital image processing techniques were conducted for the processes of radiometric and geometric correction and classification for land cover analysis. Additionally, training data for supervised classification were collected in the study area. Signature development was carried out and evaluated. Training sites were re-defined such that significant separability was obtained for all six bands of LANDSAT 7 EMT+. Finally, Supervised Classification was applied to classify the satellite image using Maximum Likelihood Classifier and five major land class cover were identified and mapped for the Nechsar National park. These are: grassland, forest land, deciduous bush land, thickets, and water bodies.

DOI:10.22034/IJHCUM.2020.02.05

INTRODUCTION

Although the benefits of integrating GIS and remote sensing data for more effective ecological mapping and monitoring are many, the time, money and expertise required taking full advantage of the technology can be initially discouraging. The information used for scientifically valid ecological mapping and monitoring needs to be frequently updated, sufficiently detailed and spatially continuous. Ecological inventories have historically been conducted through field survey a time-consuming and expensive endeavor, particularly when study sites are large and/or remote, and when long-term monitoring is a concern to resource managers (Rogan and Chen, 2004). This field work paradigm has implicitly affected both the typical study area size and the spatial scale of observations associated with ecological research. Field data are also typically collected based on some purposive sampling scheme, in which information

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on a specific ecological attribute is of primary interest, and therefore may not be appropriate for describing other attributes of subsequent interest. The availability of ecological datasets, collected through remote sensing or derived within a GIS at local to global scales, has revolutionized the way ecological research is conducted. GIS enhances the ability to derive information from remotely sensed data, and remotely sensed data can opened up wide range of avenues for effective land cover mapping providing efficient methods for analysis of land use issues and tools for land use planning and modeling (Pandian *et al*., 2014). The synoptic perspective, temporal frequency and repeatability of remotely sensed measurements have been invaluable for detecting and monitoring change (Roganet *al*., 2008). The recent review of remote sensing applications in ecological research identified three main application focus areas: land cover classification, integrated ecosystem measurements and multitemporal change detection. And there are also four ways in which GIS and RS data can be integrated: a) GIS can be used to manage multiple data types; b) GIS analysis and processing methods can be used for manipulation and analysis of remotely sensed data (e.g. neighborhood or reclassification operations); c) remotely sensed data can be manipulated to derive GIS data; and d) GIS data can be used to guide image analysis to extract more complete and accurate information from spectral data (Rogan and Miller, 2006). Remote sensing also facilitates data collection in difficult or impossible-to-reach areas and provides an important synoptic and multitemporal perspective and now providing new tools for advanced ecosystem mapping. The collection of remotely sensed data facilitates the synoptic analyses of impossible areas function, pattern, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of ecological diversity (Wilkie and Finn, 1996). Therefore, in this project attempt was made to map out land class cover map of Nechisar National Park (NNP) applying GIS and RS techniques.

Statement of the Problem

The ability to map and monitor ecological phenomena over large spatial extents has become a focus of renewed research in the context of increasing awareness of human activities and environmental change. Human activities substantially impact most of the terrestrial biosphere, currently at rates and spatial extents far greater than in any other period in human history. Numerous organizations, disciplines and initiatives have formed in the last 15 years in response to the many challenges to sustainable resource management and ecological protection. Spatial and temporal characteristics to provide the scientific understanding required to measure, model, maintain and/or restore landscapes at multiple scales(EPA, 1998; EPA, 2002).Research efforts in support of sustainable ecosystem management have focused on characterizing ecosystem condition and change, exploring the effects of different management schemes, and understanding how natural and anthropogenic processes affect ecosystem functioning (ibid). Solutions to these problems require spatially explicit and timely ecological map, often combined with statistical models in a geographic information system (GIS). Current research illustrates how ecological problems ranging from biodiversity loss to land-use change have benefited greatly from advances in geospatial technologies such as GIS and remote sensing, both in the provision of data and access to spatial data analysis tools. The integration of GIS and RS for ecological mapping and monitoring, while addressed in earlier research (Goodchild, 1994), has become even more important as these data and technologies continue to evolve, and as ecological issues become more critical. While GIS technology facilitate ecological mapping and monitoring lack of familiarity and background knowledge, equipment cost and complexity of data-processing methods and inaccessibility of an areas are often cited as factors that prevent even wider use of remote sensing approaches for land class cover Mapping. It is evident that the ground methods have limitations as whole area may not be easily accessed in most cases and the information collected may not be as accurate as is possible through RS and GIS aided by few field surveys. RS and GIS can therefore be used to supplement or partially replace the classical ground survey methods (ibid).The integration of GIS and RS for land class cover mapping, as addressed by (Franklin 1995 and Goodchild, 1994) has become even more important as these data and technologies continue to evolve, and as ecological issues become more critical. At present, most have very limited knowledge of inaccessible areas ecology, hence, peoples have been using the old topographic maps to generate management options and other maps of this areas in mapping and management, which possess a time consuming and expensive attempt, particularly when study sites are large and/or remote, and when long-term monitoring is a concern (Rogan and Chen, 2004). Therefore, the central purpose of this project was to identify the potential value of remote sensing and GIS techniques in mapping land class cover of inaccessible area so as to answer the questions of; what is the technology capable of? And what it is not capable? To access its advantages over other classical ground methods and its application limitations.

Study area

This project was conducted in Nechisar National Park. Nechisar National Park (NNP) is one of the National Parks of EthiopiaFig. 1; located at about 510 km away from Addis Ababa Countries Capital in the Amaro Special Woreda and Arbaminch Zuria Woreda of the Southern Nation Nationalities and Peoples Regional State (SNNPRS) the east of Arbaminch. NNP was established in 1974. Since its establishment, NNP has been managed in various ways. Administered by a warden and staffs responsible for Ethiopian Wildlife Conservation Organization (EWCO) until 1995, it was governed and looked after by Ethiopia Wildlife Conservation Organization (EWCO). Since 1995, the responsibility of administrating the Park was transferred to the Government of the SNNPRS. Like most other National Parks in Ethiopia, NNP was financed by public fund and operated like any other civil service department (Samson Shimles, 2010).

NNP is located at the eastern edge of Arbaminch town, southern part of Ethiopia. The Park is situated at 5^0 51\`- $6^0$ 10\` N and 37^0 32\`-$37^0$ 48\` E. It is bounded by the Amaro mountain ranges on the east, Lake Abaya in the North and Lake Chamo in the South and Arbaminch town on the west. The Park is located in the very scenic part of the Rift Valley floor between the two lakes, lakes Abaya and Chamo and includes a good portion of the two, southern most lakes of Ethiopia and the chain of hills separating the two lakes called God's bridge by local people (Fetene, *et al.,* 2011).In terms of vegetation and land cover NNP is categorized in to a) Grass Land b) Deciduous Bush land and Thickets) Forest (Ground water forest and Reverie forest) and water bodies(part of lake

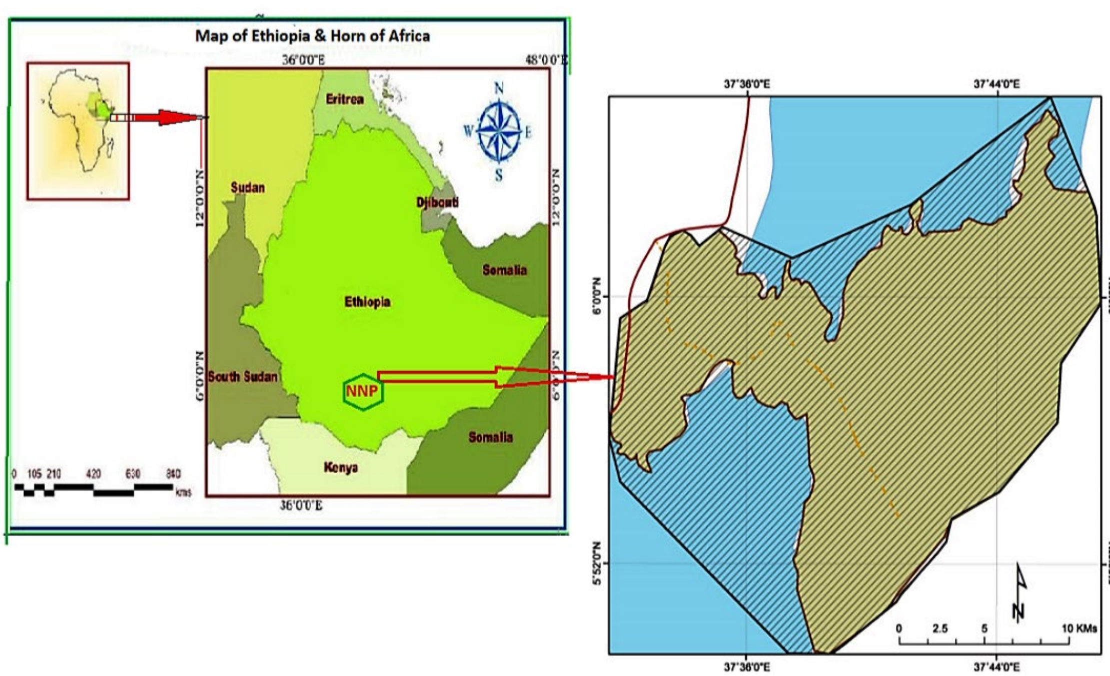

Fig.1 Location of Nechsar National Park (NNP)

Chamo and lake Abaya), (Datiko and Bekele,2011). The Arba Minch ground water forests, Kulfo and Sermele riverine forests are found within the vicinity of NNP. The ground water forests and the Sermele valley forests are located in the western and eastern part of the park, respectively, whereas, the Kulfo riverine forest is located in between the two forests but lose to the ground water forests. In this regard, the relevance of the study is to provide detailed information on land class cover maps for appropriate boundaries demarcation and accessing encroachments of NNP. The general objective of this study was to examine how RS and GIS techniques are used in land class cover mapping of inaccessible areas with particular reference to Nechisar National Park (NNP) Ethiopia. Specific objectives are; 1) To produce land class cover map of NNP using GIS and remote sensing techniques; 2) To identify other roles that this technology can perform in land class cover mapping practices, their advantages over other classical methods and their limitations/difficulties; 3) To demonstrate the power of GIS and RS techniques in land class cover mapping. This study has been carried out in Addis Abeba University in 2012 as a mini project and finally completed in Arbaminch College of Teachers' Education with major modification inculcating significant image analysis process in 2019.

MATERIALS AND METHODS

The procedure used in the current study is shown in Fig. 2; which is beginning from the acquisition and classification of multitemporal satellite image of the study area to the extraction of the required land class cover classification map of the study area.

This is a type of case study attempt to map land class cover of NNP using RS and GIS techniques, therefore the followings are materials and methodology adopted for thematic data extraction from the Satellite Imageries. For this research, multi-temporal image, Landsat-7 ETM+ 2000 topographic maps, 1:50,000 (Fig. 5) and ASTER data, ASTER DEM (Fig. 3) were used. The 1:50,000 topographic maps of the study area were scanned, georeferenced and projected to UTM coordinate system, map zone 37N of WGS-84 spheroid and datum. The World Geodetic System 1984 (WGS-84) is the geodetic

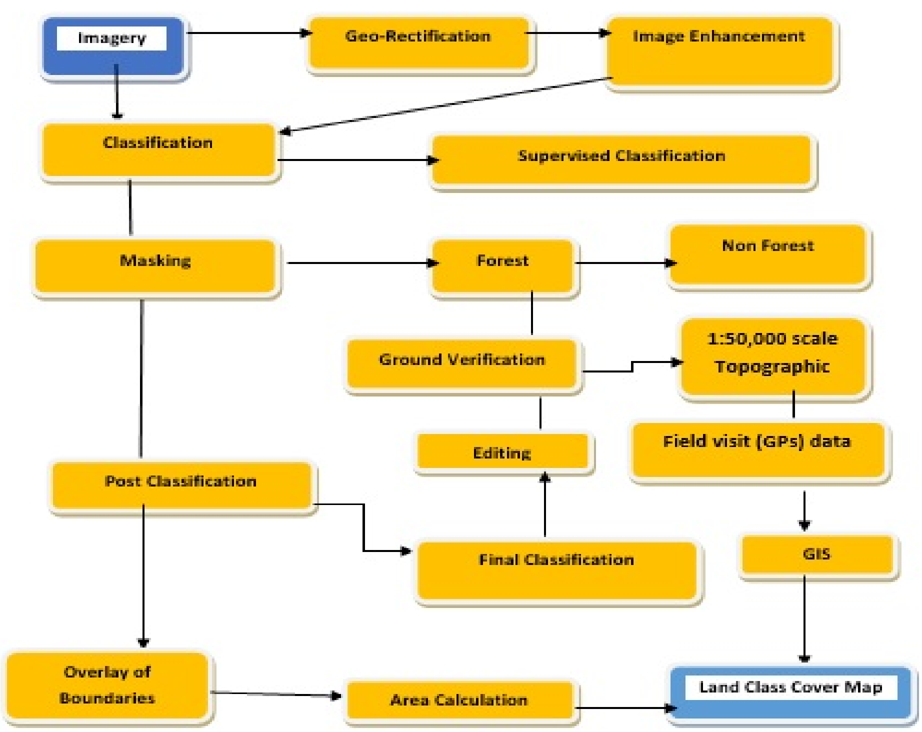

Fig. 2: Flow Chart Illustrating the Process of Digital Image processing

reference system used by GPS. It should be noted that all GPS receivers compute and store coordinates in terms of WGS-84, then transform to other datum when information is displayed. WGS-84 is also the default datum for many GIS software packages with data either being stored in or transformed via WGS-84 (Featherstone, 2007). The satellite images and the ASTER data were originally Ortho-rectified and therefore did not require georeferencing. Road and river layers were digitized from the georeferenced topographic maps. ERDAS Imagine (9.1) for image processing, ARC/GIS (9.3), and Arc/view (3.2) Software's for digitizing, editing, contour generation and mapping are the Software's used for digital processing of the spatial data. Digital image processing techniques were applied for the mapping of the land cover classes of the study area from the satellite data. The methodology applied comes under the following steps:

Geo-rectification and image extraction

Image rectification is an important procedure for many image processing applications. Simply put, it is the process of converting a raw image into a specified map projection (Sabins, 1999). The procedure involves the selection of distinguishable ground control points (GCP's) in the image. These points are then assigned the appropriate reference information, such as latitude/longitude or Universal Transverse Mercator (UTM) coordinates. This reference data can be obtained from existing map sheets or from fieldwork utilizing Global Positioning Systems (GPS). After that a certain number of GCP's have been entered and referenced, the computer program resample's the original pixels into the desired projection. The importance of rectification is that the image can now be used in conjunction with other data sets. Landsat Satellite imageries are recommendable for Land Class cover mapping (Jensen, 1996). Thus, in this project, Landsat-7 Enhanced Thematic Mapper plus (ETM+) imagery of acquisition date of 27/01/2000 Row 169 and Path 056 was used. Even if the Landsat images were georeferenced before at hand, slight shift was recognized between them. This problem was addressed by geo referencing the satellite image based on the georeferenced topographic map through image-to-image registration technique. This task was accomplished by opening the geo referenced 1:50,000 topographic maps obtained from Ethiopian Mapping Agency, (2004) and Landsat image on different viewers of ERDAS Imagine software. Coordinate values of clearly recognized features were transferred from the georeferenced topographic map to the satellite image by mouth click. The geometric registration

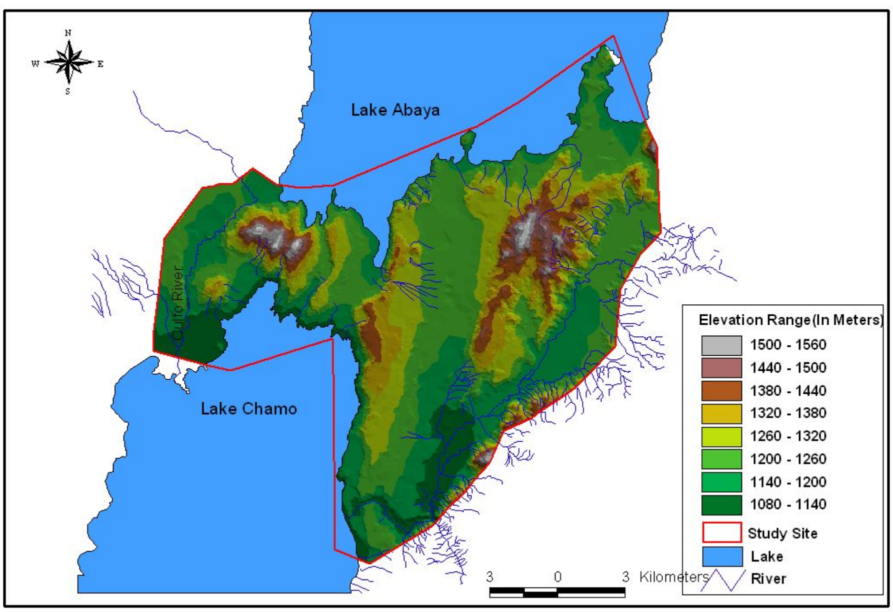

Fig. 3: Digital elevation model of Nechisar National Park with stream overlay

Principal components analysis (a)	Principal components analysis (b)	Principal components analysis (c)

Fig. 4 Principal Components Analysis (PCA) processed for satellite image spectral enhancement

methods and output Root Mean Square (RMS) error is below 0.5. After registration the study area was subset for the areas of study on ERDAS 9.1 using the boundary of NNP. Boundary of NNP was obtained from the Journal of Nature and Science, 2011 (Fetene *et al.,* 2011). The boundary was converted into digital by scanning and imported into ERDAS 9.1 software. Control points (CP) for geo-referencing the scanned maps (images) were selected from the hardcopy maps. The transformation was done using the image analyst within ERDAS 9.1 software environment. The georeferenced boundary was displayed with interface of Arc view 3.2 and the process of boundary extraction from imageries was done using the on-screen digitizing method. Advanced Space born Thermal Emission and Reflection Radiometer (ASTER) is an advanced multispectral imager that was launched on board NASA's Terra spacecraft in December 1999(Abrehams, 2000). ASTER covers a wide spectral region with 14 bands from the visible to the thermal infrared. An additional backward-looking near-infrared band provides stereo coverage. Because of the nadir looking and backward looking band 3 sensors can obtain data of the same area from different viewing angles, stereo ASTER data can be used to produce Digital Elevation Model (DEMs) (Omo-Irabor, 2016). The DEM derived from ASTER with a 30m resolution is used to generate slope map of the study area (Fig. 3). Therefore, elevation map of the study area is generated from ASTER digital elevation model. The digital elevation model (DEM) is a raster based digital dataset of the topography of the Earth, the pixels of the dataset are each assigned an elevation value, and a header portion of the dataset defines the area of coverage, the units each pixel covers, and the units of elevation (Bastin,1997). To generate the study are digital elevation model; the raw ASTER data is patched on 3D Visualization software in order to fill the missing data and exported into Arc map environment.

Then study area DEM is extracted by masking of study area shape file with the help of extraction tool in Arc GIS 9.3. The resultant map indicates that the study area has an altitude ranging from approximately 1080 to 1560 m above sea level. Then digital elevation model was classified to 6 classes with 60 m intervals and elevation map of the study area was produced. Using the drawing and editing tools of the above mentioned software's, each entity of the feature of interest was traced out. The predefined code for each entity was attached as attribute.

Image enhancement

The Landsat image was clipped to the study area to speed up the data processing. The Atmospheric Correction model(ATCOR2) developed by Richter (Richter, 1998) was utilized to perform radiometric calibration and remove the effects that change the spectral characteristics of the land features (Paolini, *et al.,* 2006).Image enhancement is one of the important image processing functions primarily done to improve the appearance of the imagery to assist in visual interpretation and analysis. The next step of this project was to perform various spectral enhancements on the rectified image. Spectral enhancements are modifications of the pixel values of an image. They can be used to improve interpretability, reduce information redundancy, and extract information from the data which is not readily visible in its raw form (Beaubien, *et al.,* 1999). The enhancement techniques utilized for this project were Noise Removal and principal component Analysis. Principal Components Analysis (PCA) is a spectral enhancement which can be used to compress the information content of a multispectral data set (Sabin's, 1999). PCA uses mathematical algorithms to transform n bands of correlated data into n principal components which are uncorrelated, such that the coordinate axes of the components are mutually orthogonal. The principal component describes most of the variation of the brightness values for the pixels of the original bands (Jensen, 1996). Subsequent components explain less and less of the data corresponding to atmospheric noise in the data rather than any ground features (Gumeet and Rupinder, 2012).

The first principal component (Fig. 4a) describes most of the variation of the brightness values for the pixels of the original bands. Subsequent PCA-3 (Fig. 4b) components explain less and less of the data, with the final PC-3 (Fig. 4c) usually corresponding to atmospheric noise in the data rather than any ground features (Sabins, 1999). The main benefit of principal components analysis is that it can reduce the amount of data (bands) without losing much of the information and typically reducing redundancy (Jensen, 2005). For example, the three visible bands (1, 2, and 3) of TM images are usually highly correlated, meaning they look roughly the same and thus provide redundant information for classification purposes. After running a principal components analysis on these three bands, we would find that the majority of the information contained within the three bands would be explained by PC-1 or (PC-3) of the three visible bands looks pretty much the same as any of the three bands viewed individually in gray scale. Thus, this one layer of data could replace the three original bands without much loss of information.

Classification scheme, training site selection and data collection

Training site was selected based on the identified land cover and the true color composite images of band 1, 2, and 3. The training site selection criteria is areas with extensive land cover categories and those areas not a big but among the pre-defined land cover categories was also included in the training site. Finally considerable amount of land cover categories were identified as "training" data set for supervised classification. Supervised classifications easily create training samples to represent the classes we want to extract. You can also easily create a signature file from the training samples, which is then used by the multivariate classification tools to classify the image (Gbola, *et al*., 2017). For its accuracy the ground truth was also consulted on the different data set such as digital globe and Base map (topographic map of the study area).The topographic map of the study area with 1:50,000 scales was Obtained from Ethiopian Mapping Agency (EMA)on the sheet Kelle, Dilla, Arbaminch, and Nechisar National Park. After each sheet numbers were scanned, using ERDAS 9.1 software they are masking and georefernced for image to image comparison.

Field surveys were also carried out. Ground truth was done by matching the pattern, texture association, shape and size of the features from the FCC for a particular topographic feature using GPS locations. The method used during the field visit was an "opportunistic transect method" as the study areas were not always accessible due to high density of under growth and absence of accessible tracks and roads. Image classification is the process of sorting pixels into a finite number of individual classes, or categories of data based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to those criteria (Richards, 1996).There are two primary types of classification algorithm applied to remotely sensed data. These are unsupervised and supervised. Unsupervised classification algorithms such as ISODATA (Iterative Self-Organizing Data Analysis) cluster data according to several user defined statistical parameters in an iterative fashion until either some percentage of pixels remain unchanged or a maximum number of iterations have been performed. This method of classification is most useful when no previous knowledge or ground truth data of an area is unavailable (Lu and Weng, 2007). Supervised classifications require a priori knowledge of the scene area in order to provide the computer with unique material groups or what are called "training sites". Regions containing a material of interest

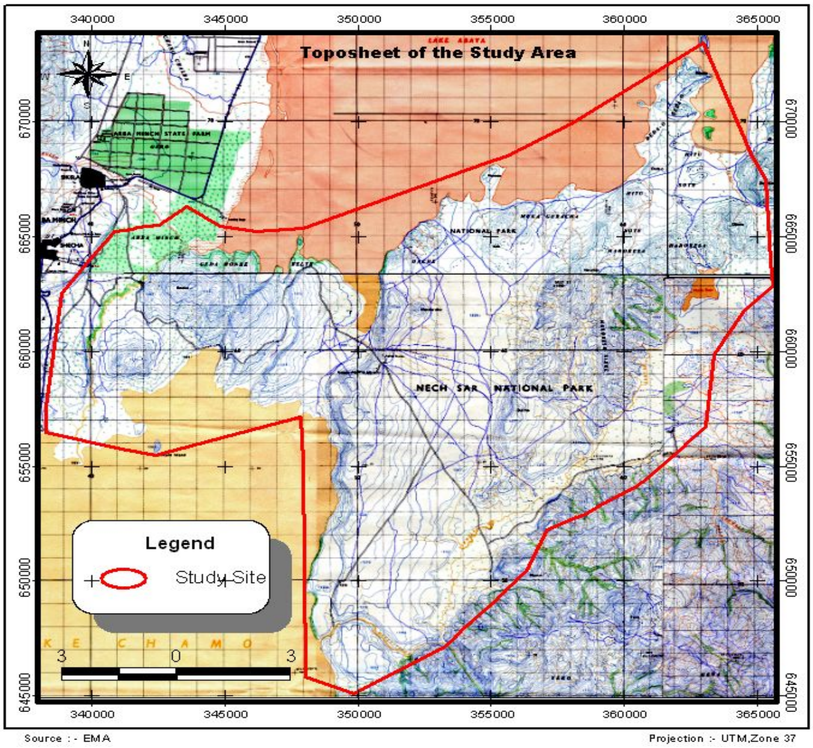

Fig. 5: Masked and Georefernced Topographic sheet of NNP

within a scene are delineated graphically and stored for use in the supervised classification algorithm. It is the job of the user to define the original pixels that contain similar spectral classes representing certain land cover class. The most common supervised classification techniques are the Maximum Likelihood classifier for parametric input data and Parallelepiped classifier for non-parametric data (Deanand Smith, 2003). Maximum Likelihood Classifier (MLC) assumes that a pixel has a certain probability of belonging to a particular class. These probabilities are equal for all classes and the input data in each band follows the normal distribution function (Omo-Irabor, 2016). Maximum Likelihood Classifier functions by using the band means and standard deviations from field collected data in order to project land cover classes as centroids in feature space. These centroids of each land cover classes are circumscribed by probability contours. The probability density function assumes that the sample values for each class are normally distributed. The unclassified pixels are plotted in the same feature space and get a posteriori probability. Usually the pixels are then assigned to the class for which they have highest membership probability. But it is possible to soften the maximum likelihood classification by using the a posteriori membership probability values as indices of class membership (Bastin, 1997).The strong advantage of Maximum Likelihood method is its use of well-developed probability theory. However, it has also serious known drawbacks under certain circumstances. First, if the histogram of the image does not follow normal distribution curve, the basic assumption of this classifier is violated and results in poor or misleading result. Moreover in case of high correlation between two bands, as it usually occurs in Landsat images, or when the data used for signature development is not sufficiently heterogeneous. Such redundancy should be removed through using (PCA) before proceeding to classification (Congalton and Poured, 2002). The method used in this study was supervised classification because of a priori knowledge of the scene area and ground truth data availabilities such as Digital Globe and Topographic Map of an area and field visit. During the field visit various land cover classes were taken using Grami-GPS devise. Finally the imagery was classified using the Maximum Likelihood supervised classification using spectral information of the known land cover categories observed. Classified data often manifests a salt and paper appearance due to the inherent spectral variability encountered by the classifier when applied on pixel-by-pixel bases. To overcome the "salt-and-pepper" effect, object-based approaches have been increasingly implemented in remote-sensed image analysis (Costa, *et al.*, 2014). Since object-based methods can avoid being affected by spectral similarity between different vegetation mosaicking variability, techniques based on objects become a more useful approach to map vegetation type types (Ning, *et al.*, 2014).And In such situations, it is also desirable to smooth the classified output to show only the dominant class (Lillisand and Kiffer, 2004). Accordingly one means of classification smoothing involves the application of a major filter. In such operations, a moving window is passed through the classified data set and the majority class within the window is determined. If the center pixel in the window is not the majority class, its identity is changed to the majority class. If there is no majority class in the widow, the identity of the center pixel is not changed. Thus, a 3*3- pixel majority filter algorithm on ERDAS 9.1 software has been applied on the classified images.

RESULTS AND DISCUSSION

From supervised classified imagery, five classes were identified as forest, grass land, deciduous bush land, thickets and water bodies but after field visit minor corrections were made because in the certain places some part of thickets were classified as deciduous bush land while certain part of forest is classified as deciduous bush land. Finally after their boundaries are overlaid and there total coverage of each land cover class was calculated Land Class cover Map of NNP was prepared. The land cover map was prepared through digital analysis of satellite data (Fig. 8) using supervised maximum likelihood classification technique. Supervised classification is a procedure

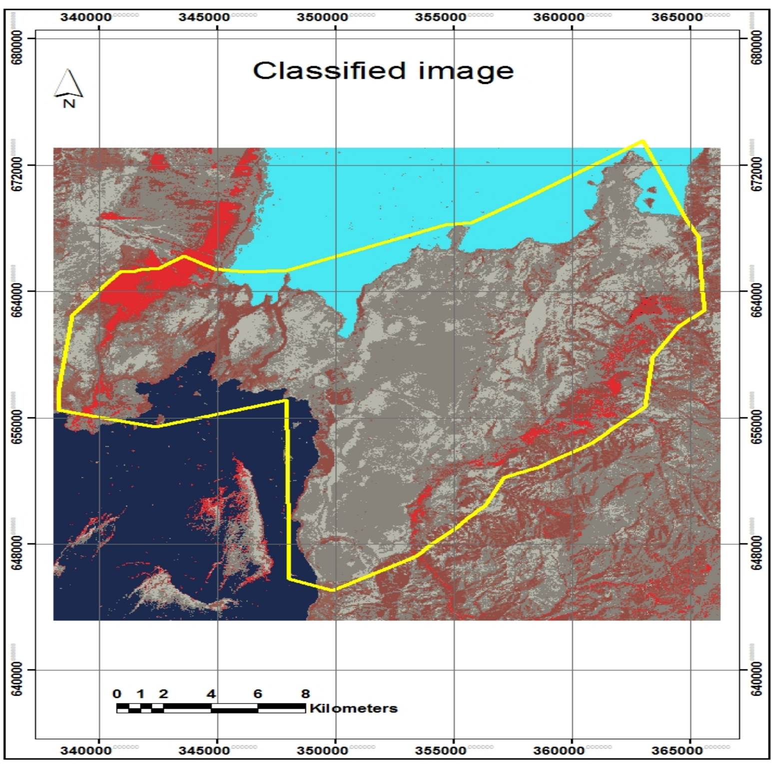

Fig. 6: Classified image with false color composite

for identifying spectrally similar areas on an image by identifying 'training' sites of known targets and then extrapolating those spectral signatures to other areas of unknown targets and accuracy assessment results were based on reference data that were independent of data used in the training phase of the classification (Khatami, *et al.,* 2016).Supervised classification relies on the previous knowledge of the location and identity of land cover types that are in the image. This was achieved through field visits of the study area. Training areas were used to "train" the classification algorithm to recognize land cover classes based on their spectral signatures, as found in the image (Lillisand and Kiefer, 1994). The maximum likelihood classifier (MLC) assumes that the training statistics for each class have a normal distribution. The classifier then uses the training statistics to compute a probability value of whether it belongs to a particular land cover category class. This allows for within-class spectral variance. In this the image analyst uses a prior knowledge to weight the probability function. The MLC provides the highest classification accuracies (Lillisand and Kiefer, 1994). After different pre-processing image enhancement techniques such as geometric and radiometric correction techniques were employed, Maximum likelihood classification was performed using the developed signatures of the land cover categories. Other methods like minimum distance to means and parallepiped classifiers which is used by determining the parallelpiped- shaped boxes for each pre-defined class (Sunitha and Suresh, 2015). The parallelpiped boundaries for the classes are determined by the minimum and maximum of pixels in a particular class. These boundaries help in assigning a pixel to a given class (Nupur and Maheshwari, 2017). Thus parallepiped classifiers was also tested but their results were not any more convincing. As the result the MLC i.e. the most commonly used parametric classifier in practice (He *et al*., 2015). Thus, because of its optimal result and its easy availability in almost any image-processing software was applied and five land class cover types were identified, including: deciduous bush land, forest, grass land, water bodies, and thicket.

Accordingly as shown in (Fig. 7) the main land class cover of the NNP consists of Deciduous Bush Land (35.53 km^2), Forest (82.99 km^2), Grass Land (237.51 km^2), Thickets (52.2 km^2) and Water Bodies made up of Lake Abaya and Lake Chamo covers 49.01 and 30.74 (km^2) respectively. On the different

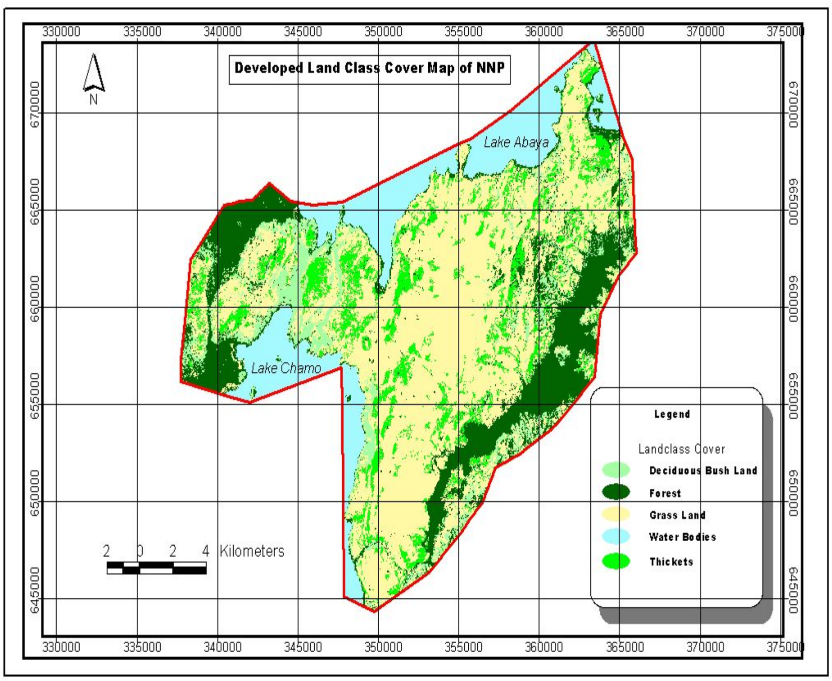

Fig. 7: Developed Land Class Cover map of the NNP

Table 1: Area covers by each “Land Cover” category

Sr. No	Land Cover Class	Area in Sq. Km	Percentages
1	Deciduous Bush land	35.53	7.28
2	Forest	82.99	17
3	Grassland	237.51	48.67
4	Lake Abaya	49.01	10
5	Lake Chamo	30.74	6.69
6	Thickets	52.2	10.69
Total area		488	100

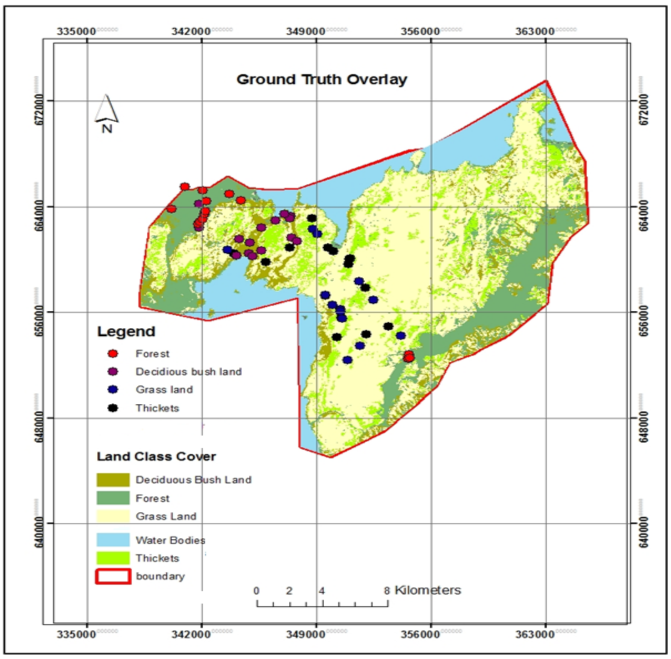

Fig. 8: Ground truth collected from field survey overlay with land class cover map

research work that was conducted on the park prior to this project the total areas of the NNP was written as 514 Sq.km (Fetene *et al.,* 2011). But the finding of this project deviated by 26 Sq.km and according to the finding of this project the total area of NNP is 488 Sq.km (Table 1).

Grass land is the largest habitat of the NNP covering the extent of 237.51 km^2 which accounts 46.67% of the total area of the plain. The plain of the “Nechisar” (white grass) were almost treeless, but most of the hill and gentler slopes of the plain were covered with deciduous bush land covering the extent of 35.53 km^2 which accounts 7.28% of the NNP. The forests of NNP are two types, ground water forest and reverie forest. The ground water forest is located in the northern part of the park which is commonly known as Arbaminch ground water forest while, Kulfo and Sermele river forests are located in the western and eastern part of the park respectively. Forest land of NNP covers 82.99 km^{2}or 17% of NNP land class cover. Thickets are discontinuous bush land located almost in all parts of the NNP and it covers 52.2 km^2 which accounts 10.69% of NNP vegetation cover. Water bodies are parts of Lake Abaya and Lake Chamo in the north and south respectively and it covers 79.75 km^2 which accounts16.98% of NNP land class cover.

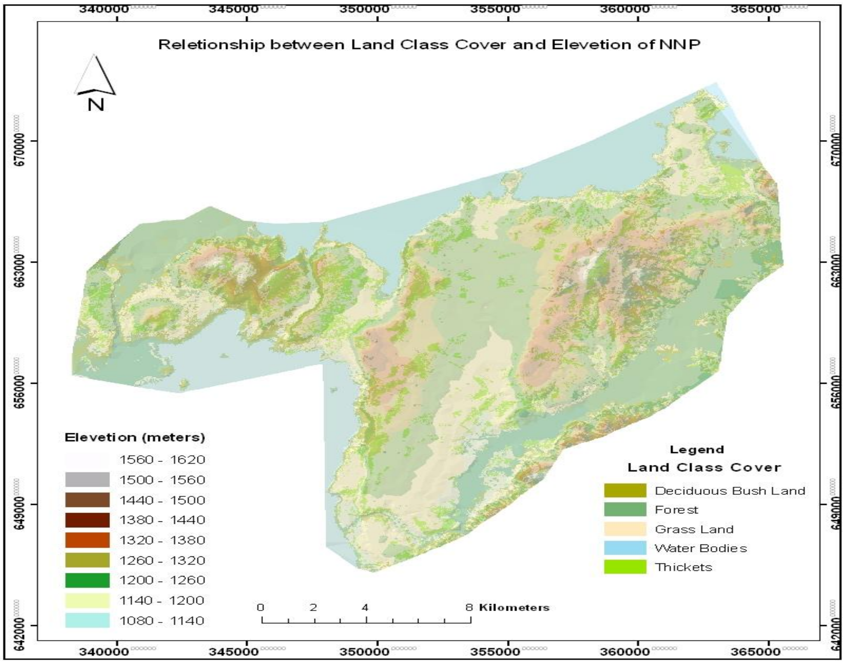

Fig. 9: Map showing relationship between land class cover and elevation of NNP

The grass land, which accounts 47% of the NNP, is found almost in all parts of the parks except in the areas covered by forest but it mainly dominate the altitudinal ranges between1200-1260. Deciduous bush lands are found relatively in the hillside part of the park dominating the eastern escarpments above 1440 meters. Like grass land, Thickets are found almost in all parts of the park except in the area covered by forest and water bodies.

CONCLUSION

This study was combined remote sensing, ERDAS (9.1) image processing software, GIS and extensive and detailed ground information to map land cover of the NNP. Satellite images data acquisition, digital image processing, training sites selection, digital image classification are the processes involved to map the Land cover of NNP. Image enhancement was applied to increase the contrast of the satellite images using the false color composite image. Using the frequency histograms of the bands and prior general knowledge of the land category together with the first principal image and false color composite image of bands 3, 4 and 5 features existing in the park could be predefined and mapped. This was used to set up a field campaign to map the training sites for supervised classification. Maximum likelihood classifier was used to obtain the final land cover map of the park. The analyzed result of the study area was composed of five major land cover types; these are: grassland, forest land, deciduous bush land, thickets, and water bodies. The quantitative evidences of land cover presented were also measured from the satellite images coupled by GIS analyses. The NNP is by far dominated by grasses (48.67%). Using well-defined training sites, supervised classification procedures and maximum likelihood classifier prove to be useful in the classification of the satellite images to obtain a reasonable land class cover map of the NNP. Finally based on the finding of this project the following recommendations were made: 1) the low computer literacy levels of end-users are among the problems that should be addressed if GIS mapping is to be fully developed. GIS and RS users must invest considerable enough time to learn complex software packages and become familiar with the large quantities of data used in its applications. Insufficient skilled personnel in GIS field, lack of awareness about the value of GIS and its potential in mappings are also other challenges; 2) The findings of this study demonstrate the potential use and advantages of using GIS and RS techniques in mapping land class cover of inaccessible areas with particular reference to NNP and establish a baseline to carry out further investigations as in this area there was no digital land cover map information; 3)These findings of this project will also useful for subsequent applications such as for tourist information map and for Management and monitor of NNP; 4) The investigation of the use of GIS and RS techniques to Map and estimate Land Class Cover of NNP is also still open. Possible improvement and subjects for future studies are: the use of various sets of satellite images covering all seasons and change detection using images of different year's interval are some of them.

AUTHOR CONTRIBUTIONS

L. Tadesse has performed the methodology, literature review, software analysis, result interpretation and validation, formal analysis, and investigation, data collection, writing original draft preparation, funding acquisition, and prepared the manuscript text and agreed to the published version of the manuscript.

ACKNOWLEDGMENT

The author is very much grateful to, Dr. Yergalem Mehiteme, for his guidance. Also, need to thank Mr. Tesema Bekele for his collaboration in sharing knowledge and invaluable comment. Author would like to express the deepest gratitude to Dr. Dessalegn Wana from Department of Geography and Environmental Studies, Addis Ababa University, for his role in providing satellite image, Ethiopian Wildlife Conservation Authority, Nechisar National Park Office and, Arbaninch College of Teacher Education for their cooperation in the data collection process.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

ABBREVIATION

%	Percent
ASTER	Thermal emission and reflection radiometer
CSA	Central statistical agency
DEM	Digital elevation model
EPA	Environmental Protection Agency
ESRI	Environment Systems Research Institute
ESCAP	Economic and Social Commission for Asia and the Pacific
ETM+	Enhanced thematic mapper
EMA	Ethiopian mapping agency
EWCO	Wildlife conservation organization
FCC	False color composite
GCP	Ground control point
GIS	Geographic information system
GPS	Global positioning system
ISODATA	Iterative self-organization data system
km^2	Kilometer square
MLC	Maximum likelihood classifier
NNP	Nechsar national park
RS	Remote sensing
WGS	World geodesic system

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HOW TO CITE THIS ARTICLE

Lemma Tadesse, A., (2020). Application of remote sensing and geographical information system In mapping land cover of national park. Int. J. Hum. Capital Urban Manage., 5(2): 139-152.

DOI: 10.22034/IJHCUM.2020.02.05

url: http://www.ijhcum.net/article_39761.html