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Assess the Trends of Rice Expansion in Fogera District, using GIS and Remote Sensing Approach

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Abstract

Land cover refers to the surface cover on the ground, whether vegetation, urban, water, bare soil or other. It is important for monitoring studies, resource management, and planning activities. Remote sensing has become an important tool applicable to developing and understanding the global, physical processes affecting the land surface. Total cultivated land, production, and productivity of rice have been significantly increased within the period of the two decades and still, it is increasing. Different data source and researcher have different figures about the land use and the area coverage of the district by rice. It shows that the trend of rice expansion, currents status and land coverage area of rice not well documented. This study aimed to detect land use land cover change and rice explanation over Fogera district using remote sensing approach. In this study, we intended to apply a long-term LULC analysis in a rural region based on a Landsat time series. In this study, we intended to apply a long-term LULC analysis in a rural region based on a Landsat 7 time series of 7 years (2013 to 2019). Here, we were investigated the use of open LULC source data to provide training samples and the application of supervised classification technique to refine the broad range of spectral signatures for each LULC class. The rate of rice explanation was assessed with three years' interval and the performance of remote sensing approach was checked the performance indicators like Producer Accuracy (%), Omission Error (%) User Accuracy (%), Commission Error (%), Overall Accuracy (%) and Kappa Coefficient (%) with the observed grand data. Landsat TM for the date December 1994 and Landsat ETM+ for the date October 2013,2016 and 2019 which have 30m, resolution was acquired. WGS_1984_UTM_Zone_37N projection was used to georeferenced and to geo rectify the images. Satellite images were classified by supervised classification through maximum likelihood classifier algorithm on GIS 10.4 and ERDAS Imagine 14. The negative value indicates that the land use land cover for forest decreases from 2013 to 2016and for other land uses the positive value indicates the increment from year to year. But our area of interest was detecting the change and trend of rice crop in Fogera plain. The land use and coved by rice crop in Fogera district in 2013, 2016 and 2019 was 17118.45 ha, 12376.44 ha and 17295.57 ha respectively. The change in detection of rice was decreasing from the base line (2013) to 2016 by 27.7% this may be due to high flood season. Whereas increases from 2016 to 2019 by 39.75%.

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Keywords

land use land cover, remote sensing, GIS, rice, detection, rice, supervised and accuracy.

Introduction

Land cover is the most important property of earth's surface defining its physical condition and biotic component; whereas land use is the modification of land cover as per human needs and actions (Prakasam, 2010). Similarly, identifying these modifications in Land Use/Land Cover (LULC) over times and not over times is known as its change detection (Anderson, 1977). Rapid changes in LULC are observed throughout the world especially in developing countries due to their heavy reliance on agricultural production and increasing population. These changes necessitate the availability of improved and updated LULC datasets (Wardlow *et al.*, 2007) for effective planning and production management, thus facilitating both farmers and policy makers (Liang *et al.*, 2013).

The increasing availability and volume of remote sensing data, such as Landsat and sentinel satellite images, have allowed the multidimensional analysis of land use/land cover (LULC) changes. Remote sensing is a means for LULC classification. The dynamics alter the availability of different land resources including soil, vegetation, water and others. Consequently, land use and cover changes could lead to a decreased availability of different products and services for human, livestock, agricultural production and damage to the environment as well.

Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Identifying, delineating and mapping land cover is important for global monitoring studies, resource management, and planning activities. Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed, and provides the ground cover information for baseline thematic maps. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use and to identify the land use changes from year to year. This knowledge will help develop strategies to balance conservation, conflicting uses, and developmental pressures. Detection of long-term changes in land cover may reveal a response to a shift in local or regional climatic conditions, the basis of terrestrial global monitoring.

Land cover/use can be determined by analyzing satellite and aerial imagery. Land cover maps provide information to help managers best understand the current landscape. To see change over time, land cover maps for several different years are needed. With this information, managers can evaluate past management decisions as well as gain insight into the possible effects of their current decisions before they are implemented. Coastal managers use land cover data and maps to better understand the impacts of natural phenomena and human use of the landscape.

The study of land use/land cover (LU/LC) changes is very important to have proper planning and utilization of natural resources and their management (Asselman and Middelkoop, 1995). Traditional methods for gathering demographic data, censuses, and analysis of environmental samples are not adequate for multicomplex environmental studies (Maktav, 2005), since many problems often presented in environmental issues and great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information Systems (GISs). These technologies provide data to study and monitor the dynamics of land resources for rice expansion (Berlanga-Robles and Ruiz-Luna, 2002). Remote sensing has become an important tool applicable to developing and understanding the global, physical processes affecting the earth (Hudak *et al.*, 1998). Recent development in the use of satellite data is to take advantage of increasing amounts of geographical data available in conjunction with GIS to assist in interpretation (Tziztiki, *et al.*, 2012). GIS is an integrated system of computer hardware and software capable of capturing, storing, retrieving, manipulating, analyzing, and displaying geographically referenced (spatial) information for the purpose of aiding development-oriented management and decision-making processes (Aboyade, 2001). Remote sensing and GIS have covered wide range of applications in the fields of agriculture (Yeh and Li, 1998), environments (Fung and Ledrew, 1987), and integrated eco-environment assessment (Long *et al.*, 2008). Present study area witnessed rapid development during past decades in terms of urbanization, industrialization, and also population increase substantially.

Ethiopian rice production trends show increases in both area and productivity. The introduction and expansion of rice production in suitable agro-ecologies could be an option to achieve food security and self-sufficiency. Even though rice is not a traditional staple food in Ethiopia, it is considered a high potential emergency and food security crop (Tereke, 2006).Total cultivated land, production, and productivity of rice have been significantly increased within the period of the two decades and still, it is increasing. In the productivity base, rice is the second highest productive cereal crop next to maize in Ethiopia (CSA, 2018). It has shown promise as to be among the major crops that can immensely contribute towards ensuring food security in Ethiopia.

Rice is a recent introduction in Ethiopia where its development and other extension components are found at infant stage. The stated increasing trend in area allocation and production of rice in the study area. Rice is common crop in the fogera district that improve the livelihood of the community. The rate of rice explanation was assessed with seven years' interval. This study aimed to detect land use land cover change and rice explanation over Fogera district using remote sensing approach. In this study, we intended to apply a long-term LULC analysis in a rural region based on a Landsat time series. Therefore, this study analyses historical patterns of land use/cover dynamic and rice expansion that occurred between 2013 and 2019 in the fogera district. Rice production has brought a significant change in the livelihood of farmers and has created job opportunities for a number of citizens along the rice value chain. Different data source and researcher have different figures about the land use and the area coverage of the district by rice. According to FAOSTAT (2017) 18484 ha of land coved by rice in fogera, according to CSA (2017/18) 29,106.79 ha and According to Fogera WAO (2017/18) 21648ha of land coved by rice in fogera. It shows that the trend of rice expansion, currents status and land coverage area of rice not well documented. For instance, investigating specific and detailed land use /land cover and its impact on rice expansion and production of the community for the fogera district could be very important, to figure out the trend change of rice for the rice development. Therefore, the study may serve as inputs for decision makers to formulate policy and rice development strategies. In addition, it could be used as a source of information to initiate further researches related to agricultural development and rice production trends and land use/land cover change.

Materials and Methods

Description of the study area

This study was conducted in the Fogera district of South Gondar Zone, which is located in the Amhara Regional State of Ethiopia. The study area is situated between110 46 to 11059N latitude and 370 30 to 370 52E longitude. The altitude ranges from1774 to 2410 meter above sea level with a mean annual rainfall of 1216 mm and mean annual temperature of 19^{c}c. The total land coverage of the district is 1111.425 square kilometer. It is bordered on the south by Dera district, on the west by Lake Tana, on the North by libokemikem district, and on the East by Farta and Ebenat districts (FWOA, 2018).

In this study, we intended to apply a long-term LULC analysis in a rural region based on a Landsat 7 time series of 7 years (2013 to 2019). Here, we were investigated the use of open LULC source data to provide training samples and the application of supervised classification technique to refine the broad range of spectral signatures for each LULC class. The rate of rice explanation was assessed with three years' interval and the performance of remote sensing approach was checked the performance indicators like Producer Accuracy (%), Omission Error (%) User Accuracy (%), Commission Error (%), Overall Accuracy (%) and Kappa Coefficient (%) with the observed grand data.

For this study the shape file of this area was taken from DIVA GIS and used as a base map Understanding the strengths andweaknesses ofdifferent types of sensor data is essential for the selection of suitable remotely senseddata forimage classification. Landsat TM for the date December 1994 and Landsat ETM+ for the date October 2013,2016 and 2019 which have 30m, resolution was acquired.WGS_1984_UTM_Zone_37N projection was used to georeferenced and to georectify the images. Satellite images were classified by supervised classification through maximum likelihood classifier algorithm on GIS 10.4 and ERDAS Imagine 14.The procedure in the preprocessing stage may be including the detection and restoration of bad lines, geometric rectification or image registration, radiometric calibration, atmospheric correction and topographic correction. Accurate geometric rectification or image registration of remotely sensed data is a prerequisite for a combination of different source data in a classification process and scan line error was employed to remove unnecessary band errors. For this study, Land sat satellite images of the Fogera district would be acquire for three periods within 3-year interval; 2013, 2016and 2019. classified image or change detection map needs to be compared against reference data, assumed tobe true, in order to assess its performance and quantify its accuracy. After having the spatial and temporal maps of the district, the accuracy of the classification of wetland maps of 2013, 2016and 2019 are assessed by error matrix, over all accuracy and Kappa(K) statics. For this method, ground truthing data were collected by guided and transect walks and GPS for 2019 but for 2013 and 2016 the training sample were taken from google earth by adjusting the date lined with the date of the satellite image was taken. In this study lands which are covered by water, forest land, grasslands, rice cultivated land and other crop cultivated land were classified.

Layer Stacking

During layer stacking, the Universal Traverse Mercator (UTM) system withWGS84 as a datum was assigned as a preference as far as projection is concerned. The nature of these different bands had to be considered to make a decision as to which three band combination would be most helpful for classification and visual interpretation.

Geo-Referencing of Images When the ground control points (GCPs) were overlaid on the color composite, Landsat ETM images whose geographical accuracy was checked with the GCPs served as a base image and ASTER as a warp image. Warp image refers to the one to be corrected using a geometrically corrected image, which will serve as a base image. At least four points are required for defining a warp polynomial so as to predict the corresponding locations of the selected GCPs in the warp image. However, more than four points were selected to improve the accuracy of registration. These included easily identifiable features that exist in both the base and warp images. Both the base and warp images were displayed side to side and effort has been made to minimize the overall registration error by relocating the position of each of the GCPs within the particular ground feature selected as ERDAS provides the flexibility to do so. Finally, positional accuracy of both corrected ASTER (warped) images was checked visually by linking it to the corresponding Landsat ETM+ scenes that served as base image and using Google earth as well.

Results and Discussion

Image classification and processing

Image classification refers to the task of extracting information classes from a multiband raster image. Place the land use into categories (classes), Forest, Other crop, Water, built-up area, rice crop and grazing land. But here we were classifying the land use land cove by supervised image classification methods in ERDAS Imagine 2014. To make image classification it needs impute data and preprocessing of the image. The Landsat 7 image was downloaded from USGS for our area of interest Fogera woreda. But the image was found with scan line error. For the analyses it needs to be removed. Here we had using Landsat tool box in Arc GIS to clear the scan line error. To ADD Land sat tool box to GIS Arc tool box, click on tool box from GIS Arc tool box > ADD tool box > select Landsat tool box from saving directory> ok. To clean scan line error, Arc tool box > click on Landsat tool box drop down > fix Landsat 7 scan line error > load the input band and give saving directory > make it ok. Continue the same procedure for other bands and we have got scan line error free images.

Supervised Image classification was employed for this study. Display ERDAS window and google earth > import composite image (imagine image format) > connect ERDS with google earth by using connecting icons in ERDAS > raster > classification > supervised classification > editing signature file > taking training sample for (water, built up area, forest, rice crop, grazing land and other crops) > then create signature file > raster > classification > maximum likelihood > input classified image and signature file > ok. Repeat this step for all images. Then we gate the classified image for 2013, 2016 and 2019.

Accuracy Assessment

After classification methods were complete, accuracy assessment was the final portion of this study. For each study area, 144 points was taken from the ground and from google earth. A minimum threshold of 30 points for each land cover class was used. For each point, the appropriate land cover type was identified from the supervised classification images. Upon identifying the supervised classification, and ground truth land cover classes for each point in each study area, these data were then compiled into error matrices. While ERDAS Imagine allowed for automated accuracy assessment for each supervised classification, the software was unable to import the points necessary for accuracy assessment for each unsupervised classification. To mitigate this technical difficulty, all accuracy assessment was completed in Microsoft Excel.

Producer’s Accuracy

Producer's Accuracy is the map accuracy from the point of view of the map maker (the producer). This is how often are real features on the ground correctly shown on the classified map or the probability that a certain land cover of an area on the ground is classified as such. The

Producer's Accuracy is complemented of the Omission Error, Producer's Accuracy = 100%-Omission Error. It is also the number of reference sites classified accurately divided by the total number of reference sites for that class.

Producer's Accuracy Example based on the above error matrix: rice : Correctly classified reference sites = 53 Total # of reference sites = 54 Producer’s Accuracy = 53/54 = 98.15% Forest: Correctly classified reference sites = 10 Total # of reference sites = 10 Producer’s Accuracy = 10/10 = 100% Water: Correctly classified reference sites = 7 Total # of reference sites = 7 Producer’s Accuracy = 7/7 =100%, grass : Correctly classified reference sites = 35 Total # of reference sites = 38 Producer’s Accuracy = 35/38 = 92.63%,other crop: Correctly classified reference sites = 30 Total # of reference sites = 33 Producer’s Accuracy = 30/33 = 90.91%,urban: Correctly classified reference sites = 7 Total # of reference sites = 9 Producer’s Accuracy = 7/9 =77.78%

User’s Accuracy

The User's Accuracy is the accuracy from the point of view of a map user, not the map maker. the User's accuracy essentially tells us how often the class on the map will actually be present on the ground. This was referred to as reliability. The User's Accuracy is complemented of the Commission Error, User's Accuracy = 100%-Commission Error. The User's Accuracy is calculated by taking the total number of correct classifications for a particular class and dividing it by the row total. User’s Accuracy Example based on the above error matrix: rice : Correctly classified reference sites = 53 Total # of reference sites = 53 user’s Accuracy = 53/553 = 100%, Forest: Correctly classified reference sites = 10 Total # of reference sites = 10 user’s Accuracy = 10/10 = 100%, Water: Correctly classified reference sites = 7 Total # of reference sites = 7 user’s Accuracy = 7/7 =100%, grass : Correctly classified reference sites = 29 Total # of reference sites = 35 user’s Accuracy = 29/35 = 82.86%,other crop: Correctly classified reference sites = 30 Total # of reference sites = 33 users Accuracy cy = 30/33 = 90.91%,urban: Correctly classified reference sites = 7 Total # of reference sites = 7 user’s Accuracy = 7/7 =100%. The user and producer accuracy for any given class typically are not the same. In the above examples the producer’s accuracy for the Urban class was 100% while the user's accuracy was 77.78%. This means that even though 100% of the reference urban areas have been correctly identified as “urban”, only 77.78% percent of the areas identified as “urban” in the classification were actually urban.

By analyzing the various accuracy and error metrics we can better evaluate the analysis and classification results. Often you might have very high accuracy for certain classes, while others may have poor accuracy. The information is important so you and other users can evaluate how appropriate it is to use the classified map.

Errors of Omission

Errors of omission refer to reference sites that were left out (or omitted) from the correct class in the classified map. The real land cover type was left out or omitted from the classified map. Error of omission is sometime also referred to as a Type I error.

An error of omission in one category will be counted as an error in commission in another category. Omission errors are calculated by reviewing the reference sites for incorrect classifications. This is done by going down the columns for each class and adding together the incorrect classifications and dividing them by the total number of reference sites for each class. A separate omission error is generally calculated for each class. This will allow us to evaluate the classification accuracy and error for each class.

Errors of Commission

Errors of omission are in relation to the classified results. These refer sites that are classified as to reference sites that were left out (or omitted) from the correct class in the classified map. Commission errors are calculated by reviewing the classified sites for incorrect classifications. This is done by going across the rows for each class and adding together the incorrect classifications and dividing them by the total number of classified sites for each class.

Table.1 Spectral property of satellite images used for this project (source: Eng. manual, 2003)

Name of Satellite	Sensor	Band number	Band wavelengths (µm)	size of Pixels (m)
Landsat 7	ETM	1	0.45 to 0.52	30
		2	0.52 to 0.6	30
		3	0.63 to 0.69	30
		4	0.76 to 0.9	30
		5	1.55 to 1.75	30
		6	10.4 to 12.5	120
		7	2.08 to 2.35	30
	PAN	4	0.5 to 0.9	12

Table.2 Accuracy assessment of 2019

Land use class	water Body	Forest	Rice	Grazing land	other crops	town	Total	User accuracy (%)
water Body	**7**	0	0	0	0	0	7	100.00
Forest	0	**10**	0	0	0	0	10	100.00
Rice	0	0	**53**	0	0	0	53	100.00
Grazing	0	0	1	**29**	3	2	35	82.86
other crops	0	0	0	3	**30**	0	33	90.91
Town	0	0	0	0	0	**7**	7	100.00
Total	7	10	54	38	33	9	**145**	
Producer accuracy (%)	100.00	100.00	98.15	90.63	90.91	77.78		

Table.3 Commission and omission error in 2019

Land Use	User	Commission	Producer	Omission	Overall	Kappa
	Accuracy (%)	Error (%)	Accuracy (%)	Error (%)	Accuracy (%)	Coefficient (%)
water Body	100.00	0.00	100.00	0.00	0.94	0.92
Forest	100.00	0.00	100.00	0.00		
Rice	100.00	0.00	98.15	1.85		
Grazing land	100.00	0.00	90.63	7.89		
other crops	90.91	9.09	90.91	9.09		
Town	100.00	0.00	77.78	22.22		
Average	95.63	4.37	92.91	7.92	overall error	0.06

Table.4 Accuracy assessment of 2016

Land use class	water Body	Forest	Rice	Grazing land	other crops	town	Total	Users Accuracy (%)
water Body	4	0	1	0	0	1	6	66.67
Forest	0	5	0	1	0	0	6	83.33
Rice	0	0	35	6	1	1	43	81.40
Grazing land	0	0	1	29	3	2	35	82.86
other crops	0	0	3	13	22	5	43	51.16
town	0	0	0	0	0	6	6	100.00
Total	4	5	40	49	26	15	139	66.67
Producer Accuracy (%)	100	100	87.50	59.18	84.62	40.00		

Table.5 Commission and omission error in 2016

Land Use	User	Commission	Producer	Omission	Overall	Kappa
	Accuracy (%)	Error (%)	Accuracy (%)	Error (%)	Accuracy (%)	Coefficient (%)
water Body	66.67	33.33	100.00	0.00	0.73	0.64
Forest	83.33	16.67	100.00	0.00		
Rice and others	81.40	18.60	87.50	12.50		
grass land	82.86	17.14	59.18	40.82		
other crops	51.16	48.84	84.62	15.38		
Urban	100.00	0.00	40.00	60.00		
Average	77.57	22.43	78.55	21.45	overall error	

Table.6 Accuracy assessment 2013

Land use class	water Body	Forest	Rice	Grazing land	other crops	Town	Total	Use Accuracy (%)
water Body	4	0	0	0	0	0	4	100.00
Forest	0	5	0	0	0	0	5	100.00
Rice	0	0	53	4	6	0	63	84.13
Grazing land	0	0	2	49	2	0	53	92.45
other crops	0	0	3	6	31	0	40	77.50
Town	0	0	0	0	0	6	6	100.00
Total	4	5	58	59	39	6	171	
Producer accuracy%	100	100	84.13	92.45	77.5	100		

Table.7 Commission and omission error 2013

Land Use	User	Commission	Producer	Omission	Overall	Kappa
	Accuracy (%)	Error (%)	Accuracy (%)	Error (%)	Accuracy (%)	Coefficient (%)
water Body	100.00	0.00	100.00	0.00	0.87	0.81
Forest	100.00	0.00	100.00	0.00		
Rice and others	84.13	15.87	91.38	8.62		
grass land	92.45	7.55	83.05	16.95		
other crops	77.50	22.50	79.49	20.51		
Urban	100.00	0.00	100.00	0.00		
Average	92.35	7.65	92.32	7.68	overall error	0.13

Table.8 Rating criteria of kappa statistics

s.no	Kappa statistics	strength of agreement
1	<0.00	poor
2	0.00-0.20	slight
3	0.21-0.40	Fair
4	0.41-0.60	moderate
5	0.61-0.80	substantial
6	0.81-1.00	almost perfect

Table.9

Area coverage (ha)			
LU/LCC	**2013**	**2016**	**2019**
Forest	981.45	609.39	994.95
Town	1600.11	10337.85	5450.13
Water	3861.9	1301.13	1783.26
Grass Land	43073.37	57053.34	49365.81
Rice	17118.45	12376.44	17295.57
Other agricultural area	43285.86	29464.83	36176.04
Cloud cover	1221.84	0	0
Change in detection			
LU/LCC	2013	2016	2019
Forest	BASE LINE	-37.9092	63.26983
Town	BASE LINE	546.0712	-47.2799
Water	BASE LINE	-66.3086	37.05471
Grass Land	BASE LINE	32.45618	-13.4743
Rice	BASE LINE	-27.7012	39.74592
Other agricultural area	BASE LINE	-31.9297	22.77702

Flow chart.1

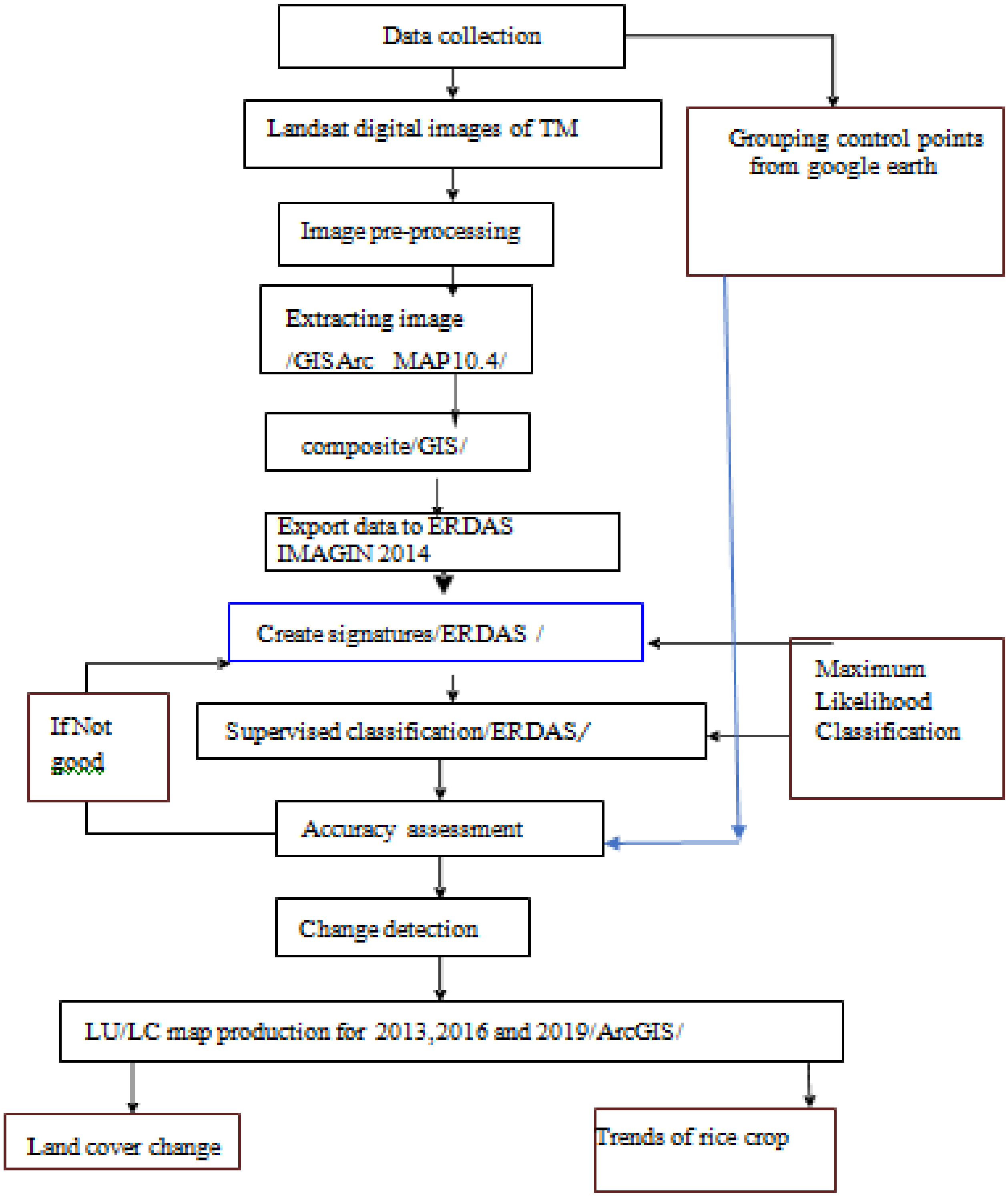

Data collection
Landsat digital images of TM
Grouping control points from google earth
Image pre-processing
Extracting image /GIS Arc MAP 10.4/
composite/GIS/
Export data to ERDAS IMAGIN 2014
Create signatures/ERDAS /
Maximum Likelihood Classification
If Not good
Supervised classification/ERDAS/
Accuracy assessment
Change detection
LU/LC map production for 2013,2016 and 2019/ArcGIS/
Land cover change
Trends of rice crop

Fig.1 Trends of rice production and productivity in Ethiopia ,2001-2017

Source; FAOSTAT,2019 and USDA,2019

Fig.2 Map of the study area

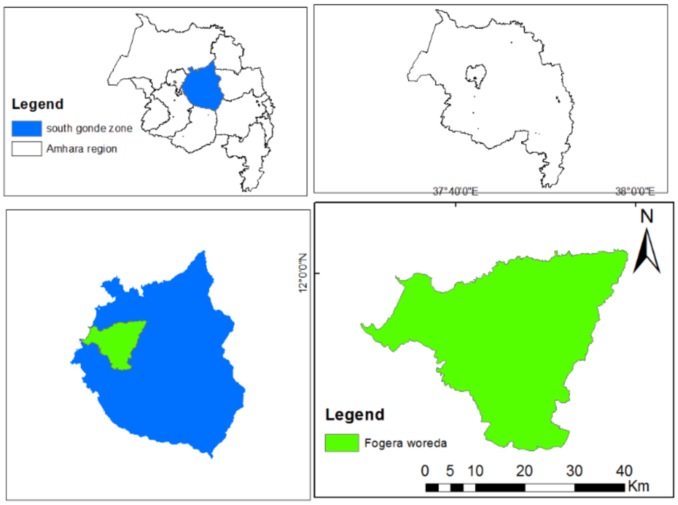


Fig.3 Image with and without scan line error

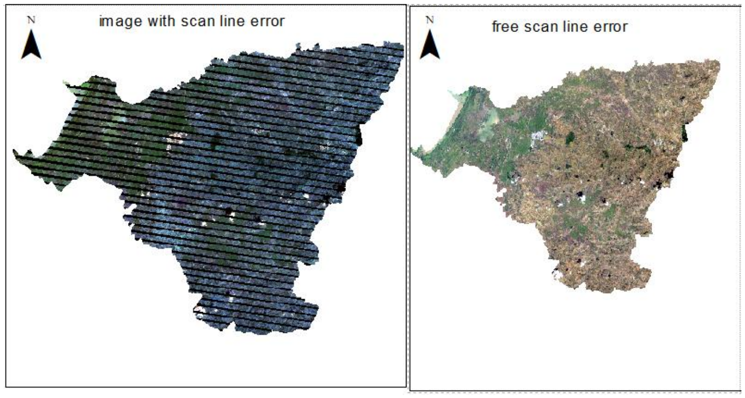


Fig.4 Ground control point for 2013

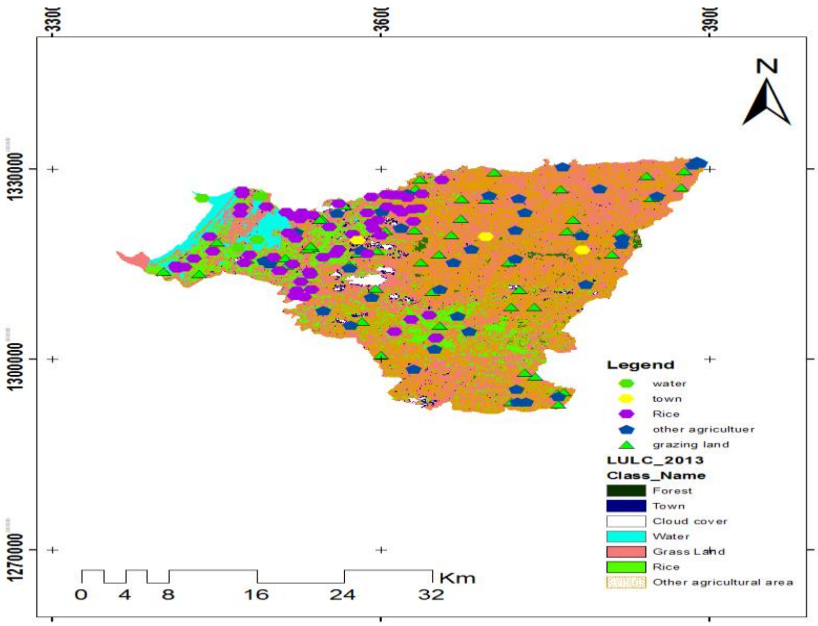


Fig.5 Ground control point for 2016

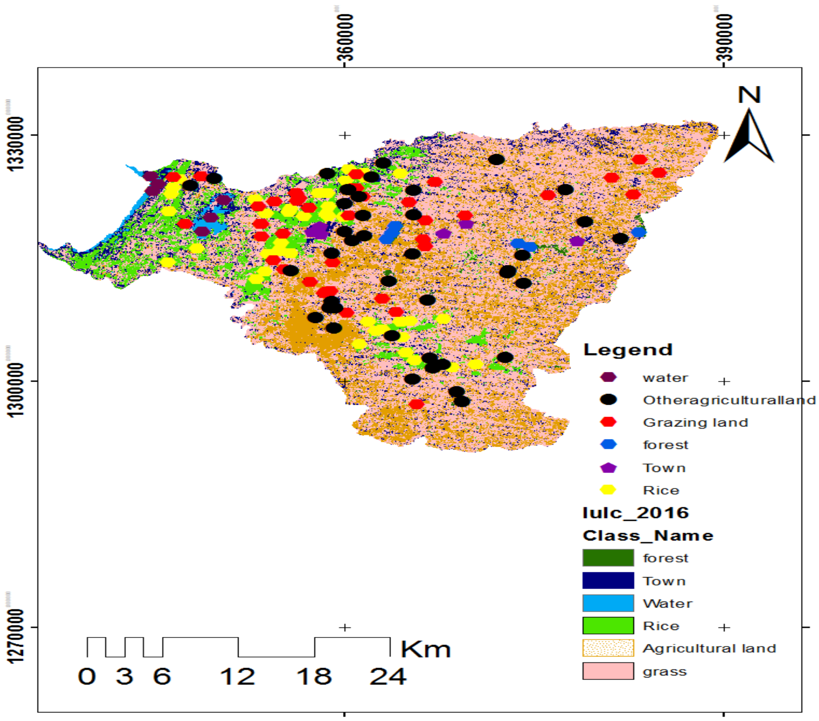


Fig.6 Land use land cover of the study area in 2013

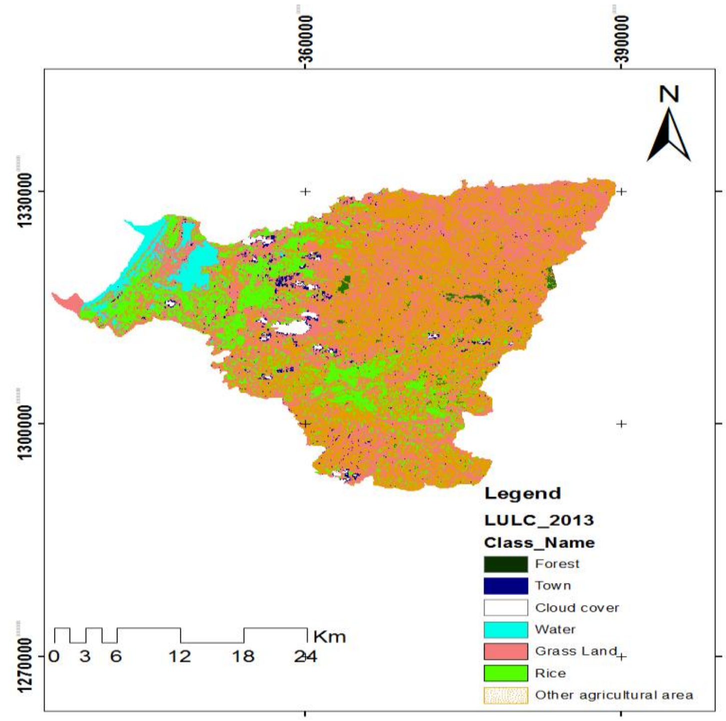


Fig.7 Land use land cover of the study area in 2016

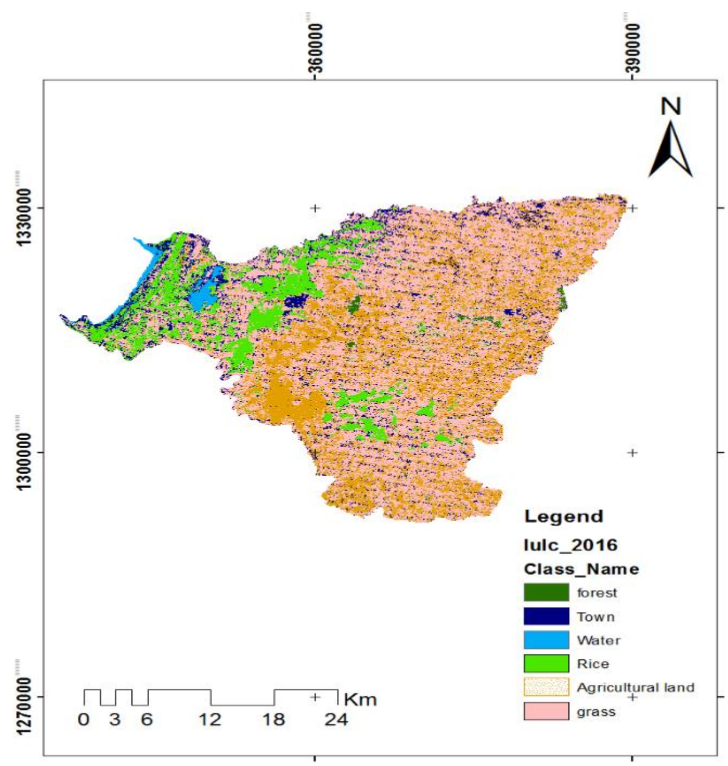


Fig.8 Land use land cover of the study area in 2019

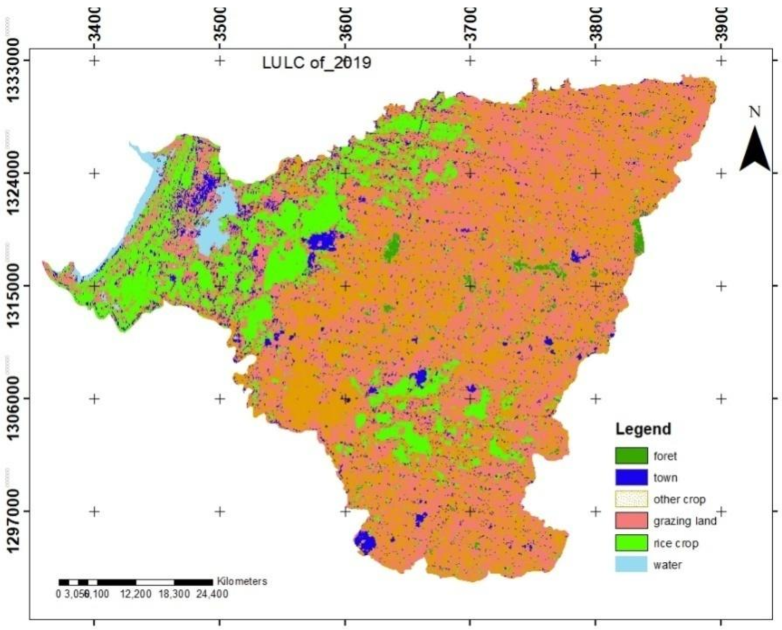
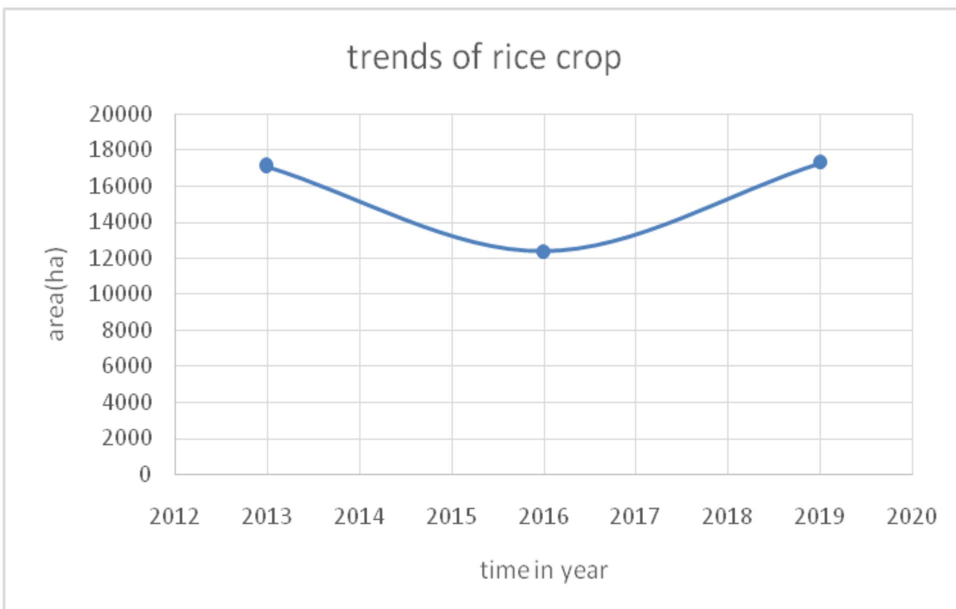


Fig.9 Trends of rice expansion in Fogera



Accuracy Metrics

There are many different ways to look at the thematic accuracy of a classification. The error matrix allows you calculate the following accuracy metrics: Overall Accuracy and Error, Errors of omission, Errors of commission, User’s accuracy, Producer’s accuracy and Accuracy statistics (Kappa)

Overall accuracy

Overall Accuracy is essentially telling us out of all of the reference sites what proportion were mapped correctly. The overall accuracy is usually expressed as a percent, with 100% accuracy being a perfect classification where all reference site was classified correctly. Overall accuracy is the easiest to calculate and understand but ultimately only provides the map user and producer with basic accuracy information the diagonal elements represent the areas that were correctly classified. To calculate the overall accuracy, you add the number of correctly classified sites and divide it by the total number of reference site.

Example based on the above error matrix: Number of correctly classified site: 7 + 10+ 53+29+30+7 = 136 Total number of reference sites = 145

Overall Accuracy = 136/145 = 94%. We could also express this as an error percentage, which would be the complement of accuracy: error + accuracy = 100%. In the above example the error would be the number of sites incorrectly classified divided by 145 or 136/1455 = error, = 6%. We could also determine the overall error by subtracting the accuracy percentage from 100: 100-94=6%.

Kappa Coefficient

The Kappa Coefficient is generated from a statistical test to evaluate the accuracy of a classification. Kappa essentially evaluate how well the classification performed as compared to just randomly assigning values, i.e. did the classification do better than random. The Kappa Coefficient can range from -1 t0 1.

A value of 0 indicated that the classification is no better than a random classification. A negative number indicates the classification is significantly worse than random. A value close to 1 indicates that the classification is significantly better than random.

The Cohen's kappa is a statistical coefficient that represents the degree of accuracy and reliability in a statistical classification. It measures the agreement between two raters (judges) who each classify items into mutually exclusive categories. This statistic was introduced by Jacob Cohen in the journal Educational and Psychological Measurement in 1960.

$$k=\frac{p_o-p_e}{1-p_e}$$

pe=0.25

Po=0.94

K=(0.94-0.25)/(1-0.25)= 92%

where p_o is the relative observed agreement among raters, and p_e is the hypothetical probability of chance agreement.

Interpret the Cohen's kappa

To interpreted the result Cohen's kappa results you can refer to the following guidelines (see Landis and Koch (1977). kappa is always less than or equal to 1. A value of 1 implies perfect agreement and values less than 1 imply less than perfect agreement. It's possible that kappa is negative. This means that the two observers agreed less than would be expected just by chance.

Analysis of the trends of rice expansion in Fogera district

By using satellite images of Landsat 2013, 2016 and 2019 water, forest land, grass lands, rice cultivated land and other crop cultivated land were classified and identified. These land use and land covers had spatial pattern and subject to change over time. Among these land uses, change in area of rice was the objective of this study.

Change in detection

The change in detection indicates that the change in land use land cover from year to another year. In our case the change in detection is indicated in the table below

The negative value indicates that the land use land cover for forest decreases from 2013 to 2016and for other land uses the positive value indicates the increment from year to year. But our area of interest was detecting the change and trend of rice crop in Fogera plain. The land use and coved by rice crop in Fogera district in 2013, 2016 and 2019 was 17118.45 ha,12376.44 ha and 17295.57 ha respectively. The change in detection of rice was decreasing from the base line (2013) to 2016 by 27.7% this may be due to high flood season. Whereas increases from 2016 to 2019 by 39.75%. The trends of rice crop from 2013 to 2019 was illustrated the graph bellow.

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