International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

Spatio-Temporal Land Cover Changes in Wassa Amenfi East and Upper Denkyira East Districts of Ghana

Dr. Saviour Mantey[1] and Dr. Michael S. Aduah[2]
[1, 2]Geomatic Engineering Department
University of Mines and Technology
Tarkwa, Ghana

***Abstract*—Land cover changes have become critical element in global environmental studies. Changes in land cover plays a major role in most of the environmental problems seen today. For this reason, modelling and projecting land cover changes is essential for the management and monitoring of our natural resources. The Wassa Amenfi East and Upper Denkyira East Districts in Ghana, have experienced extensive land cover changes for the past eleven years, mostly due to small-scale and illegal mining activities and accelerated urbanisation. This study therefore sought to identify and quantify the land cover changes in the study areas. The procedures used in this study include converting digital numbers (DN) to radiance values and reflectance, classifying satellite images using supervised (maximum likelihood) method. Ground truth observations were performed to check accuracies of the classified land cover classes. Results showed that substantial areas of forest cover vanished during the period of study which may be due to rapid urbanisation, small-scale and illegal mining activities in the study areas. In the Upper Denkyira East District, farmland and urban experienced an increase of 41% and 33% whilst the forest and water bodies decreased by 93% and 8%, respectively. Also, in the Wassa Amenfi East District, the urban and water bodies increased by 130% and 108%, respectively, whilst farmland and forest also decreased by 8% and 11%, respectively.**

Keywords*— *Wassa Amenfi East, Upper Denkyira East, Spatio-temporal land cover changes

I. INTRODUCTION

Over the years land cover of Wassa Amenfi East and Upper Denkyira East districts of Ghana have undergone significant changes. Human activities such as small-scale and illegal mining (*galamsey*) activities, farming and rural-urban migration have led to these changes. The study of land cover changes is therefore important for proper planning, utilisation, management and monitoring of the natural resources [1, 2]. Land is the most important natural resource on which all human activities depend on [3, 4]. Land cover change is also regarded as the most important variable of global change affecting ecological systems [3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. The high spatial variability in land cover type, biophysical and socio-economic drivers of land cover change around the world result in the variability in the causes and process of land cover change [13, 14]. Literature indicates that demographic changes account for land cover changes more than any other process [15, 16]. Others indicate the superiority of economic factors to be the major contributing factor [11]. Some socio-economic factors of land cover change include; poverty, tenure, insecurity and availability of market and credit facilities [17, 18, 19]. Human beings, consciously or unconsciously create pressure on land in their attempt to get the maximum benefit of the land. These pressures may take the form of either conversion or modification of the land cover [8, 11]. Land conversion can more easily be measured and monitored than modification in the composition within the land cover category [8].

Wassa Amenfi East and Upper Denkyira East districts have undergone changes in land cover over the years due to mainly small-scale and illegal mining (*galamsay*) activities (Figures 1 and 2) and rural-urban migration [20]. These migration and illegal mining activities put pressure on the land of these districts, because new buildings and infrastructure have to be put up to accommodate the increasing population. Also, illegal miners dig parts of the land in search for gold and other minerals (Figure 3). These adversely affect the land cover in the districts, hence the need to assess the impact of this changes in order to properly manage the environment.

Fig. 1 Illegal Mining Activity in Wassa Amenfi East

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

Fig. 2 Illegal Mining Activity in Upper Denkyira East

Fig. 3 Ponds created by Illegal Mining Activities

II. MATERIALS AND METHODS

Study Area: Wassa Amenfi East district was carved out from Wassa Fiase Mpohor district in 1988. The district forms part of the twenty-two (22) Metropolitan, Municipal and Districts in the Western Region of Ghana. The Administrative capital is Wassa Akropong, which is 6.7 km from the Cape Coast Takoradi main road. The district shares boundaries with Mpohor district to the West, to the East with Twifo/ Heman/ Lower Denkyira and Twifo-Ati Mokwa and to the South with Shama district and Komenda/Edina/Eguafo/Abirem Municipal [20]. The district lies between latitudes 5° 30' N and 6°15' N and longitudes 1° 45' W, and 2°11' W.

The Upper Denkyira East district is one of the twenty (20) Administrative districts of the Central Region. The Administrative Capital is Dunkwa-On-Offin. It lies within latitudes 5º 30' N and 6º 02' N of the Equator and longitudes 1º W and 2º W of the Greenwich Meridian. It shares common boundaries with Adansi South in the North, Assin North Municipal in the East and Twifo Atti-Mokwa district in the West and Upper Denkyira West district in the North-West [20].

Materials: In this study, data used include; Landsat 7 satellite images from the United States Geological Surveys (USGS) website using the Global Visualisation Viewer (GloVis), a shapefile of Wassa Amenfi East and Upper Denkyira East districts (Table 1) and ground truth coordinates were obtained from the field using a Garmin handheld GPS receiver.

Table 1 Characteristics Dataset Used

Data Type	Path and Row	Date of Acquisition	Spatial Resolution/Scale
Landsat 7 ETM+	194/056	2018-01-27	30
Landsat 7 ETM+	194/056	2007-01-13	30
Shapefile of study area	-	2010	1:50000

Before image data can be processed and analysed, various pre-processing routines appropriate to the desired output must be applied to the imagery. These pre-processing routines enhances the quality of the image data by reducing various radiometric and geometric errors that arises due to both internal and external factors [21]. Geometric correction procedures are applied to rectify errors in the relative position of pixels due to factors such as variation in altitude, attitude and velocity of the sensor platform, earth curvature, panoramic distortion, relief displacement and non-linearities in the sweep of a sensor [21]. Radiometric correction on the other hand is performed to correct the data for sensor irregularities and unwanted sensor or atmospheric noise.

Methods: In standard comparative analysis of multi-temporal images acquired on different dates and by different sensors, radiometric calibration is important. Every sensor has its own calibration parameters, data acquired from the Landsat ETM+ sensor were subjected to various routines. The various bands were extracted and converted from Digital Numbers (DN) to Radiance. The output feature classes (Radiance) were then converted to Reflectance for further analysis. Figure 4 shows a summary of the various steps undertaken.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

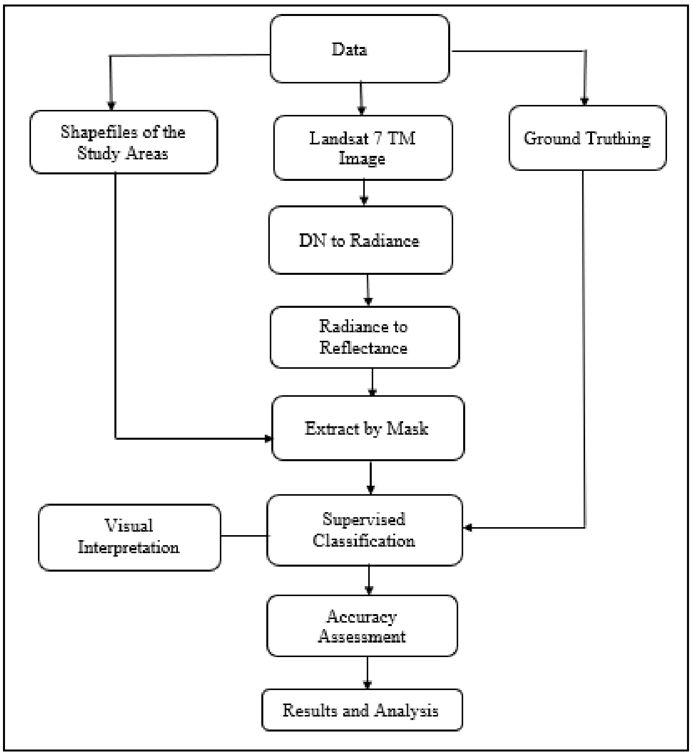

Fig. 4 A Flow Chart showing Methods Used

The Landsat Enhanced Thematic Mapper plus (ETM+) satellite sensor records reflected energy from the surface of the earth and stores them in digital numbers. This raw data encoded in 8-bit format (corresponding to 256 DN levels) cannot be used directly for analysing the land covers or surfaces. In order to make spatio-temporal analysis digital numbers of the data were converted to their corresponding radiance [22, 23, 24, 25]. Digital numbers were converted using Equation 1.

$$L\lambda = ((LMAX\lambda - LMIN\lambda) / (QCALMAX - QCALMIN)) * (QCAL - QCALMIN) + LMIN\lambda$$

Equation 1

where:
$L\lambda$ = Spectral Radiance at the sensor's aperture.
Gain =Re-scaled gain (the data product "gain" contained in the Level 1 product header or ancillary data record) or $(LMAX - LMIN)/255$
Bias =Re-scaled bias (the data product "offset" contained in the Level 1 product header or ancillary data record)
QCAL = the quantized calibrated pixel value in DN
LMINλ is the spectral radiance that is scaled to QCALMIN in mWcm-2sr-1
QCALMIN is the minimum quantized calibrated pixel value (corresponding to LMINλ) in DN
QCALMAX is the maximum quantized calibrated pixel value (corresponding to LMAXλ) in DN

The reflectance value can be obtained by converting radiance to Top-of-Atmosphere (TOA) reflectance using Equation 2

$$\rho\lambda = (\pi d^2 L\lambda) / (ESUN\lambda \cos\theta s)$$

Equation 2

where:
$\rho\lambda$ = reflectance as a function of bandwidth
d = Earth-sun distance correction
$L\lambda$ = radiance as a function of bandwidth
$ESUN\lambda$ = mean solar exo-atmospheric spectral irradiance
θs = solar zenith angle in degrees

In order to extract the satellite images of the study area, a shapefile of the study area was used as a mask. With fore knowledge of the study area, homogeneous areas called training samples were digitised into classes. These training samples were then used to perform supervised classification using the maximum likelihood algorithm, as shown in Table 2.

Table 2 Land Cover Classes

Land cover classes	Detailed composition
Urban / Barren Land	These includes all Residential, and Commercial Complexes. Transportation, Communications, and Utilities Mixed Urban or Built-up Land, Bare exposed rock, and disturbed ground at building sites
Farmland/Grass Land	These includes Cropland, Pasture, Other Agricultural and Grass Land
Forest/Dense Shrubs	Evergreen, Deciduous, and mixed forests
Water Bodies	Lakes, Streams

Accuracy Assessment: A set of ground control points were obtained from ground truthing. These control points though obtained using selective sampling method, adequately represented the diverse land cover classes within the study area. The points were plotted and were assigned their respective classes. Upon performing the supervised classification, a statistical accuracy assessment was performed. The overall classification accuracy of the study was 85.45% as presented in Table 5. Anderson *et al* [26] stated that accuracies of 85% are required for land use data for resource management. The overall accuracy was calculated using Equation 3 [7, 18, 22].

$$\frac{Total\ No.of\ correctly\ classified}{Total\ no.of\ pixels} \times 100$$

Equation 3

The training pixels with the ground truth data was measured using kappa coefficient technique. The kappa values are in range of +1.0 to -1.0, high positive value indicates high accuracy and vice versa. A value of zero kappa coefficient indicates no correlation in the classification. The kappa coefficient is calculated from Equation 4 [7, 18].

$$K = \frac{n\sum_{i=1}^{p} x_{ii} - n\sum_{i=1}^{p} x_{io}x_{oi}}{n^2 \sum_{i=1}^{p} x_{io}x_{oi}}$$

Equation 4

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

where:

n = total number of pixels
p = total number of classes
$\sum xii$= total number of elements in confusion matrix
$\sum xio$ = sum of row i
$\sum xoi$= sum of column i

The kappa coefficient obtained from this study was 0.92 which shows high accuracy.

Table 5 Classification Accuracy Table for 2018

Class Names	Reference Total	Number Correct	User's Accuracy (%)
Urban	18	14	77.78
Farmland	14	12	85.71
Water Bodies	11	9	81.82
Forest	12	12	100
Total	55	47	
Overall Accuracy=85.45%			

III. RESULTS AND DISCUSSION

Results: Four land cover classes were identified. The total areas for each class are shown in Tables 3 and 4. Figures 5 and 6 show the land cover classes for Upper Denkyira East in 2007 and 2018, respectively. Also, Figures 7 and 8 show the land cover classes for Wassa Amenfi East in 2007 and 2018 respectively. From Table 3, in the Upper Denkyira East district, the study revealed an increase in the urban area from 39.523 km^2 in 2007 to 92.049 km^2 in 2018 and decrease of forest cover from 186.666 km^2 in 2007 to 13.177 km^2 in 2018. From Table 4, in the Wassa Amenfi East district, the study also observed an increase of 130% in the urban area from 2007 to 2018, while the forest area decreased by 11% from 2007 to 2018.

Table 3 Land Cover Changes for Upper Denkyira East District

Areas in Kilometers Square					
Land cover classes	**2007**	**2018**	**Diff.**	**Increase (%)**	**Decrease (%)**
Urban	39.523	92.049	52.526	32.899	-
Farm land	295.934	418.720	122.786	41.491	-
Forest	186.666	13.177	-173.489	-	92.941
Water	22.842	21.019	-1.823	-	7.981
Total	544.965	544.965			

Table 4 Land Cover Changes for Wassa Amenfi East District

Areas in Kilometers Square					
Land cover classes	**2007**	**2018**	**Diff.**	**Increase (%)**	**Decrease (%)**
Urban	17.953	59.225	41.272	129.889	-
Farm land	533.600	490.072	-43.528	-	8.157
Forest	582.609	520.338	-62.271	-	10.688
Water	59.864	124.391	64.527	107.789	-
Total	1194.026	1194.026			

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

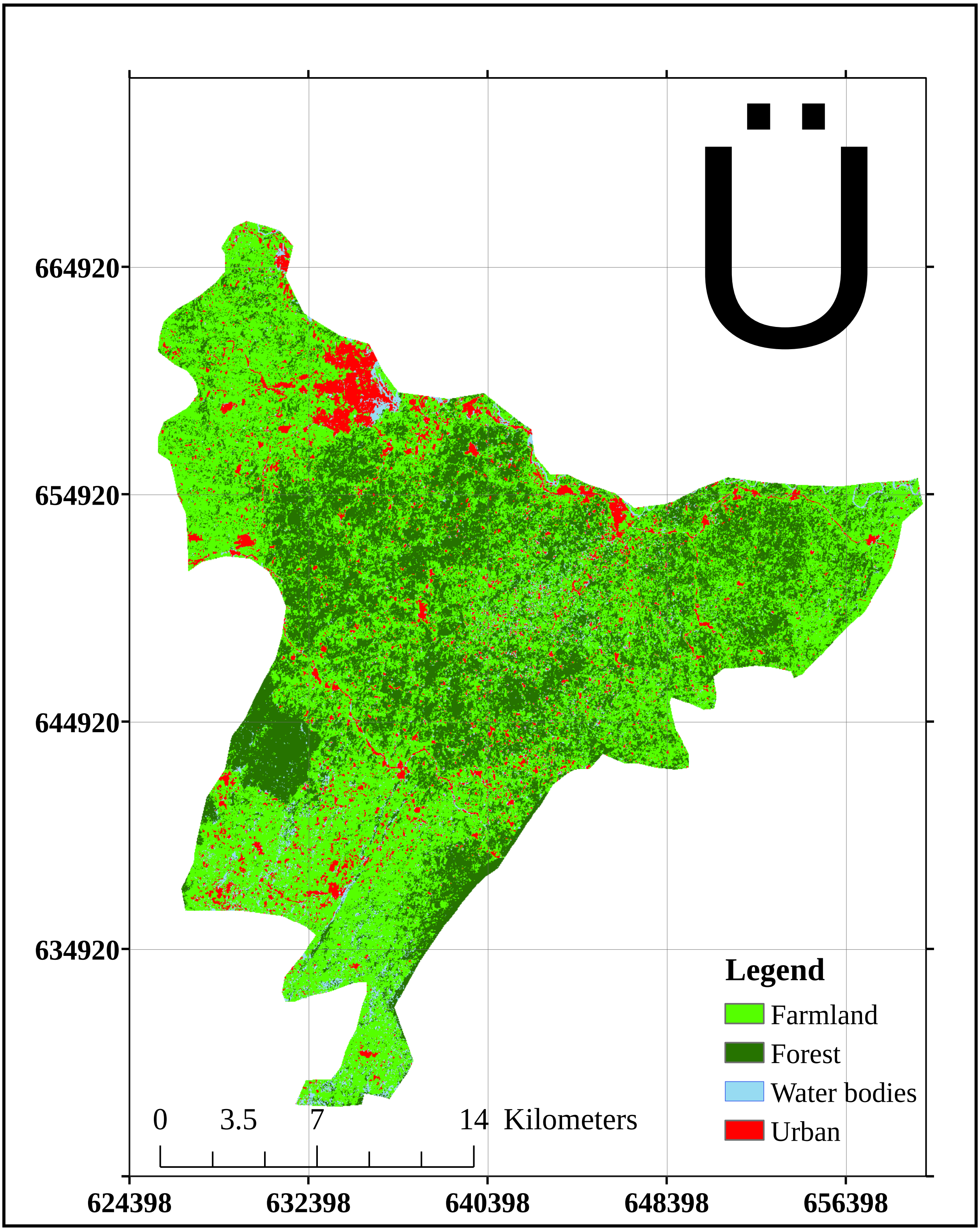

Fig. 5 Land Cover Classes (2007) for Upper Denkyira East District

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

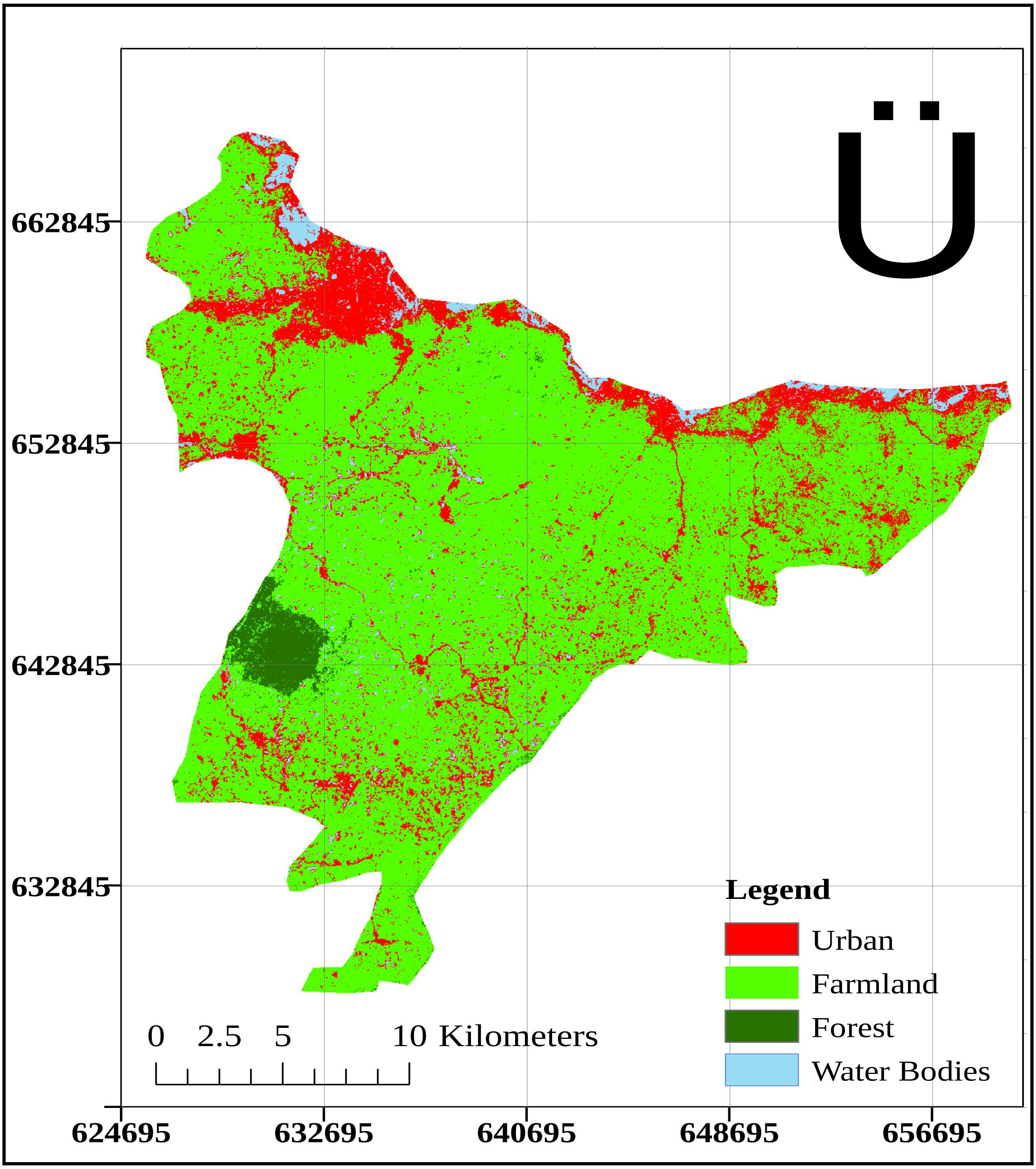

Fig. 6 Land Cover Classes (2018) for Upper Denkyira East District

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

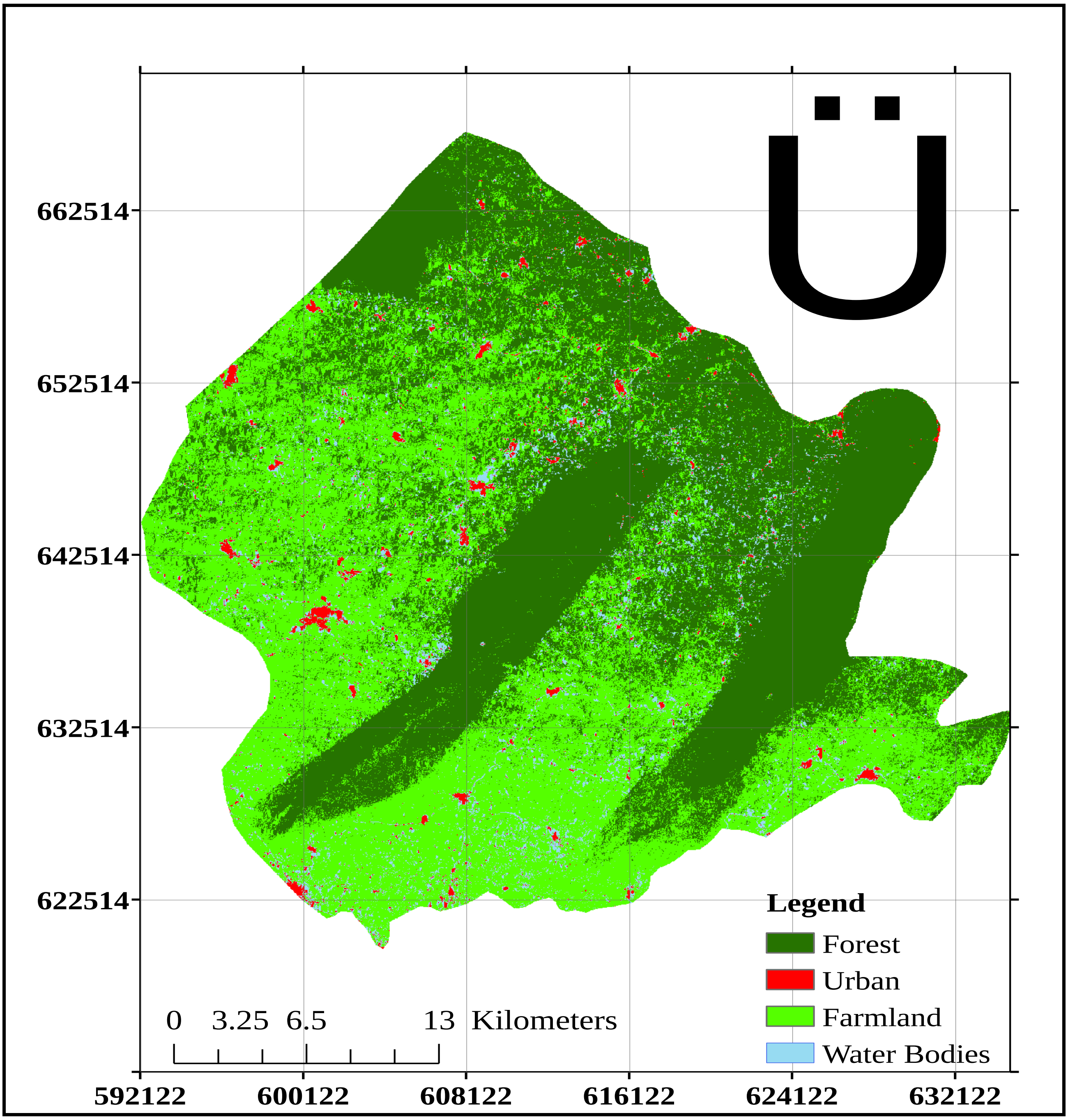

Fig. 7 Land Cover Classes (2007) for Wassa Amenfi East District

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 03, March-2020

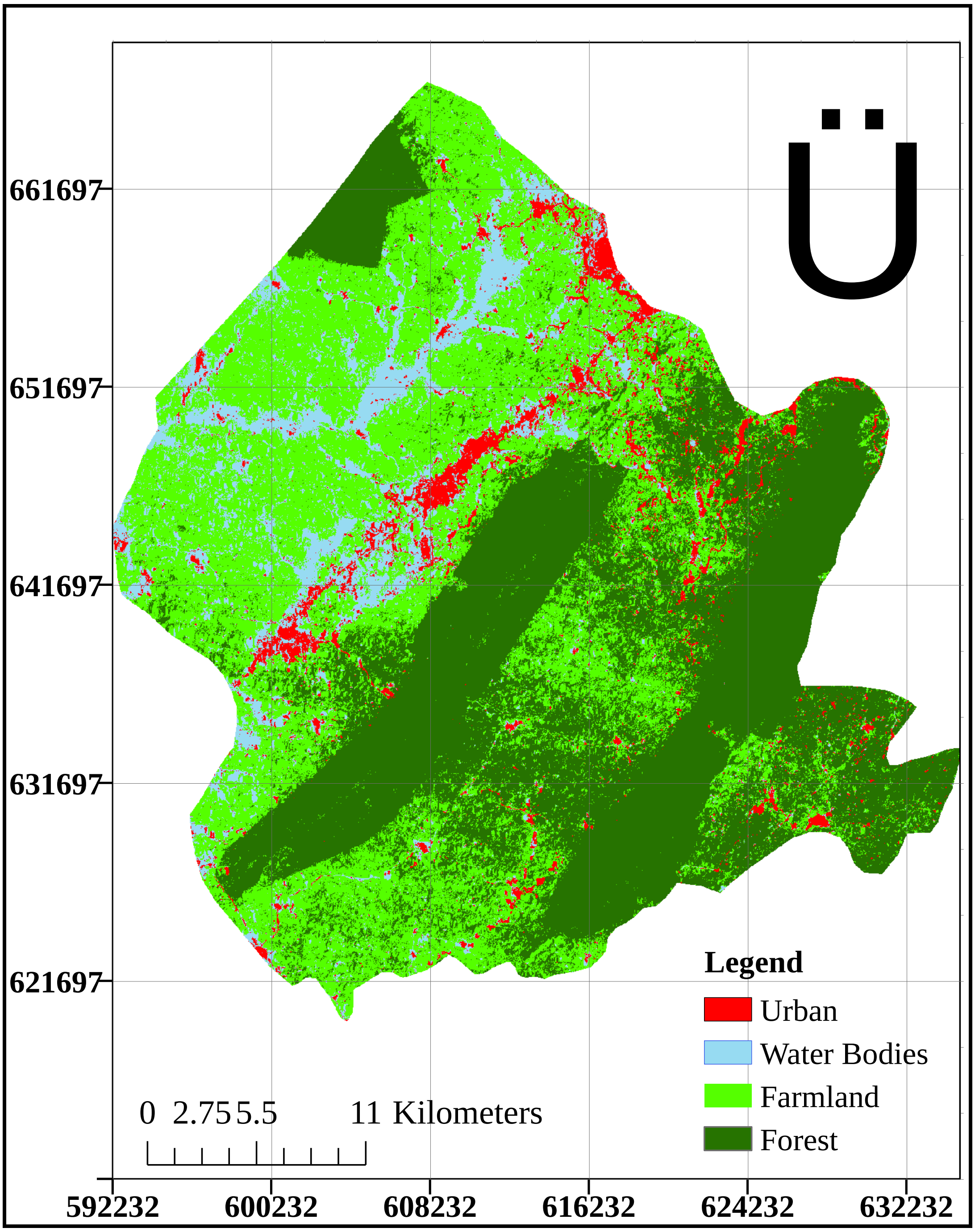

Fig. 8 Land Cover Classes (2018) for Wassa Amenfi East District

Discussion: Tables 3, 4 and Figures 5, 6, 7, 8 show changes in the various land covers. In the Upper Denkyira District, the urban areas increased by 33%. This may be due to the increase in the rural-urban migration. Increase in the small-scale mining especially in the district capital might have led to the influx of many people from various towns and villages in search of jobs. Farmlands increased by 41%. Although most of the people are farmers, the farms are mainly subsistence type, which does not generate much revenue for both the local people and the local government. It can be observed that there was a 93% reduction in the forest cover, which may be the result of many factors including the increase in farms, small-scale and illegal mining and timber lumbering. The water bodies also decreased by 8%, which may also be the result of the small-scale mining activities in and around water bodies.

Wassa Amenfi East District land cover also experienced changes. The urban land cover increased by 130% which may be because of increased in population. Normally it will be suspected that water bodies may decrease due to the extensive nature of small-scale and illegal mining in the district. Water bodies in the district has increase by 108%

because of uncovered pits by both small-scale and illegal mining activities. These uncovered pits accumulate large volumes of water forming lakes. In 2010, report from the district indicated farming as the major occupation of the district [20]. It was expected that as the district's major occupation is farming, farmland would increase, however this study shows that farmlands have decreased by 8% because some farmers sold their farmlands for small-scale and illegal mining activities. The largest land cover type in the district is forest. The forest cover also decreased by 11% and this is due to lumbering, and some people clearing the forest cover for small-scale mining activities.

IV. CONCLUSIONS AND RECOMMENDATION

Conclusions: In conclusion, four land cover classes were produced for the study areas as urban, farmlands, water bodies and forest. The studies show that there have been significant changes in the land cover types. In the Upper Denkyira East District the farmland and urban experienced an increase of 41% and 33% respectively due to population growth and farming as the major occupation. Lumbering, small-scale and illegal mining with other factors resulted in the decrease of the forest and water bodies by 93% and 8%, respectively.

Wassa Amenfi East District also experienced land cover changes. The urban and water bodies increased by 130% and 108%, respectively. Farmland and forest also decreased by 8% and 11%, respectively. Some of the driving forces of these land cover changes are small-scale and illegal mining, population growth and lumbering.

Recommendation: This study recommends that, Laws regulating small-scale and illegal mining as well as lumbering should be enforced to ensure proper management of the environment. Afforestation program should also be implemented to conserve the depleting forest.

REFERENCES

[1] Asselman, N. E. M. and Middelkoop, H. (1995), "Floodplain sedimentation: quantities, patterns and processes," *Earth Surface Processes & Landforms*, Vol. 20, No. 6, pp. 481–499.

[2] Singh, A. (1989), "Digital Change Detection Techniques Using Remotely-Sensed Data," *International Journal of Remote Sensing*, Vol. 25, No. 6, pp. 989-1003.

[3] Vitousek, P.M. (1994), "Beyond Global Warming: Ecology Global Change", *Ecology*, Vol. 75, No. 7, pp. 1861-1876.

[4] Skole, D. L., (1994), "Data on global land-cover change: acquisition, assessment and analysis", In: W. B. Meyer, B. L. Turner II (Eds.), *Changes in land use and land cover: a global perspective*, Cambridge: *Cambridge University Press*, pp. 437– 471.

[5] Lillesand, T. M., and Kiefer, R.W. (1994), "Remote Sensing and Image Interpretation", *John Willey and Sons Inc., New York*, pp. 613.

[6] Prakasm, C. (2010), "Land Use and Land Cover Change Detection through Remote Sensing Approach", *International Journal of Geomatics and Geosciences*, Vol 1, No. 2 pp. 1-2.

[7] Campbell, J. B. (2002), Introduction to Remote Sensing, *Taylor and Francis*, London, 621pp.

[8] Meyer, W. B., and Turner II, B. L (1992), "Human Population Growth and Global Land-Use Cover Change", *Annual Review of Ecology and Systematics*, Vol. 23, pp. 39-61.

[9] Nagendra, H., Munroe, D. K. and Southworth, J. (2004), "From Pattern to Process: Landscape Fragmentation and the Analysis of and Cover/Land Use Change", *Agriculture, Ecosystems and Environment*, Vol. 101, pp. 111-115.

[10] Lambin, E F., Turner, B. L, Agbola, S. B. and Angelsen, A. (2001), "The Causes of Land-Use and Land-Cover Change; Moving Beyond the Myths", *Global Environmental Change*, Vol. 11, pp. 261-269.

[11] Geist, H. J. and Lambin, E. F. (2001), "Global Land-Use and Land-Cover Change: What Have You Learn So Far?" *Global News Letter*, pp. 305-320.

[12] Veldkamp, A. and Lambin, E. F. (2001), predicting land use change", *Agriculture, Ecosystems and Environment*, Vol. 85, pp. 1-6.

[13] Serneels, S. and Lambin, E. F. (2001) "Proximate Causes of Land Use Change in Narok District, Kenya: A Spatial Statistical Model", *Agriculture, Ecosystems and Environment*, Vol. 85, pp. 65-81.

[14] Lambin, E. F., Helmult, J. G. and Lepers, E. (2003). "Dynamics of Land Use and Land Cover Change in Tropical Regions. "*Annual Review Resources*, Vol 28, pp. 205-241.

[15] Anon., (2010), Ghana Districts; Amenfi East District and Upper Denkyira East District *http://www.ghanadistricts.com,* [Accessed December 20, 2019]

[16] nderson, J.R., E.E. Hardy, J.T. Roach and R.E. Witmer, (2001), A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964, *United States Government Printing Office, Washington*, pp. 40.

[17] Briassoulis, H. (2000) "Analysis of Land Use Change: Theoretical and Modelling Approaches", *In the Web Book of Regional Research Institute*, Loveridge, S. (ed.), West Virginia University, Morgantown, West Virginia", pp. 1-25.

[18] Bruce, C. M. and Hilbert, D. W. (2004), "Pre-processing Methodology for Application to Landsat TM/ETM+ Imagery of the Wet Tropics", Research Report, Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns Australia, 44 pp.

[19] Campbell D. J., Losch D. P. and Smucker T. A. (2005) Multiple methods in the study of driving forces of land use and land cover change: a case study of SE kajiado District Kenya, *Human Ecology*, Vol. 33, pp. 763–794.

[20] Chander, G., B.L. Markham and D.L. Helder, 2009. Summary of current radiometric calibration coefficients for landsat MSS, TM, ETM+ and EO-1 ALI sensors, *Remote Sensing of Environment*, Vol. 113, pp. 893-903.

[21] Lillesand, T. M. and Kiefer, R. W (2008), Remote Sensing and Interpretation, *John Willey and Sons Inc*., New York, pp. 715.

[22] Mather A. S. and Needle C. L., (2000), The relationship of population and forest trends, *Geographical Journal*, Vol. 166, pp. 2–13.

[23] Phukan, P., Thakuriah G. and Saiku R. (2013), "Land Use Land Cover Change Detection Using Remote Sensing and GIS Techniques: A Case Study of Golaghat District of Assam, India", *International Research Journal for Earth Scientists*, pp. 12-14.

[24] Wang, X., Zheng, D., and Shen, Y. (2007), Land Use Change and its Driving Forces on the Tibetan Plateau during 1999-2000, *Science Direct*, Vol. 72, pp. 56-66.

[25] Bauer, M.E., Yuan, F., Sawaya, K. E and Loeffelholz, B.C. (2005) "Land Cover Classification and Change Analysis of The Twin Cities (Minnesota) Metropolitan Area by Multitemporal Landsat Remote Sensing", *Remote Sensing of Environment*, Vol. 98, pp. 317-328.