Assessment of The Impact of Human Activities on Vegetation in Kaltungo-East of Kaltungo Local Government Area, Gombe State, Nigeria

KWARAMS, S.H.[1], VICTOR, J.[2], MALANGALE, A.[3]
[1]*Research Scientist National Centre for Remote Sensing Jos, Plateau State, Nigeria*
[2]*Student Geography Department Gombe State University, Gombe Gombe State, Nigeria*
[3]*Research Scientist National Centre for Remote Sensing Jos, Plateau State, Nigeria*

Abstract- This project considered the impact of human activities on vegetation in Kaltungo-East, Kaltungo LGA, Gombe State, Nigeria, over 20 years (2003–2023), centering on the effect of human exercises on vegetation. High-resolution lackey pictures from 2003, 2013, and 2023 were analyzed utilizing administered classification strategies in ArcGIS Master 3.4 to classify the scene into four LULC classes: vegetation, built-up regions, uncovered arrive, and shake outcrops. The outcome uncovered noteworthy changes in arrive utilize designs. Vegetation cover declined definitely from 17.24 km² (17.24%) in 2003 to 3.28 km² (3.28%) in 2023, speaking to an 80.95% misfortune over the think about period. Built-up zones extended from 1.35 km² (1.35%) in 2003 to 3.07 km² (3.07%) in 2023, showing urban development. Uncovered area changed, at first expanding to 50.38 km² (50.38%) in 2013 sometime recently declining to 42.84 km² (42.84%) in 2023. Rock outcrops consistently extended from 36.71 km² (36.71%) in 2003 to 54.53 km² (54.53%) in 2023, reflecting expanded soil disintegration and arrive corruption. Slant examination uncovered that vegetation misfortune was most articulated between 2003 and 2013 (-1.36 km²/year), with a critical lull from 2013 to 2023 (-0.035 km²/year). Alter discovery investigation shown that vegetation was generally changed over to uncovered arrive and built-up zones, driven by deforestation, rural extension, and urbanization. These discoveries highlight the pressing require for feasible arrive administration hones to relieve natural corruption. Suggestions incorporate afforestation, disintegration control, maintainable urban arranging, and community-based preservation activities. This investigate underscores the significance of utilizing GIS and farther detecting advances for checking and overseeing arrive utilize changes, advertising experiences for policymakers and natural organizers.

Indexed Terms- Vegetation, deforestation, classification and GIS

I. INTRODUCTION

Vegetation facilitates both energy and carbon transmission across the earth's atmosphere and the ground surface. The dependence relation between human activity and vegetation change was remarkable in some ecosystems with significant vegetation change Xin, *et al* (2008), Lu, *et al.*, (2010) Feng, *et al* (2015). The plants of the earth's surface, which consists of a variety of plant species and ground cover, is critical to ecosystem health. In addition, to these direct impacts on ecosystems, vegetation is also capable of serving as an indicator of ecosystems degradation, which has attracted growing interest Sun, *et al*. (2018), Gilad, *et al*. (2007).

In recent years, rapid urban sprawl and its associated dense population and economic conditions have exerted an increasingly great influence on the eco-environment Lu, *et al* (2010), Yao, (2019) which has changed the bio-physical and chemical characteristics of different land use types Foley, *et al* (2005), Kaufmann, *et al* (2007), Zhang, *et al* (2008), especially for vegetation Xiangyuan, *et al* (2022). Population growth and rising economic demands put pressure on land use/cover. This pressure results in unplanned and uncontrolled changes in LULC Seto, *et al* (2002). LULC changes usually occur by misuse of farms, cities, range, and forest lands, which results in severe environmental issues such as erosion and flooding.

Population growth and rising incomes are generating even greater demands on agriculture to supply food, fuel, fibre, and animal feed Alexander, *et al* (2015), Alexandratos, *et al* (2015). As the global population is projected to reach approximately 10 billion by 2050 United Nations Department of Economic and Social Affairs (2019), it is likely that these demands will only increase further, putting pressure on the natural environment Van, *et al* (2016), Leroux, *et al* (2017). The intensification of agricultural practices and agricultural expansion have both contributed to meeting these increasing demands Gibbs, *et al* (2010); Arvor, *et al* (2012); Byerlee, *et al* (2014); Chamberlin, *et al* (2014); Maitima, (2009). Agricultural expansion, defined as the conversion of natural vegetation to land-use for agriculture Arvor, *et al* (2012). However, this expansion may also threaten a wider array of provisioning and regulating ecosystem services that are provided by areas of natural vegetation Gibbs, *et al* (2010); Laurance, *et al* (2014); Newbold, *et al* (2015); Reed, *et al* (2017), Food and Agriculture Organization (2018), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). Agricultural expansion into natural vegetation, such as grasslands, woodlands or forests Gibbs, *et al* (2010); Byerlee, *et al* (2014); Shoyama, *et al* (2018) is typically a non-linear process Lambin, *et al* (2010), Qasim, *et al* (2013) and caused by different factors, such as market incentives and institutional arrangements Lambin, *et al* (2001). That expansion may be to increase crop or grazing land Piquer, *et al* (2018), and whether it occurs is influenced by both bio-physical aspects of the landscape, a weak or strong land governance Peres and Schneider (2012).

Remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of LULC changes over large areas Carlson, *et al* (1999), Guerschman, (2003), Rogana and Chen (2004), Zsuzsanna, *et al* (2007) Past and present studies conducted by organizations and institutions around the world, mostly, has concentrated on the application of LULC changes. GIS provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for change detection Demers (2005), Wu, *et al* (2006).

The study has examined the following objectives: Identifying the types of land use and land cover from satellite images, it measures the area of each of the land use and land cover, the study has also analyzed the trend of changes in vegetation cover in the area over from 2003 to 2023.

II. METHODOLOGY

Kaltungo-East is located between Latitude 10° 6' 0" to 10° 36' 0" North of the Equator and Longitude 11° 6' 0" to 11° 30' 0" East of the Greenwich Meridian. Kaltungo-East is situated in Kaltungo Local Government Area (LGA) of Gombe State in Northeastern Nigeria. This region features a variety of geography, including rolling hills and flat plains. The study area has a total land area of 104km^{2}Ministry of Land and Survey, Gombe state, (2008).

The vegetation, which consists of a variety of grasses, shrubs, and scattered trees, is typical of the savannah zones of Sudan and Guinea. Acacias, baobabs, and other grasses that are acclimated to the seasonal climate are important species. However, the natural vegetation cover has been drastically changed by human activities including farming, grazing, and urbanization Hamidu, *et al* (2015).

Farming is the main occupation of the people in the study area, done mainly through mixed farming for subsistence purposes. Crops like maize, beans, millet, sorghum, fruits and vegetables are also grown. Despite most parts of the area receiving favorable climate. Subsistence crop farming and keeping of local breeds of livestock is common. This implies that the main source of food and income for the people of the study area comes from agriculture Gimba, *et al* (2015).

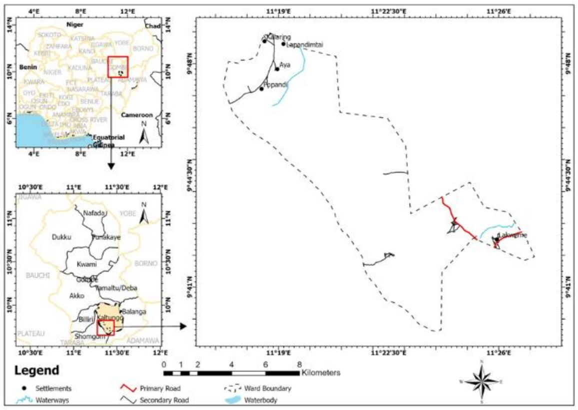

Figure 1: Map of the Study Area

III. RESEARCH DESIGN

Research design which includes; Reconnaissance survey, observation and field study was used for this study for the mapping and the analysis of the vegetation cover using remote sensing and GIS techniques. Field surveys was as well conducted to understand how human activities affects vegetation changes.

Types of sources of data
Landsat satellite imageries that were available from an open source, United State Geological Survey (USGS) through Earth Explorer in Landsat archive was used for this study.

Table 1: Types and sources of data

S/N	Data type	Year	Resolution	Spectral bands	Source
1.	Landsat 7 ETM+	2003	30M	4 Bands [Blue, Green, Red and Near infrared	USGS
2.	Landsat 8 OLI	2013	30M	4 Bands [Blue, Green, Red and Near infrared	USGS
3.	Landsat 8 OLI	2023	30M	4 Bands [Blue, Green, Red and Near infrared	USGS

Image Processing
The satellite images were processed, which include geometric correction, features extraction, geo-processing, resampling, and image filtering using ArcGIS 10 Pro.

Data Analysis
The processed satellite images were classified using ArcGIS 10 Pro. With the used of supervised classification, four different land use vegetation, built up, bare land and rock-out crop were classified to see the extent of change in the years under study.

Table 2. Types of Land Use and Land Cover

Land Cover Classes	Description
Vegetation	Includes forests, shrubs, grasslands, or any areas dominated by plant cover.
Built-Up Areas	These are areas dominated by human habitation and infrastructure.
Bare Land	Refers to areas with exposed soil, sand, or degraded lands with little to no vegetation cover.
Rock outcrops	include natural rocky areas as well as exposed bedrock

IV. RESULTS AND DISCUSSION

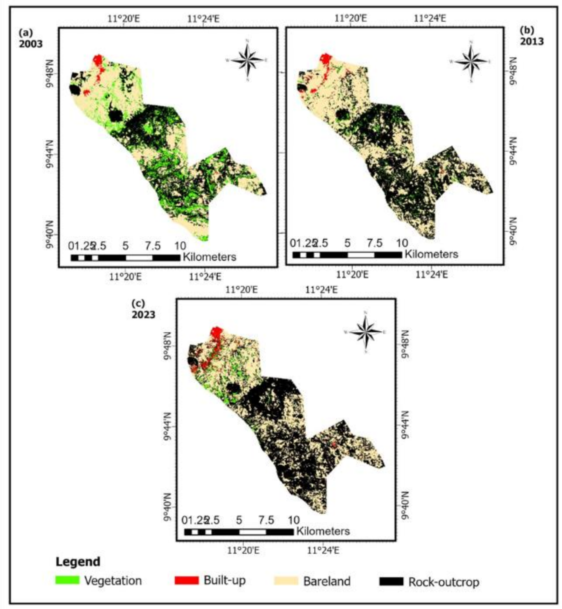

Figure 2: Land Use and Landcover Map of the study Area from 2003 to 2023

The figure above presents the result of the Land Use and Land Cover (LULC) map derived from satellite photos which depicts the spatial distribution of various land cover classes in the research area. Each class; vegetation, built-up areas, bare land, and rock outcrop is clearly color-coded for

clarity and interpretation. These maps are critical for understanding land use changes over time, as well as the variables that influence them.

Measuring the Area of Each LULC

Table 3: Measurement of land use land cover

LULC Class	2003 Area (Km²)	% (2003)	2013 Area (Km²)	% (2013)	2023 Area (Km²)	% (2023)	Change (2003–2013)	Change (2013–2023)	Total Change (2003–2023)
Vegetation	17.24	16.61 %	3.63	3.50 %	3.28	3.16 %	-13.61	-0.35	-13.96
Built-up	1.35	1.30 %	1.72	1.66 %	3.07	2.96 %	+0.37	+1.35	+1.72
Bare land	48.52	46.74 %	50.38	48.52 %	42.84	41.27 %	+1.86	-7.54	-5.68
Rock outcrop	36.71	35.35 %	48.08	46.32 %	54.53	52.61 %	+11.37	+6.45	+17.82
Total	103.82	100.00 %	103.82	100.00 %	103.82	100.00 %			

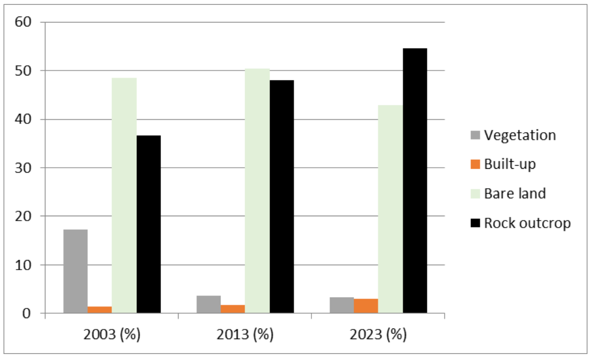

Figure 3. Bar chart of Land cover types (2023 to 2023)

The table shows how land use and land cover (LULC) changed in the study area in 2003, 2013, and 2023. It contains the areas in square kilometers, percentages, and changes observed over time for four LULC classes: vegetation, built-up areas, bare land, and rock outcrops.

Vegetation: In 2003, vegetation occupied 17.24 square kilometers, or 17.24% of the total area. By 2013, the area had shrunk dramatically to 3.63 square kilometers, accounting for 3.63% of the total area and representing a loss of 13.61 square kilometers over a decade. In 2023, vegetation decreased to 3.28 square kilometers, accounting for 3.28% of total area. The drop from 2013 to 2023 was lesser, at 0.35 square kilometers, for a total loss of 13.96 square kilometers for the 20-year period. This steady trend indicates extensive deforestation or conversion of vegetated land to other uses, maybe as a result of agricultural growth or urbanization.

Built Up: In 2003, built-up areas, which represent human settlements and infrastructure, accounted for 1.35 square kilometers, or 1.35% of total area. By 2013, this had risen to 1.72 square kilometers, or 1.72%, with a 0.37 square kilometer gain. In 2023, the built-up area increased significantly to 3.07 square kilometers, or 3.07% of the total area, up 1.34 square kilometers from 2013. Throughout the time, built-up areas rose by 1.71 square kilometers, demonstrating the consequences of urban growth and development.
Bare land: bare land represented the majority of the study area at 48.52 square kilometers (48.52%) in 2003, increased marginally to 50.38 square kilometers (50.38%) by 2013, representing a 1.86 square kilometer gain. However, by 2023, bare land had dropped to 42.84 square kilometers, accounting for 42.84% of the total area, a considerable decrease of 7.54 square kilometers since 2013. This overall decrease of 5.68 square kilometers between 2003 and 2023 indicates that bare land was either reclaimed for other uses or saw natural regrowth, maybe in regions previously utilized for agriculture or degraded land.
Rock outcrop: rock outcrops were the second largest LULC class in 2003, occupying 36.71 square kilometers or 36.71% of the total area. This class exhibited a strong increase to 48.08 square kilometers (48.08%) in 2013, an expansion of 11.37 square kilometers. By 2023, rock outcrops will have grown to 54.53 square kilometers, accounting for 54.53% of the entire area, an increase of 6.45 square kilometers since 2013. Over the two decades, rock outcrops expanded by 17.82 square kilometers, indicating exposure of rocky surfaces, most likely owing to soil erosion, vegetation loss, or land degradation

The entire area of the study area remained stable at 103.82 square kilometers during the three years. The changes in LULC classes reflect major alterations in land use patterns, with vegetation losing the most ground, while built-up areas and rock outcrops expanded significantly. Bare land fluctuated, increasing in the first decade and then reducing in the second, indicating dynamic interactions between natural recovery and anthropogenic stresses. These findings highlight the environmental impact of human activities such as urbanization and deforestation, as well as the importance of sustainable land management strategies to prevent further degradation.
Trend of LULC in Vegetation Cover (2003–2023)

To assess the trend of vegetation cover throughout the 20-year period, the computed areas for vegetation in 2003, 2013, and 2023 were compared. A substantial diminishing trend was noted, with the area decreasing from 17.24 square kilometers in 2003 to 3.28 square kilometers in 2023. This reflects a total loss of 13.96 square kilometers, corresponding to an 80.95% decline in vegetation cover over two decades. Between 2003 and 2013, vegetation decreased by 13.61 square kilometers, which can be ascribed to deforestation, agricultural growth, and urbanization. From 2013 to 2023, the decline slowed, with a reduction of only 0.35 square kilometers. This shows that the majority of vegetation loss occurred early in the research period, despite ongoing impacts on vegetation.

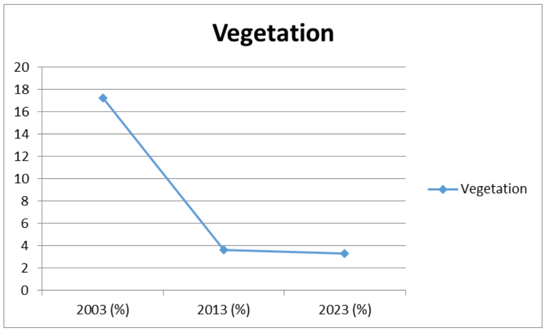

Figure 4: line chart of vegetation cover (2023 to 2023)

Change Detection Analysis:
A change detection analysis with classified maps was carried out to better understand the changes. This revealed not only the extent of vegetation loss, but also the transfer of vegetation to other LULC classes, particularly bare land and built-up areas.

Rate of change:
The annual rate of vegetation loss was calculated with the formular:

$$Rate\ of\ Change = \frac{Change\ in\ Area}{Time\ Period}$$

Between 2003 and 2013, the rate was approximately -1.36 square kilometers per year, while from 2013 to 2023, it was -0.035 square kilometers per year. This shows a significant slowdown in the rate of vegetation loss over time.

CONCLUSION

The analysis shows a major alteration in Kaltungo-East's LULC from 2003 to 2023, which is driven by both human activities and natural factors. Vegetation cover has dramatically decreased, showing the environmental consequences of deforestation, urbanization, and land degradation. Built-up areas have grown to accommodate population increase and urban development. Bare land showed a dynamic trend, whereas rock outcrops showed consistent expansion, indicating environmental degradation and exposure of rocky surfaces.

These changes highlight the crucial need for sustainable land management to combine human growth with environmental conservation. The observed reduction in the rate of vegetation loss from 2013 to 2023 is a promising indicator, but it has to be strengthened by deliberate interventions.

RECOMMENDATIONS

i. Afforestation and Reforestation Programs: To counteract land degradation and restore vegetation, large-scale tree planting activities should be performed through afforestation and reforestation programs.
ii. Sustainable Urban Planning: Zoning restrictions should be used to manage urban growth and limit encroachment on vegetated and agricultural land.
iii. Land Rehabilitation: Degraded fields should be restored using soil conservation measures and the introduction of native plants.
iv. Erosion Control: Terracing, contour plowing, and vegetation barriers should be used to avoid further soil erosion and the exposing of rock outcroppings.
v. Community Awareness and Participation: Local communities should be informed on sustainable land use practices and actively participate in conservation activities.
vi. Policy Enforcement: To reduce deforestation and illicit land use, environmental regulations must be enforced more strictly.
vii. Long-Term Monitoring: Regular LULC assessments should be carried out utilizing GIS and remote sensing technology to track changes and assess the efficacy of treatments.

REFERENCES

[1] Alexander, P.; Rounsevell, M.D.A.; Dislich, C.; Dodson, J.R.; Engström, K.; Moran, D. (2015). Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy. *Glob. Environ. Chang*, *35*, 138–147.

[2] Arvor, D.; Meirelles, M.; Dubreuil, V.; Bégué, A.; Shimabukuro, Y.E. (2012). Analyzing the agricultural transition in Mato Grosso, Brazil, using satellite-derived indices. *Appl. Geogr*. *32*, 702–713.

[3] Byerlee, D.; Stevenson, J.; Villoria, N. (2014). Does intensification slow crop land expansion or

encourage deforestation? *Glob. Food Secur. 3*, 92–98.

[4] Carlson, T.N.; Azofeifa, S.G.A. (1999). Satellite Remote Sensing of land Use changes in and around San José, Costa Rica. *Remote Sensing of Environment*. *70*, 247–256.

[5] Chamberlin, J.; Jayne, T.S.; Headey, D. (2014). Reassessing the potential for cropland expansion in Africa. *Food Policy*. *48*, 51–65

[6] Demers, M. N. (2005). *Fundamentals of Geographic Information Systems*; John Wiley&Sons, Inc.: Newyork, USA.

[7] FAO. *The State of the World's Forests 2018: Forest Pathways to Sustainable Development*; Food and Agriculture Organisation of the United Nations: Rome, Italy.

[8] Gibbs, H.K.; Ruesch, A.S.; Achard, F.; Clayton, M.K.; Holmgren, P.; Ramankutty, N.; Foley, J.A. (2010). Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proc. Natl. Acad. Sci. USA*. *107*, 16732.

[9] Guerschman, J.P.; Paruelo, J.M.; Bela, C.D.; Giallorenzi, M.C.; Pacin, F. (2003) Land cover classification in the Argentine Pampas using multi-temporal Landsat TM data. *International Journal of Remote Sensing*. *24*, 3381–3402.

[10] Kaufmann, R.K.; Seto, K.C.; Schneider, A.; Liu, Z.; Zhou, L.; Wang, W. (2007). Climate response to rapid urban growth: Evidence of a human-induced precipitation deficit. *J. Clim.*, *20*, 2299–2306.

[11] Lambin, E.F.; Meyfroidt, P. (2010). Land use transitions: Socio-ecological feedback versus socio-economic change. *Land Use Pol. 27*, 108–118.

[12] Lambin, E.F.; Turner, B.L.; Geist, H.J.; Agbola, S.B.; Angelsen, A.; Bruce, J.W.; Coomes, O.T.; Dirzo, R.; Fischer, G.; Folke, C. (2001). The causes of land-use and land-cover change: Moving beyond the myths. *Glob. Environ. Chang. 11*, 261–269.

[13] Laurance, W.F.; Sayer, J.; Cassman, K.G. (2014). Agricultural expansion and its impacts on tropical nature. *Trends Ecol. Evol. 29*, 107–116.

[14] Leroux, L.; Bégué, A.; Lo Seen, D.; Jolivot, A.; Kayitakire, F. (2017). Driving forces of recent vegetation changes in the Sahel: Lessons learned from regional and local level analyses. *Remote Sens. Environ. 191*, 38–54.

[15] Lu, D.; Xu, X.; Tian, H.; Moran, E.; Zhao, M.; Running, S. (2010). The Effects of Urbanization on Net Primary Productivity in Southeastern China. *Environ. Manag. 46*, 404–410.

[16] Maitima, J.; Mugatha, S.; Reid, R.; Gachimbi, L.; Majule, A.; Lyaruu, H.; Pomery, D.; Mathai, S.; Mugisha, S. (2009). The linkages between land use change, land degradation and biodiversity across East Africa. *Afr. J. Environ. Sci. Technol. 3*, 310–325.

[17] Newbold, T.; Hudson, L.N.; Hill, S.L.L.; Contu, S.; Lysenko, I.; Senior, R.A.; Börger, L.; Bennett, D.J.; Choimes, A.; Collen, B.; (2015). Global effects of land use on local terrestrial biodiversity. *Nature* 2015, *520*, 45–50.

[18] Peres, C.; Schneider, M. (2012). Subsidized agricultural resettlements as drivers of tropical deforestation. *Biol. Conserv. 151*.

[19] Piquer-Rodríguez, M.; Butsic, V.; Gärtner, P.; Macchi, L.; Baumann, M.; Gavier Pizarro, G.; Volante, J.N.; Gasparri, I.N.; Kuemmerle, T. (2018). Drivers of agricultural land-use change in the Argentine Pampas and Chaco regions. *Appl. Geogr. 91*, 111–122.

[20] Qasim, M.; Hubacek, K.; Termansen, M. (2013). Underlying and proximate driving causes of land use change in district Swat, Pakistan. *Land Use Pol. 34*, 146–157.

[21] Reed, J.; van Vianen, J.; Foli, S.; Clendenning, J.; Yang, K.; MacDonald, M.; Petrokofsky, G.; Padoch, C.; Sunderland, T. (2017). The ecosystem service contribution of trees to food production and livelihoods in the tropics. *For. Policy Econ. 84*, 62–71.

[22] Rogana, J.; Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*. *61*, 301–325.

[23] Seto, K.C.; Woodcock, C.E.; Song, C.; Huang, X.; Lu, J.; Kaufmann, R.K. (2002). Monitoring land use change in the Pearl River Delta using

Landsat TM. *International. Journal of Remote Sensing 23*(10), 1985–2004.

[24] Shoyama, K.; Braimoh, A.K.; Avtar, R.; Saito, O. (2018). Land Transition and Intensity Analysis of Cropland Expansion in Northern Ghana. *Environ. Manag. 62*, 892–905.

[25] UNDESA. World Population Prospects. 2019. Available online: https://population.un.org/wpp/DataQuery/ (accessed on 20 March 2020).

[26] Van Ittersum, M.K.; van Bussel, L.G.J.; Wolf, J.; Grassini, P.; van Wart, J.; Guilpart, N.; Claessens, L.; de Groot, H.; Wiebe, K.; Mason-D'Croz, D. (2016). Can sub-Saharan Africa feed itself? *Proc. Natl. Acad. Sci. USA*. *113*, 14964

[27] Wu, Q.; Li, H.Q.; Wang, R.S.; Paulussen, J.; He, H.; Wang, M.; Wang, B.H.; Wang, Z. (2006). Monitoring and predicting land use change in Beijing using remote sensing and GIS. *Landscape and Urban Planning*. *78*, 322–333.

[28] Xiangyuan Li, Lin Du, Xiong Li, Panfeng Yao, Zhuoran Luo and Zhiyuan Wu. (2022). Effects of Human Activities on Urban Vegetation: Explorative Analysis of Spatial Characteristics and Potential Impact Factors.

[29] Xin, Z.; Xu, J.; Zheng, W. (2008). Spatiotemporal variations of vegetation cover on the Chinese Loess Plateau (1981–2006): Impacts of climate changes and human activities. *Sci. China Ser. D Earth Sci.51*, 67–78.

[30] Yao, R.; Cao, J.; Wang, L.; Zhang, W.; Wu, X. (2017). Urbanization effects on vegetation cover in major African cities during. *Int. J. Appl. Earth Obs. Geoinf.* 2019, *75*, 44–53.

[31] Zhang, C.; Tian, H.; Pan, S.; Liu, M.; Lockaby, G.; Schilling, E.B.; Stanturf, J. (2008). Effects of Forest Regrowth and Urbanization on Ecosystem Carbon Storage in a Rural-Urban Gradient in the Southeastern United States. *Ecosystems*. *11*, 1211–1222.

[32] Zsuzsanna, D.; Bartholy, J.; Pongracz, R.; Barcza, Z. (2005). Analysis of land-use/land-cover change in the Carpathian region based on remote sensing techniques. *Physics and Chemistry of Earth*. *30*, 109–115.