LAND USE/LAND COVER AND VEGETATION (GREENBELT) CONVERSION IN SOKOTO METROPOLIS, SOKOTO STATE, NIGERIA 1986-2015

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ABSTRACT

This research focused on Land use/Land Cover (LU/LC) and Vegetation (greenbelt) conversion. Worldwide scholars opined that, urban areas grow at the expense of forests (Hutyra et al. 2011; Pretzsch, 2015) Sokoto State Nigeria, was not an exception and the LU/LC conversion has taken place as a result of different anthropogenic influences. How much of the conversion is yet to be ascertain, the research will therefore, detect, map and evaluate the Spatio-temporal LU/LC and vegetation conversion. Normalized Difference Vegetation Index (NDVI) was computed for the study area after applying image pre-processing and processing, standard algorithms to near-anniversary dry season, Landsat data of 1986, 1994, 2005 and 2015. Z-scores were calculated for the NDVI images, while each was classified using 1 standard deviation to the mean ($\mu \pm \sigma$) algorithm. Computation of NDVI was carried out to determine the vegetation change. The finding indicates a total land cover of 10, 673 hectares in 1986; vegetation (32%), open space (55%) and built-up (13%) However, in 2015; vegetation (11%) open space (58%) and built-up (31%). Thus, 11% vegetation remains, indicating 2/3 (21%) of the vegetation lost to other land uses in three decades (1986-2015)

Keywords: Urban Planning, Land use/Land cover, Vegetation, Greenbelt Conversion,

INTRODUCTION

Generally, vegetation plays a vital role in an environment by providing environmental protection and numerous benefits that brings balanced ecosystem. Thus, considering the juxtaposition of Sokoto Metropolis adequate preservation of vegetation is paramount for sustainable vegetation ecosystem, similarly in the past the ancient city of Sokoto (*Tsohon birni)* was fortified with trees diversity like, *Ceiba Pentendra (Silk cotton tree/Rini), Butyreospermus Paradoxum (*Shea/Kade), *Anogewisus Leocarpus* (Chew stick tree/Marke) and *Combretum Glutinosum* (Taramnniya) which still reflects the old city gates names. We are in a new urban era in which the ecology of the planet as a whole is increasingly influenced by human activities, with cities as sources of environmental impacts (Solecki, et al. 2013; Hodson and Marvin, 2010: Elmqvist, et al. 2015) Current projections of rapid expansion of urban areas present fundamental challenges and also opportunities to plan more liveable, healthy and resilient cities (Elmqvist, et al. 2015).

Forest clearing due to anthropogenic activities has been a major problem affecting biodiversity (Laurance, 1999; Etter et al. 2006: Ramachandra et, al 2016) Land use cover change (LUCC) has been regarded as one of the dominant causes of ecological environment change and it is obvious vegetation cover change which serve as one of the most important components of land cover change (LUCC) (Xiaoxia, et al 2008) Urban trees are well recognized as effective tools

for mitigating urban runoff (Xiao et al. 2000, Xiao and McPherson 2003; Susan et al. 2010) Cities are a key nexus of the relationship between people and nature and huge centres of demand for ecosystem services and generate extreme large environmental impacts (Elmqvist et al. 2015) there were building-free zones separating the later (city periphery) from the former (city centre) covered by expanse of wilderness and/or plantations in Sokoto metropolis.

The rationale for such segregation policy was attributed to health reasons so that 'the Europeans shall not be exposed to the attacks of mosquitoes and be infected with malaria or yellow fever; also as a safeguard to bush fire common to native (areas) during the dry season, and finally to remove inconveniences felt by Europeans whose rest (was) disturbed by drumming and other noises dear to natives' (Isah, 2004) Sokoto like other metropolitan cities in the world is faced with the challenge of dense population, as majority of the people are urban dwellers, resulting to urban growth leading to aggravated 'urban sprawl pressure'. Consequently, given birth to vegetation conversion culminating to land use cover change, and little or no attention have been given towards understanding and proffering solutions to this urban environmental menace of vegetation (greenbelt) conversion. Therefore the specific objective of this paper is to; detect, map and evaluate the Spatio-temporal LU/LC and vegetation (greenbelt) conversion in Sokoto metropolis 1986-2015.

1.1 Conceptual Framework

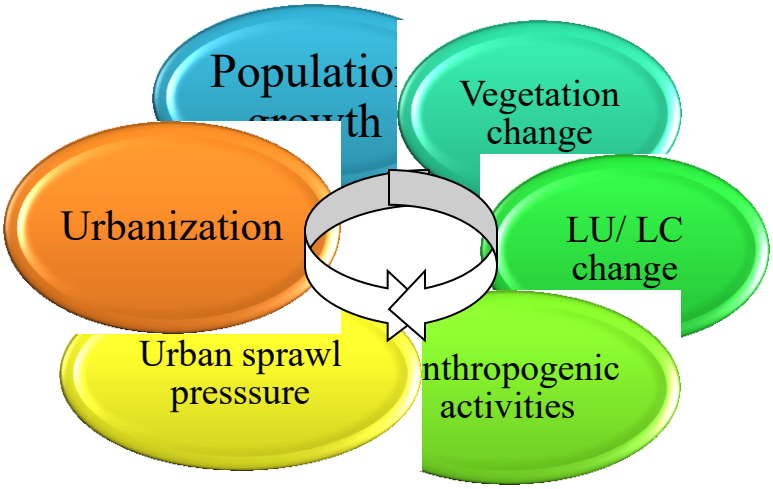

Fig. 1 Process of Urban Landuse Conversion; Adapted from (Pouyat et al. 2010)

A central principle in urban ecological theory presupposes that anthropogenic drivers will dominate natural drivers in the control of ecosystem response variables (Alberti, 1999; Kaye et al. 2006: Pouyat, et al. 2010). Therefore, from the above conceptual framework (fig 1) the process of urbanization emanated as a result of population growth leading to urban sprawl pressure resulting to different anthropogenic activities thus, leading to the conversion of the vegetation.

MATERIALS AND METHODS

Study Area

Sokoto metropolis is located between longitudes 5.17^0 and 5.27^0 E and latitudes 12.98^0 and 13.09^0 N (Fig. 2), occupying approximately 254.3 square kilometers (Eniolorunda, 2010a; Adamu et al. 2017). Located in the Sudan savannah (Olayinka, 2003; Adamu eta l, 2017), annual rainfall stands around 600mm while average daily temperature is about 36^0C (Odjugo, 2010; Ifabiyi and Eniolorunda, 2012; Umar, 2013; Adamu et al. 2017). Generally, vegetation is mainly of short and stunted shrubs and grasses around the metropolis, but the inner part and the precincts have vestiges and patches of vegetation composed mainly of trees (Eniolorunda, 2010a; Adamu et al. 2017). In the north of the Metropolis is the Sokoto-Rima river floodplain which prevents the city growth in that direction. This and a number of anthropogenic factors are contributory to land use/land cover changes that impact on the vegetation within the metropolis (Adamu et al, 2017).

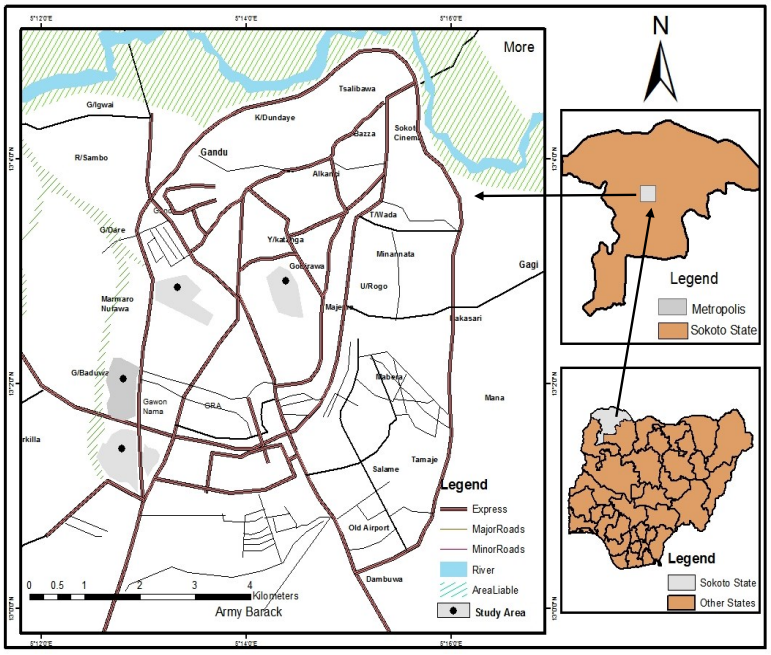

Fig. 2 Sokoto Metropolis

Source: ESRI (Compiled by GIS Lab. Department of Geography UDUS 2017

Materials

Image Data

Landsat imageries provides the advantage of frequent revisit, large-scale coverage, and low cost provided multi-temporal data for urban land use mapping, change detection, and environmental monitoring; (Maurer et al 2000; Sagof, 2005; Al- Amin and Aliyu, 2014) thus, Landsat data collected by Thematic Mapper (TM) of 1986 and 1994 (23-11-1994), enhanced thermal mapper (ETM+7) 2005 and Operational Land Imager-Thermal Infrared Sensor (OLI-TIRS) of 2015 (02-

12-2015) located in path/row 191/051 of the archive centre of the United States Geological Survey (USGS) were used. These are near-anniversary and dry season images. Surviving dry season vegetation in a semi-arid environment composed mainly of trees. Thus, the selection of the images at irregular intervals was done to avoid cloudy images, ground thruthing; data processing with an overall accuracy (OA) level at 94 was employed.

Image Pre-processing

The selected images were cloud free and Level 1T corrected based on their metadata; however, they were all subjected to haze suppression. This was carried out using Dark Object Subtraction (DOS) within the PANCROMA environment. The 1986 image was subsampled to a resolution of 30m from 60m for image co-registration and integration with newer Landsat data, following, Yingcheng (1999) the characters of each image was improved separately for merging the Landsat imageries. This was to ensure perfect overlay or image merging between the Landsat images, and was followed by the sub-mapping of Sokoto metropolis from each of the scenes. Thus, size covering the study area was sub-mapped from each of the Landsat scenes

Image Processing

Normalized Difference Vegetation Index (NDVI) was computed with the Red and Near-Infrared (NIR) bands of each image selected using: NDVI = (NIR-RED)/ (NIR+RED) where: NIR is the Near Infrared band while RED is the Red band of the Landsat data. For the Landsat TM and ETM, bands 3 and 4 are RED and NIR respectively, while bands 4 and 5 are RED and NIR for the OLI-TIRS. NDVI is an index of choice for characterizing vegetation phenology as it is capable of differentiating between vegetated and non-vegetated surfaces (Lunette and Elvidge, 1998; McDonald *et al.,* 1998). Z-scores were computed for each of the NDVI data, after which it was classified using 1 standard deviation to the mean ($\mu \pm \sigma$) algorithm (Eastman, 2009; Abubakar and Eniolorunda, 2016; Adamu et al. 2017)

Image Change Detection

The techniques of land-cover change analysis offer productive advances in the sorts of data and interpretation useful to understanding environmental transformation in places undergoing shifts in the underlying relationship between human societies and their natural environment (Harberl, et al. 2001) Therefore, the area coverage of each classified NDVI was calculated, and Post Classification Comparison was used to detect vegetation changes from one date to another (Eniolorunda *et al*., 2016; Adamu et al 2017) Study area of interest was mapped and isolated. The hectares changed were computed per decade (1986-1994, 1994-2005 and 2005-2015) for comparison.

RESULTS

Land Use/Land Cover and Vegetation Conversion in Sokoto Metropolis (1986-2015)

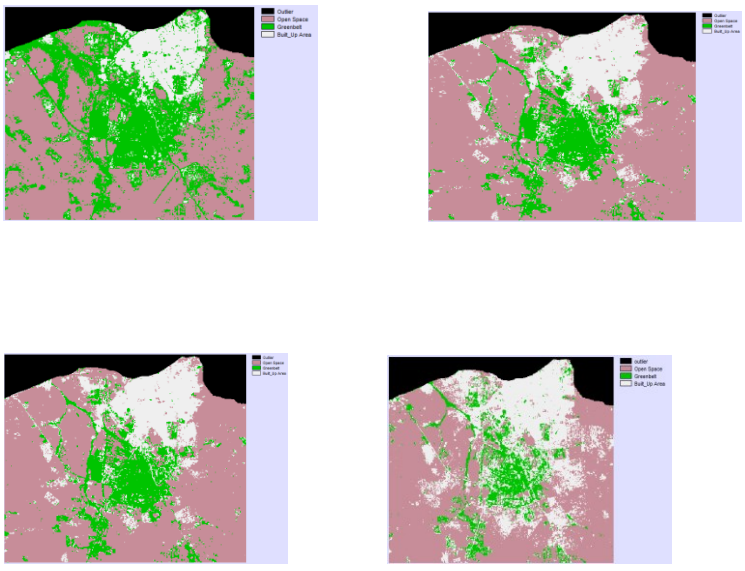

Fig 3.2 Classifications of Land use/Land cover of Sokoto Metropolis TM 1986, 1994, ETM+ 2005 and OLIS-TIRS, 2015 (Compiled:- Author (2018)

Table 3.1 Accuracy Assessment
Error Matrix: Ground Truth (Columns) on Land Use Land Cover 2015 (rows)

	Open Space	Greenbelt	Buildup	Total	EC	UA
Open Space	**105**	03	05	113	07	93
Greenbelt	02	**86**	02	90	09	91
Buildup	01	02	**64**	67	12	88
Total	108	91	71	**270**		
EO	03	05	07			
PA	97	95	93			
OA	94					

EC = Error of Commission, UA = User's Accuracy, EO = Error of Omission,
PA = Producer's Accuracy, OA = Overall Accuracy

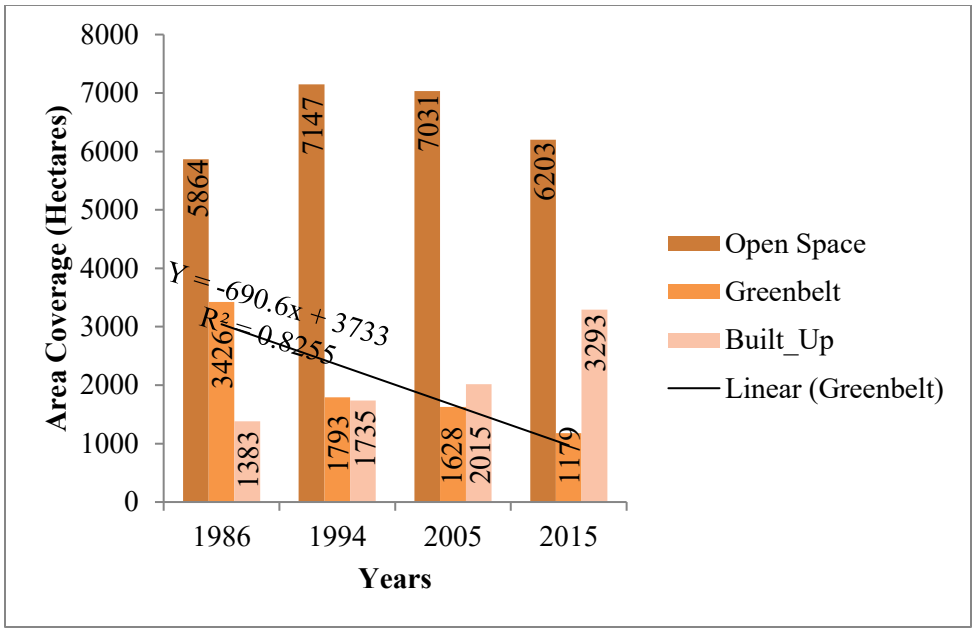

Fig. 3.3 Land use conversion in Sokoto Metropolis 1986-2015 (Compiled: - Author (2018)

Land use/Land cover and Vegetation (greenbelt) Conversion 1986-2015

The total land cover of Sokoto Metropolis as at 1986 was 10, 673 hectares and vegetation patterns of the date 1986-2015 as presented in Fig. 3.3 indicates three classes of Post Classification Comparison (PCC) The open space (55%), vegetation (greenbelt), (32%) and built-up (13%). However, in 2015, the open space increased to (58%) vegetation (greenbelt) decreased to (11%) and built-up increased to (31%) of the land use land cover. Thus, 32% of the original vegetation as at 1986 was left with only isolated patches of about 11%, while 89% of the study area is covered with the open space and built–up (Fig 3.3) This implies that, due to the unplanned urbanization, urban growth and urban sprawl pressure coupled with the climatic semi-arid juxtaposition characterizing the study area, there is little or no replacement of the lost vegetation. However, previous researches in the study area revealed that, The trend of negative changes in vegetation shows the rapidity of urbanization of Sokoto Metropolis (Adamu, et al. 2017) also, Eniolorunda (2010a:) observed 16% loss of the Giginya greenbelt area between 1986 and 2005, adding that the area was not under any serious management (Adamu, *et al.* 2017) again, Yelwa *et al*. (2009) also observed that between 2003 and 2009, Sokoto Metropolis expanded by 15.82%. The authors concluded that such an expansion had effect on any form of fallowed land. (Adamu, *et al*. 2017) Eniolorunda (2010b) declared that Sokoto metropolis expanded in size by 201% between 1985 and 2007, while Eniolorunda *et al*. (2012) argued, that residential land use would expand by 31% and non-residential land uses within the built-up area by 27% between 2005 and 2020 (Adamu, et al. 2017)

Deforestation causes threats to biodiversity (Ray and Jason, 2012) the ecosystem functions are altered with changes in landscape structure. Fragmentation of large continuous forests to small and isolated forest patches either by natural phenomena or anthropogenic activities leads to drastic change in forest sizes, shape and heterogeneity (Ramachandra, *et al.* 2016). The existence of green

open space area is very important in preventing soil erosion of the Yogyakarta city (Kusamandari, 2014) The situation of deforestation is attributed to people's adaptation to a city without vegetation and seems to lack or ignore to its consequences (Al-Amin and Aliyu, 2014)

As urban expansion progresses in the study area, degradation of more vegetation patches is anticipated. This is already evident in the depletion and near-depletion of the study patches in Sokoto Metropolis (Adamu, *et al*. 2017) in the same vein, Urban vegetation study of Kaduna Metropolis using GIS and Remotely sensed data by Al-Amin and Aliyu (2014) indicated that only 1.267km2 out of the total study area segmentation of 11.832km2 in Kaduna Metropolis are covered with a regular pattern vegetation distribution, constituted about 10.72% vegetation area while 89.28% lack vegetation. They also opined that areas without vegetation was 89.28% and densely populated with high commercial activities and high traffic, while the area with vegetation cover amount to 10.72% has scarcity population with very low commercial activities and low traffic. European Commission identified urban sprawl as one of the most urgent of today's urban planning and design issues. The Commission expressed that 'sprawl is generally greater around the largest urban areas of (over 500,000 inhabitants) with housing and industrial or commercial uses as the dominant new land uses'. These are precisely the areas which, in England but not in many other European countries, are protected from sprawl by greenbelt policy. (CPRE, 2010)

Available evidence show that while forest degradation has slowed down in the developed industrialized world; it has accelerated in the developing world (Allen and Barnes, 1985: Boahene, 1988 in Abubakar et al. 2013). There is increasing deforestation in African countries in recent past 2000-2005 (Motel, et al. 2008) Furthermore in the past three decades about 50%-75% of Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara States have been plagued by desertification (Abdu and Kio, 1988; Onyewotu et al.. 2003; Abubakar et al. 2013)
The overall duration and intensity of the observed forest change in Bialowieza National forest of Poland indicates that, the strict reserve forest stands cover 4584 hectares and constitute the oldest part of Bialowieza placed under a protection in 1921 (Miscicki, 2016) The African Sahel-Sudan zone is a dynamic ecosystem that response to fluctuations in climate and anthropogenic land use pattern (Hermann et al. 2005: Tewari and Ariya, 2005: Abubakar et al. 2013) Forests occupy the largest percentage of forested areas, 42.6% of the total forest stock, in South Korea (Korea Forest Service, 2016: Noh, et, al. 2017) Encroachment into forest and their subsequent destruction mainly through rapid expansion of agricultural frontiers affect ecosystems functions and services, land atmosphere interactions and climate and have caused land degradation, social tension and rapid precarious urbanization (Dregne and Chou, 1992: Alves, 2002: Yelwa and Eniolorunda, 2012: Abubakar et al. 2013).

Hashiba et al. (1998) indicated that, the area of vegetation cover in Tokyo has decreased due to urbanization whereby, about 50% of the vegetation cover has been changed to Artificially developed area between 1972–1991 However, according to official statistics quoted by the United Nations Environment Programme in (2007) stating that between 1997 and 2001 approximately 29,000 square kilometres (2,900,000 hectares, or 11,740 square miles) of undeveloped agricultural or forestry land in the USA was developed. In the same period, only 314 square kilometres of

undeveloped land in England was developed, and in turn only approximately 5% of this undeveloped land was in the designated Greenbelt. (CPRE, 2010)

DISCUSSION

However, the 21% out of the original 33% of the vegetation in 1986 was lost to other land uses in three decades 1986-2015 indicated that, Sokoto Metropolis like other developing cities of the world is not secured and protected from anthropogenic activities due to unplanned urbanization; whereby, the visual screening, beautification and aesthetics benefits provided by vegetation are fast eroding, also functions of barrier to urban expansion, wind-breakers is lacking which may result in the parking-off of roofing and buildings during windstorms. The micro climate of the area is affected with temperature rise due to felling of trees; generally the spate at which the trees are felled without replacement has posed a serious environmental threat such as lacks of balanced ecosystem with its inherent biodiversity.

Furthermore, it is disheartening and source of environmental concern to affirm that, vegetation (greenbelt) conversion is still prevailing in Sokoto Metropolis of the North-Western Nigeria, and little effort is being done to salvage, preserve and conserve the existing vegetation in forms of gardens, parks and forest reserves that provides quality environment in the study area; this may be due to ignorance on the benefits of vegetation on the part of the urban dwellers as well as attempts by the politicians to circumvent environmental laws/ regulations.

CONCLUSION AND RECOMMENDATIONS

The ground thru thing evidences suggest, with the current trend of greenbelt conversion in Sokoto Metropolis, the greenbelt may seize to exist in the next 10 years to come; by (2025) which may further deteriorate the environment thus, it is recommended that government should protect the greenbelt area to conserve it through stopping further encroachment and fragmentation, this is necessary to continue to enjoy and maintain a quality environment. This calls for strong political will on the part of the government, legislatures, urban planning authorities, philanthropist and urban dwellers, to be responsive in implementing urban planning rules, so as to mitigate further environmental deterioration in Sokoto Metropolis.

REFERENCES

Abubakar, S.A., G.B. Abubakar, and N.B. Eniolorunda. 2013. *Effect of forest degradation on the soil quality in the Kware Kwasa forest reserve of Kebbi State, Nigeria.* 1-9

Adamu, I.A., M. Dangulla, N.B. Eniolorunda, and Y.S. Isah. 2017. *An Inventory of Biodiversity Resources in some Vegetation Patches in Sokoto Metropolis,* Sokoto State, 2-9.

Al- Amin, M.A., and D-G Aliyu. 2014. Urban Vegetation Study of Kaduna Metropolis using GIS and remotely sensed Data**,** *journal of social sciences research* 4(2): 1-11

CPRE. 2010. *Greenbelt: a greener future A report by Natural England and the Campaign to Protect Rural England* www.naturalengland.org.uk/publications also from the CPRE

website at: Catalogue Code: NE196 www.cpre.org.uk. Catalogue Code: 2-179, down loaded 9/8/ 16. 4.53 am

Elmqvist, T., H. Setala, S.N. Handel, S. Van der Ploeg, J. Aronson, J.N. Blignaut, E. Gomez-Baggethun, D.J. Nowak, J. Kronenberg, and R. de Groot. 2015. *Benefits of restoring ecosystem services in urban area, Science Direct,* 14:101-108

Haberl, H., S. Batterbury, E. Moran. 2001. *Using and shaping the land: a long-term perspective.* Land Use Policy, 18: 1-8

Hashiba, H., K. Kameda, and K. Takasaki. 1998. *Land use change in periphery of Tokyo during last twenty years using the same seasonal Landsat data,* 22(5): 681-684

Isah, Y.S. 2004. Recent Land Use Conversion in the Greenbelt Area of Sokoto City. A dissertation submitted for an award of M.Sc. Degree in Geography, Usmanu Danfodiyo University Sokoto. (In press)

Kusamandari, A. 2014. *Soil Erodibility of Several Types of Green Open Spaces Areas in Yogyakarta City*, Indonesia, Science Direct, Procedia Environmental Sciences, 20: 732-736

Miscicki, S. 2016. *Changes in the stands of the Bialowieza National Park from 2000-2015* Lesne Prace Badaweze, *Forest Research Paper*. 7 (4): 371-379

Mohler, R.L. and Goodin, D.G. 2010 *A comparison of red, NIR, and NDVI for monitoring Temporal burn signature change in tall grass prairie',* Remote Sensing Letters, 1:1, 3-9

Motel, P.C., R. Pirand, J.L. Combes. 2008. *A methodology to estimate impacts of domestic policies on deforestation compensated successful efforts for "avoided deforestation"* (REDD) Centre for Environmental Research and Development (CERD), 65; boulevard; Mitterrand 6500. Clemont Ferrand, France. 680-683

Noh, N.J., T.K. Yoon, R.H. Kim, N.W. Bolton, C. Kim, and Y. Son. 2017. *Carbon and Nitrogen Accumulation and Decomposition from Coarse Woody Debris in a Naturally Regenerated Korean Red Pine* (Pinus densiflora S. et Z.) Forest, *Forest*, 8: 214

Pouyat, R.V., K. Szlavecz, P.M. Groffman, K. Schwarz. 2010. *Chemical, Physical and Biological Characteristics of Urban Soils Agronomy Monograph* 55 Urban Ecosystem Ecology, 119-152

Pretzsch, H., P. Biber, E. Uhl, J. Dahlhausen, T. Rotzer, J. Caldentey, T. Koike, A. Tran van con. Chavanne, T. Seifert, C. Ben du Toit, Farnden, S. Pauleit. 2015. *Crown size and growing space requirement of common tree species in urban centres, parks and forests,* Urban Forestry and Urban Greening, 14: 466-479

Ramachandra, T.V., B. Setturu, and S. Chandran. 2016. *Geospatial analysis of forest fragmentation in Uttara Kannada District*, India. *Forest Ecosystem* 3(10): 1-11

Ray, T., and F. Jason. 2012. *Carbon in the bank: Ontario's Greenbelt and its role in Mitigating Climate Change* (smart cities research services) for the David Suzuki Foundation. August, 1-24

Susan, D., P. Day, E. Wiseman, B.D. Sarah, and R.J. Harris. 2010. *Tree Root Ecology in the Urban Environment and Implications for a Sustainable Rhizosphere*, Arboriculture and Urban Forestry 36(5)

USGS. 2014. *Gap Filling Landsat 7 SLC- off Simple Scenes using ERDAS Imagine Available* via: http: // Landsat. usgs.gov, downloaded 28/12/2014

Xiaoxia, S., J. Zhang, and Z. Liu. 2008. *Vegetation Cover, Annual Change based on Modis Terra NDVI in the three Gorges Reservoir Area,* Chinese Academy of Surveying and Mapping Beijing, P.R. China

Yingcheng, L., C. Liangchai, G. Tongying, X. Yanli, L. Xueyou, D Xiaobo, and L. Xiaolong. .1999. *Land use Change and Urban Growing monitoring in china* Chinese Academy of Survey and Mapping, Beijing, Peoples Republic of China. 1