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Land use dynamics in rural-urban environs: a study of the Kumasi metropolis and its adjoining districts – Ghana

Dynamika zmian użytkowania ziemi na granicy rolno-miejskiej: studium metropolii i okolic Kumasi – Ghana

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Abstract

Land development and consumption have spun out of control in major cities in Ghana. Kumasi as the second main and fastest growing city with an annual population growth rate of 5.4% in Ghana is experiencing this phenomenon. Land use/cover change in rural–urban peripheral is foremost to these dynamic changes. This study is premised on remote sensing and GIS methods to explore urbanization in Kumasi rural–urban fringe. Satellite data (Landsat multi-temporal images and Disaster Monitoring Constellation-DMC) and GIS techniques were used to analyze and compute the land cover changes (amount, trend and location) that had transpired for the period of 1986 to 2011. This study assesses the nature, extent and impact of urban growth (compact and sprawl) on Kumasi and surrounding districts. The study showed that, forest loss is massive, agricultural activities in Kumasi is receding as the years go but intensifying in the fringe districts. Settlements are expanding in all directions at the expense of farmland but firstly along the roads.

Key words: Satellite remote sensing, urban sprawl and growth, land use, land cover, population growth.
Słowa kluczowe: Teledetekcja satelitarna, urbanizacja, użytkowanie ziemi, pokrycie terenu, wzrost populacji.

W większości miast Ghany rozwój miast dokonuje się poza wszelką kontrolą. Kumasi, drugie największe i najszybciej rozrastające się miasto kraju, z rocznym wzrostem populacji rzędu 5,4%, doświadcza tego procesu. Zmiany użytkowania ziemi i pokrycia terenu na peryferiach miasta są najlepszym tego przykładem. Prezentowana praca, wykorzystując teledetekcję i GIS pokazuje ekspansję Kumasi na tereny rolnicze. Zdjęcia satelitarne (wieloterminowe zobrazowania wykonane przez satelity serii Landsat – TM, ETM+ i DMC) zostały wykorzystane do klasyfikacji, a wraz z materiałami referencyjnymi – do analiz zmian pokrycia terenu (zasięgu, lokalizacji i trendów zmian) w okresie od 1986 do 2011 r. Praca ocenia powody, zasięg i wpływ rozrastania się miasta na Kumasi i tereny otaczające. Analizy pokazały, że z biegiem lat następują ogromne straty pokrywy leśnej, aktywność rolnicza w Kumasi zanika, ale intensyfikuje się na obrzeżach. Zabudowa rozprzestrzenia się we wszystkich kierunkach zajmując tereny rolnicze, ale w pierwszej kolejności wzdłuż dróg.

Introduction

Urban growth process is one of the most important dimensions of economic, social and physical change (Pieterse, 2008; Simon, 2007). Rapid urban population surge has led to growing demand for land, predominantly for housing and associated urban land uses needs (Aguilar &Ward 2003). Growing demand for land is impacting rural–urban peripheries, where urban enlargement in many countries is already impinging on land for agricultural uses and rural community (Thuo, 2010). Competitive land use in West Africa is reckoned to affect the quality of water from headwork's situated near expanding cities (Koranteng & Zawiła-Niedźwiecki, 2014)changes in land use and land cover. Multi-temporal satellite imagery allows for assessing the extend and intensity of this phenomenon (1986-2007-2011.

The world's urban regions are growing doubly faster than their respective populations (Angel et. al., 2011). Even though urban land cover is a comparatively smaller portion of the entire Earth, urban areas is deemed to drive worldwide environmental change (Grimm, et. al., 2008). Land-cover change in urban communities portends biodiversity and disturbs ecosystems via habitat loss, biomass, and carbon storage (Seto et. al., 2012)biomass, and carbon storage. However, despite projections that world urban populations will increase to nearly 5 billion by 2030, little is known about future locations, magnitudes, and rates of urban expansion. Here we develop spatially explicit probabilistic forecasts of global urban land-cover change and explore the direct impacts on biodiversity hotspots and tropical carbon biomass. If current trends in population density continue and all areas with high probabilities of urban expansion undergo change, then by 2030, urban land cover will increase by 1.2 million km(2. About 40% biological diversity could be wiped out due to land cover change in tropical regions of the world (Pimm & Raven, 2000).

Sub-Saharan Africa economic prosperity in the recent times has resulted in increasing rates of yearly GDP growth and rapid urbanization in many countries (Mckinsey Global Institute, 2013).

Remote sensing has been employed widely in observing the changing pattern of land use/cover. It provides a precise means of measuring the extent and pattern of changes over a period of time (Miller et. al., 1998; Opoku-duah et. al., 2013; Teotia & Santos, 2010). Satellite data application have assumed a foremost importance in change detection because of the repetitive coverage of the satellites at short intervals (Mas, 1999; Rogan & Chen, 2004; Shalaby & Tateishi, 2007). Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh 1989). It is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest (Giri, et. al., 2007).

This paper studies the nature and extent of urban development in Ghana within the Kumasi metropolis and adjoining districts. It aims at quantifying the changes that have transpired for the periods 1986, 2007 and 2011 via satellite imagery, identifying the causes and manifestations of urban sprawl at the peri-urban areas of the metropolis.

Urban Growth and Sprawl

Urban growth is explained as the (relative or absolute) increase in the number of people who live in towns and cities. This growth could be regulated organized or haphazard. Urban sprawl is a form of land use in an urbanized area that displays small levels of several combination following distinct dimensions: density, continuity, concentration, compactness, centrality, nuclearity, diversity and proximity (Sarzynski et al., 2014). The roots causes of urban growth in a regular form and sprawl are quite similar (table 1).

In Ghana, urban sprawl is a direct outcome of systemic failures in urban development control policies. Urban sprawl in Kumasi is characterized by the destruction of the natural environment, farmlands and the contamination of water bodies and air. Poor sanitary situations, low housing density and high traffic generations on the roads are other features (Cobbinah & Amoako, 2012).

Methodology

Study Area. The Ashanti region lies approximately at the center of Ghana (Figure 1). It covers an area of 24,390 km^2 representing 10.2% of the land area of Ghana. The Region is endowed with large deposits of gold and other bauxite. Other mineral deposits of economic value found in the Region include manganese, iron, silica, clay and limestone. Traces of copper, platinum, lithium, tin arsenic and mica are also found (www.ghanaweb.com). It is the most populous region in Ghana. According to the 2010 Population Census, the Region recorded a total of 4,780,380 representing 19.4% of national total of 24,658,823 (GSS, 2013). The study area for this study contains (Fig. 1) the

Table 1. Causes of urban growth which may result in compact and/or sprawled growth (Bhatta, 2010).
Tabela 1. Przyczyny i formy ekspansji obszarów zabudowanych (Bhatta, 2010).

Causes of urban growth *Przyczyny rozwoju miast*	**Compact growth** *Wzrost zwarty*	**Sprawled growth** *Wzrost rozproszony*
Population growth *Wzrost populacji*	•	•
Independence of decision *Niezależność decyzji*		•
Economic growth *Rozwój ekonomiczny*	•	•
Industrialization *Uprzemysłowienie*	•	•
Speculation *Spekulacja*		•
Expectations of land appreciation *Oczekiwania aprecjacji gruntów*		•
Land hunger attitude *Głód ziemi*		•
Legal disputes *Spory*		•
Physical geography Środowisko *przyodnicze*		•
Development and property tax Rozwój i podatek od nieruchomości		•
Living and property cost *Koszty życia i nieruchomości*		•
Lack of affordable housing *Brak tanich mieszkań*		•
Demand of more living space Popyt na więcej przestrzeni życiowej	•	•
Public regulation *Regulaje przez władze publiczne*		•
Transportation *Transport*	•	•
Road width *Szerokość drogi*		•
Single-family home *Dom jednorodzinny*		•
Nucleus family *Rodzina*	•	•
Credit and capital market *Kredyty i rynek kapitałowy*		•
Government developmental policies *Rządowe strategie rozwojowe*		•
Lack of proper planning policies *Brak odpowiedniej polityki planowania*		•
Failure to enforce planning policies *Niewygzekwowanie polityki planowania*		•
Country-living desire *Chęć życia na prowincji*		•
Housing investment *Inwestycje mieszkaniowe*		•
Large lot size *Duży rozmiar*		•

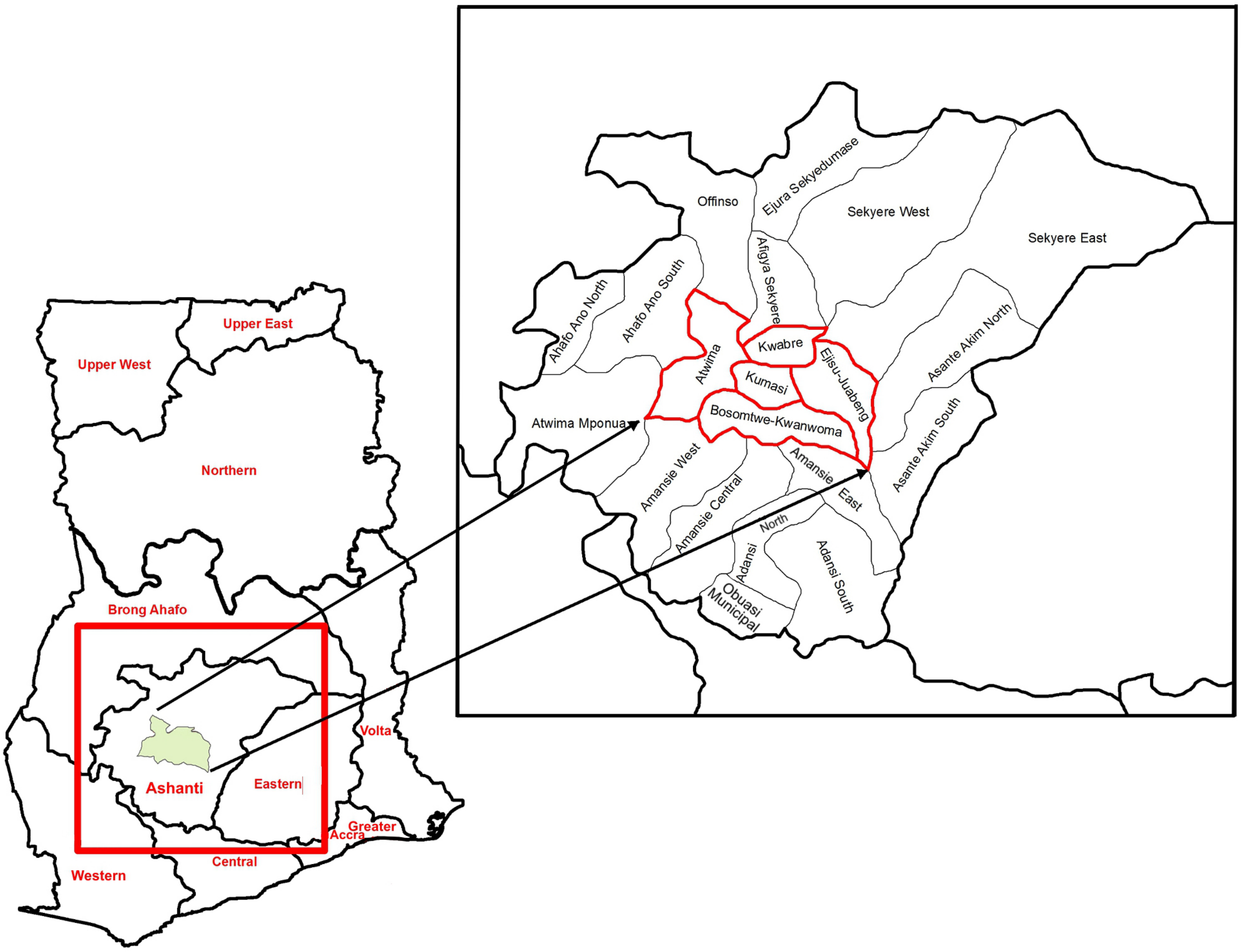

Fig. 1. The study area – the city of Kumasi and surrounding districts
Ryc. 1. Obszar badań – miasto Kumasi i otaczające je okręgi.

Kumasi Metropolis, Kwabre, Ejisu-Juabeng, Bosomtwe--Kwanwama and Atwima administrative districts. The meteorite lake called Bosumtwi – a tourist hotspot is located in the scene (Jones et al., 1981; Shanahan et al., 2012.

Materials. For the remote sensing part of this study, satellite data and reference data were acquired from the Forestry Commission of Ghana, under the Forest Preservation Program (FPP-Ghana) 2011/2012.

Image Processing. Quantifying the dynamic and complex occurrence, such as urban growth, necessitate land use change studies. ERDAS and ArcGIS software were employed for this study. Standardized image processing procedures – pre-processing, image classification, accuracy assessment, and production of a change map) were undertaken. The study focused on land use land cover change for 1986, 2007 and 2011 spanning twenty five (25) years.

Single bands (1, 2, 3, 4, 5 and 7) of each Landsat TM and Landsat ETM+ images were put together into one image using the Layer Stack tool in the Utilities toolbar of ERDAS Imagine 9.1 for the each respective year. Band 6 measures thermal reflectance was not added because, of its different spatial resolution of 120m and heat reflectance which was not the focus of the study. The subsequent stacked images which were in the global coordinate system, UTM WGS 84 were re--projected onto the Ghana datum, War Office which is based on Traverse Mercator Projection.

The images (Landsat TM, Landsat ETM+ and DMC) were resampled to 30 x 30 meter pixel resolution to ensure accurate analysis and comparability possible via Reproject in the Utilities toolbar of ERDAS Imagine 9.1.

Image Classification and Change detection. Post-classification change detection method was used to identify land cover land use changes that have transpired over the study period 1986 – 2011. This method is based on two thematic maps of different dates to detect changes. Stratified random sampling method used for the selection of training areas. By means of the reference data in Table 2 and the authors local knowledge about the study area, sixty-five (65) training sites indicating the various land use/cover classes (Forest-15, Agriculture-25, Settlement-18 and Water-7) were digitized on

Table 2. Satellite Images.
Tabela 2. Obrazy satelitarne.

Data *Dane*	**Years** *Rok*	**Acquisition Date** *Data pozyskania*	**Resolution** *Rozdzielczość* (m)	**Path and Rows** *Oznaczenie lokalizacji*
Landsat TM	1986	29/12/1989	28,50	WRS-194, WRS055
Landsat ETM+	2007	19/02/2000	28,50	WRS-194, WRS055
DMC	2011	19/01/2011	22,00	

Table 3. Reference data.
Tabela 3. Dane referencyjne.

Reference Data *Dane referencyjne*	**Acquisition Date** *Data pozyskania*	**Scale** *Skala*	**Sources** *Źródła*
Topographical Maps *Mapy topograficzne*	2008	1:50 000	Survey Department, Ghana
Aerial Photograph *Zdjęcia lotnicze*	2004	1:10 000	Survey Department, Ghana
Land Cover Map *Mapa użytkowania ziemi*	2002		Forestry Department, Ghana
Digitised Topographical Maps *Cyfrowe mapy topograficzne*	2002	1:50 000	Geomatic Engeneering Department, KNUST
FPP Ground truthing and verification data *Weryfikacyjne dane terenowe*	2012		Forestry Department, Ghana

the individual images using the AOI tool and named consequently in the signature editor of ERDAS imagine 9.1. The 65 classes emanating from the supervised image classification were recoded into the various classes via the Image Interpreter/GIS Analysis/Recode tool in ERDAS Imagine 9.1. Forest classes were recoded as one and designated the colour deep green; Agriculture recoded as Class two and given colour yellow; Built-Ups classes recoded as three and apportioned colour Maroon and water recoded as four with colour blue.

Supervised classification was used to classify the individual images into the various land use categories. Stratified random sampling was employed in the choice of the training sites for the image classification. Using expert knowledge, the field area is dispersed into strata that maximize the differences between units, and minimize the variation within each unit. One or more strata designated are assessed to be key drivers of the scheme under observation. A random sample is subsequently drawn from each stratum or unit. A random sample is subsequently drawn from each stratum or unit. Once known variances exist between the units, stratified random sampling with balanced allocation gives a better estimation short of adding bias (Snedecor & Cochran, 1989).

The major advantage of employing stratified random sampling is that, it produces results that are both largely unbiased and accurate. Stratified frequently gives data which is more representative of the entire population due the exceptional attention it gives to the smaller subgroups within the population. It is finest way to get results that replicate the diversity of the population in this study.

Reference data extracted from table 3 were used to undertake Accuracy Assessment. The Classifier toolbar of ERDAS Imagine 9.1.

Accuracy of the classified images were verified from the matrix generated. Computation of the land use land cover classes were measured in hectares for each study year.

Results

The figures 2, 3 and 4 are the delineted images from Landsat TM 1986 Landsat ETM+ 2007 and DMC 2011 indicating the study area.

Stratified random sampling method were employed to select reference points for the whole of the study area. Accuracy assessment of image classification and an assessment report was generated in an error matrix, and a Kappa statistics. 85% was attained as overall classification accuracy. Overall Kappa statistics of 0.74 was comprehended.

Land use maps. Table 4 gives the extent of the area of the individual land cover categories in hectares and the percentage they occupied. Figure 5 is the graph depicting the of land use land cover.

The land use map 1986 (Figure 6) showed half of the study area being dominated by forest. The agriculture is the land use at 30%. Settlement takes 13%

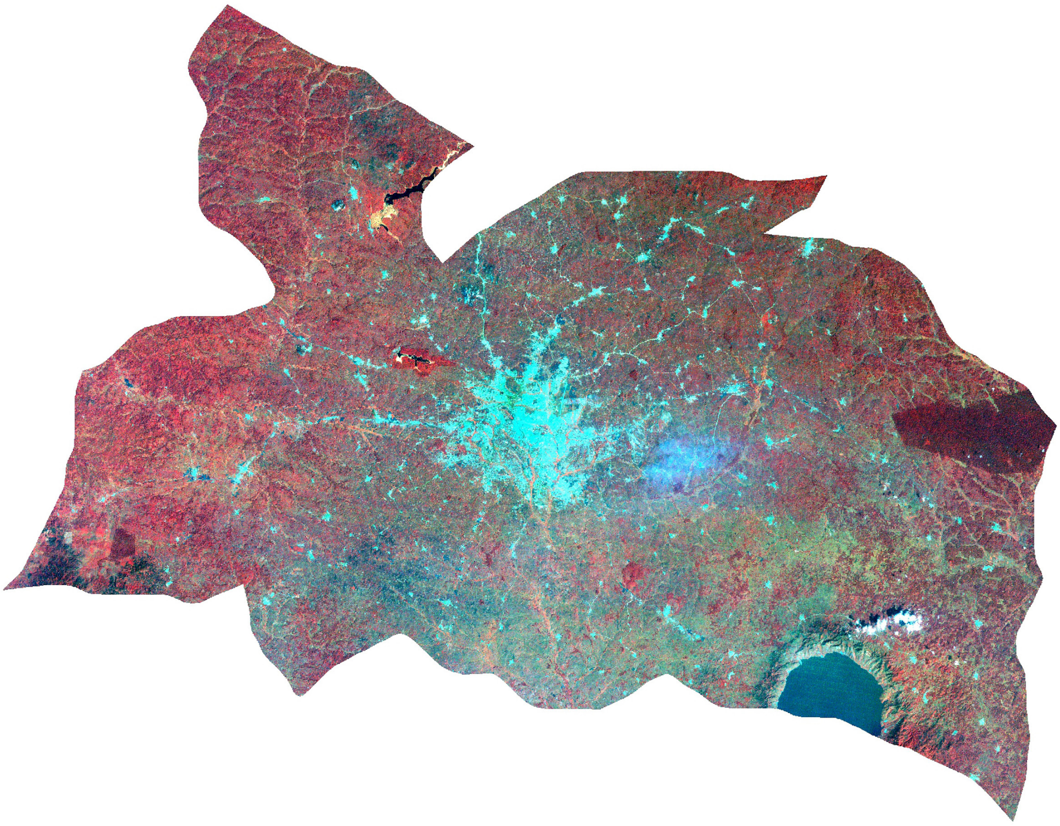

Fig. 2. Landsat TM image of 1986.
Ryc. 2. Zdjęcie Landsat TM z 1986 r.

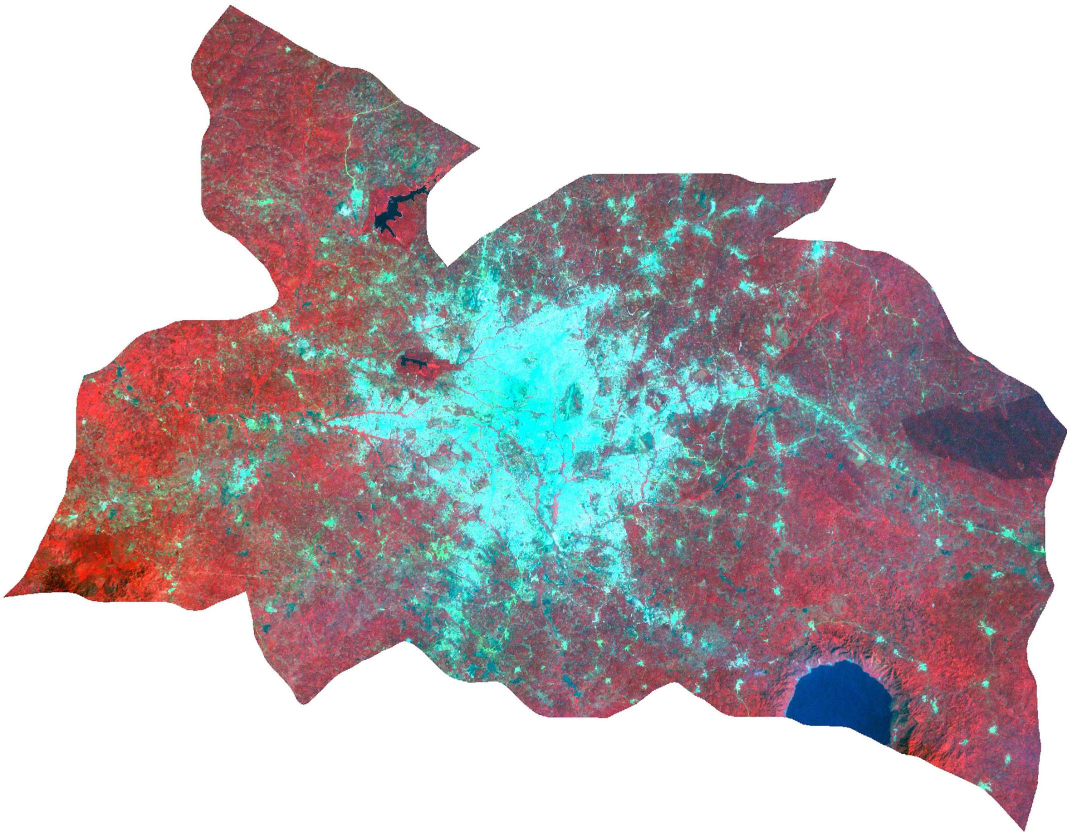

Fig. 3. Landsat *ETM+* image of 2007.
Ryc. 3. Zdjęcie Landsat ETM+ z 2007 r.

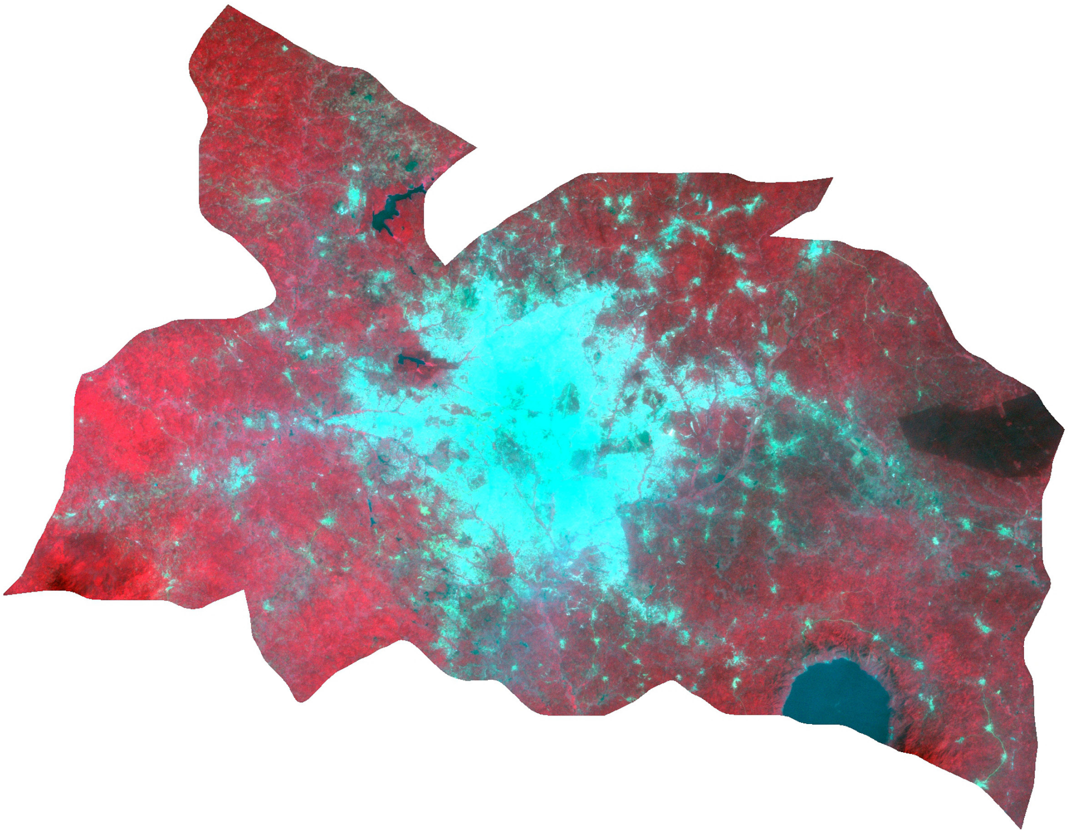

Fig. 4. Landsat DMC image of 2011.
Ryc. 4. Zdjęcie Landsat DMC z 2011 r.

and water is a little abobe 1%. Figure 7 portray Kumasi metropolis as relatively small having the largest Built-ups. Outskirts of the metro has farmland and forests. The Owabi headworks and surrounding forest reserve is intact. In the neighboring districts, the Builts are smaller and forests and agricture are dominant land use. The Barekese headworks in

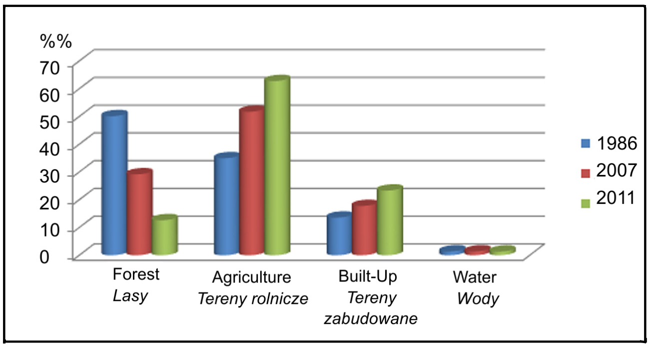

Fig. 5. Land use/cover of Kumasi and surrounding districts.
Ryc. 5. Użytkowanie ziemi/pokrycie terenu w Kumasi i otaczających okręgach.

Table 4. Area of categories in Hectare-Kumasi and its environs.
Tabela 4. Zestawienie powierzchniowe i procentowe użytkowania ziemi – Kumasi i okolice.

Categories *Klasy*	**Classified Area** *Powierzchnia* ( )			**Classified Area** *Udział* (%)		
	1986	**2007**	**2011**	**1986**	**2007**	**2011**
Forest *Las*	130940.6	76206.60	32982.86	50,11	29,16	12,62
Agriculture *Rolnictwo*	91350.59	135131.80	164019.80	34,96	51,71	62,77
Settlement *Zabudowa*	35459.59	46392.12	60872.87	13,57	17,75	23,30%
Water *Woda*	3555.949	3576.24	3431.17	1,36	1,37	1,31
Sum *Razem*	261306.70	261306.70	261306.70	100,00	100,00	100,00

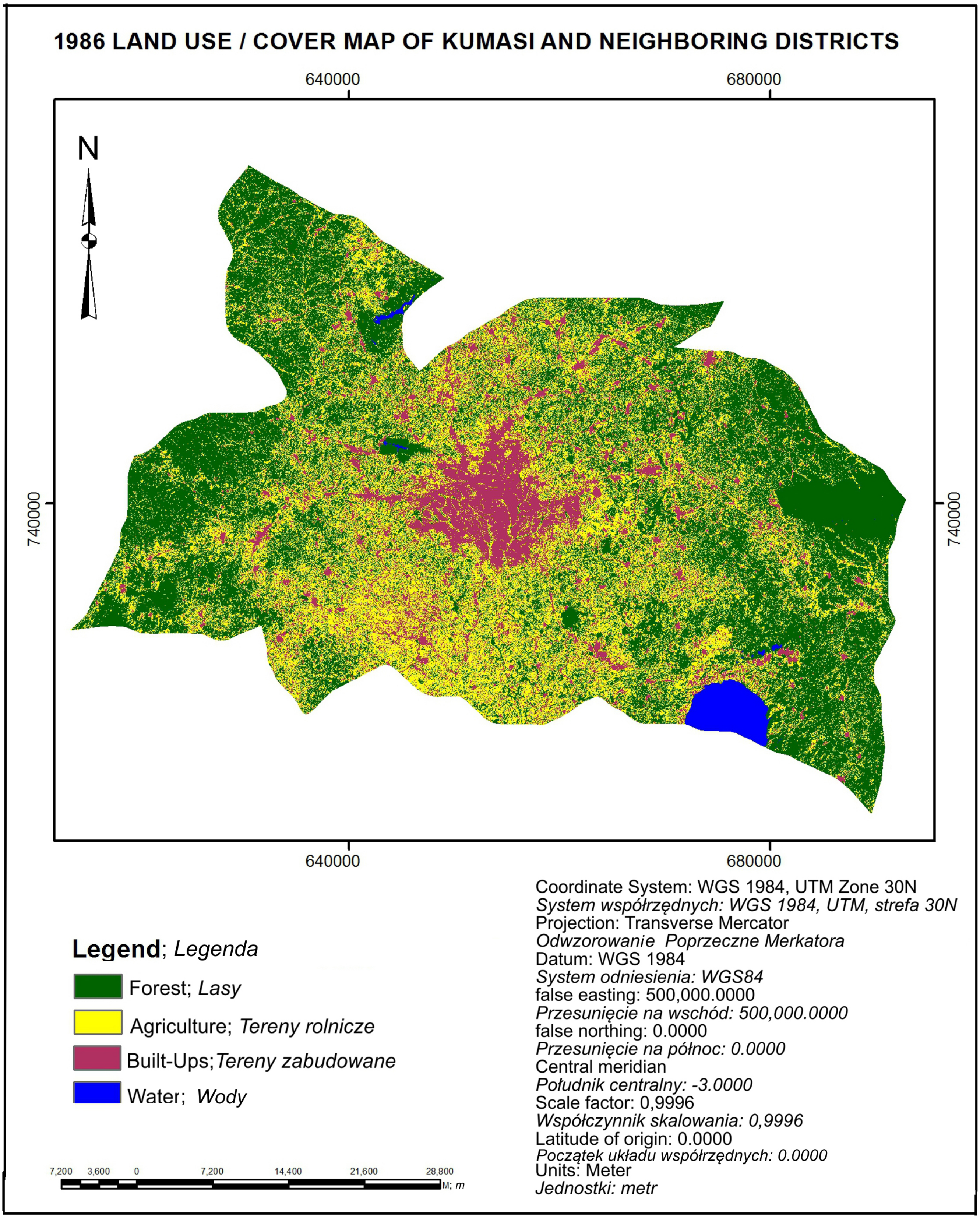

Fig. 6. Land use map Kumasi and fringe districts – 1986.

Ryc. 6. Mapa użytkowania ziemi Kumasi i otaczających okręgów – 1986.

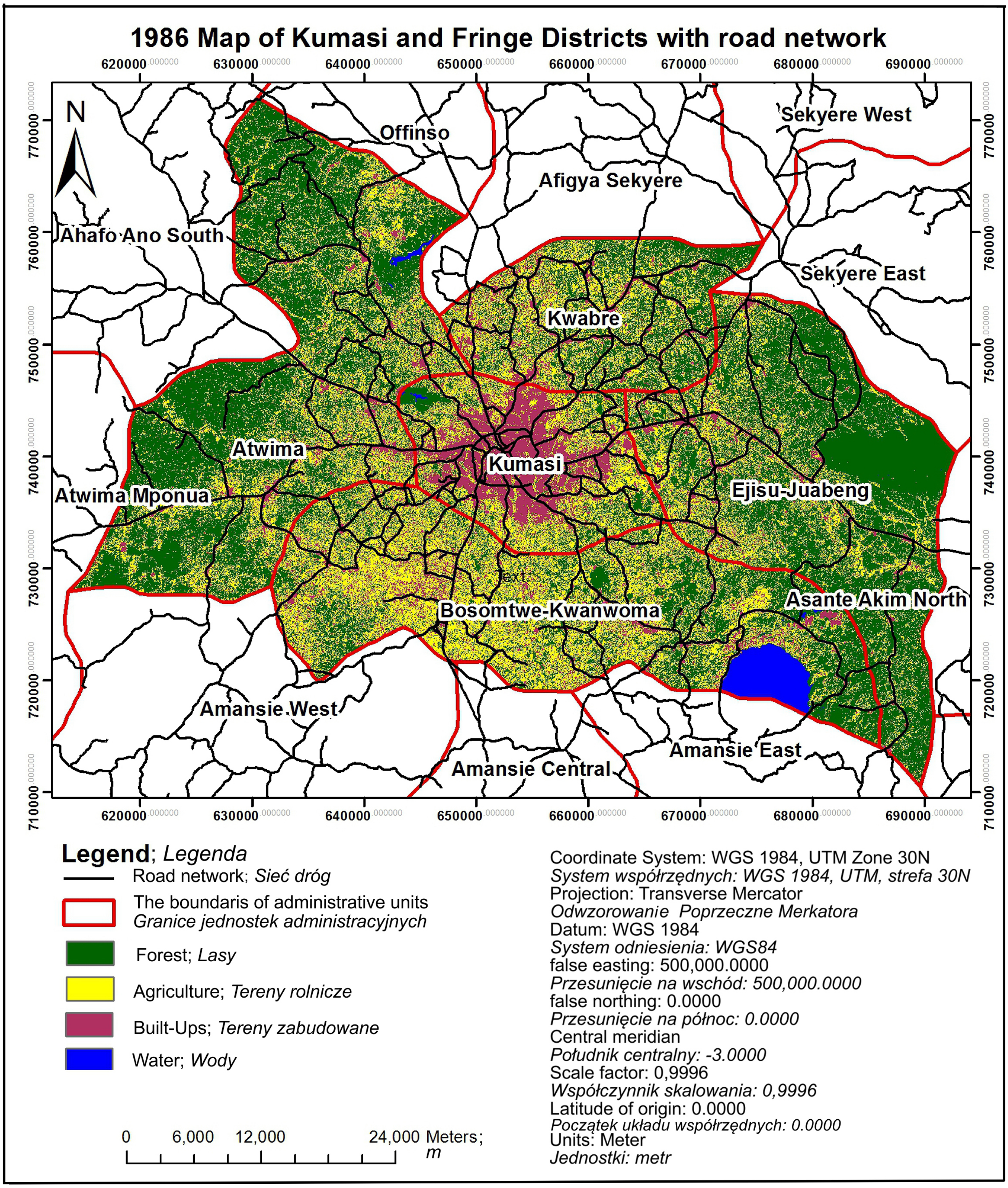

Fig. 7. LULC map with districts and road – 1986.

Ryc. 7. Mapa LULC z granicami administracyjnymi i drogami – 1986.

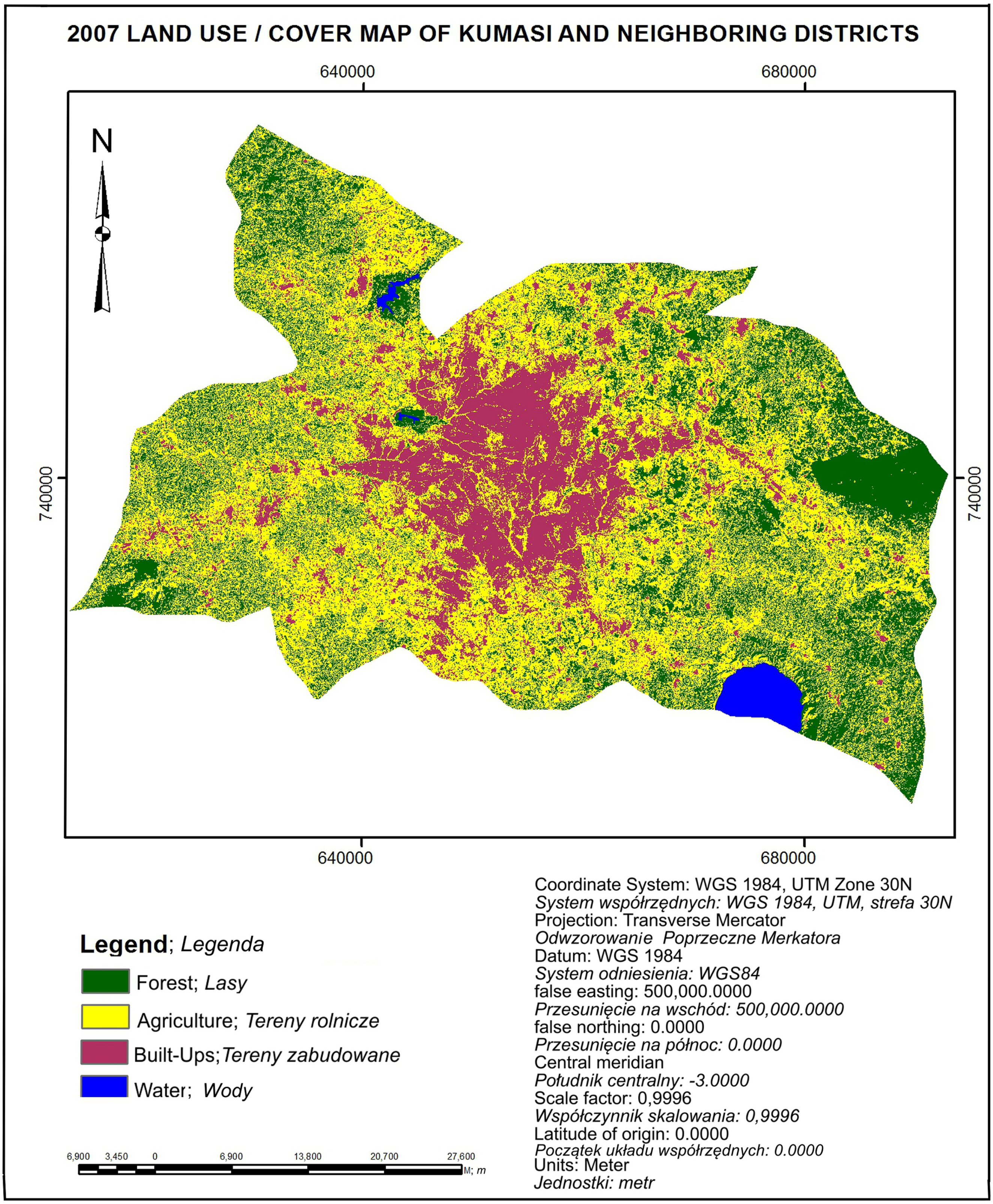

Fig. 8. Land use map Kumasi and fringe districts – 2007.

Ryc. 8. Mapa użytkowania ziemi Kumasi i otaczających okręgów – 2007.

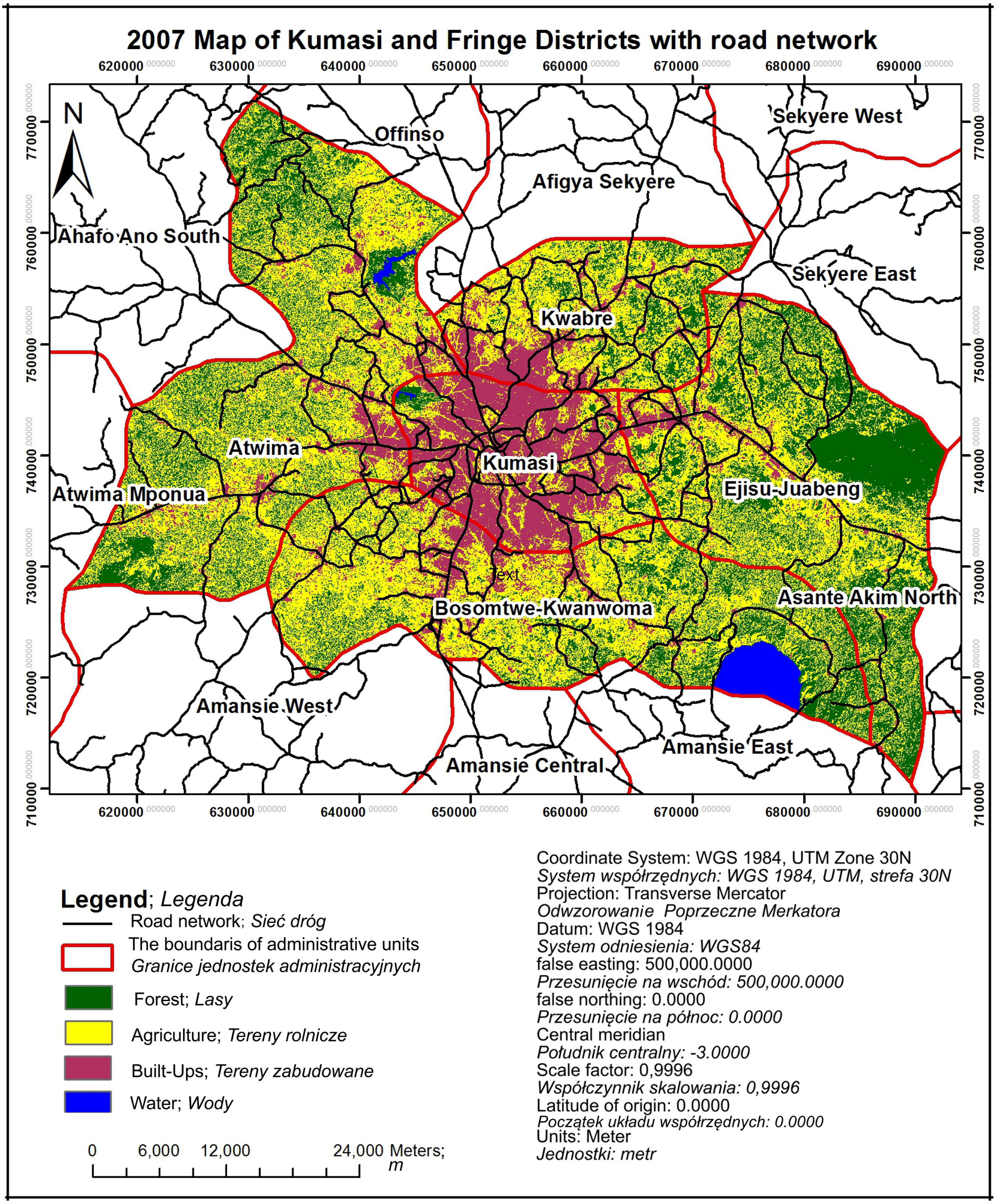

Fig. 9. LULC map with districts and road – 2007.

Ryc. 9. Mapa LULC z granicami administracyjnymi i drogami – 2007.

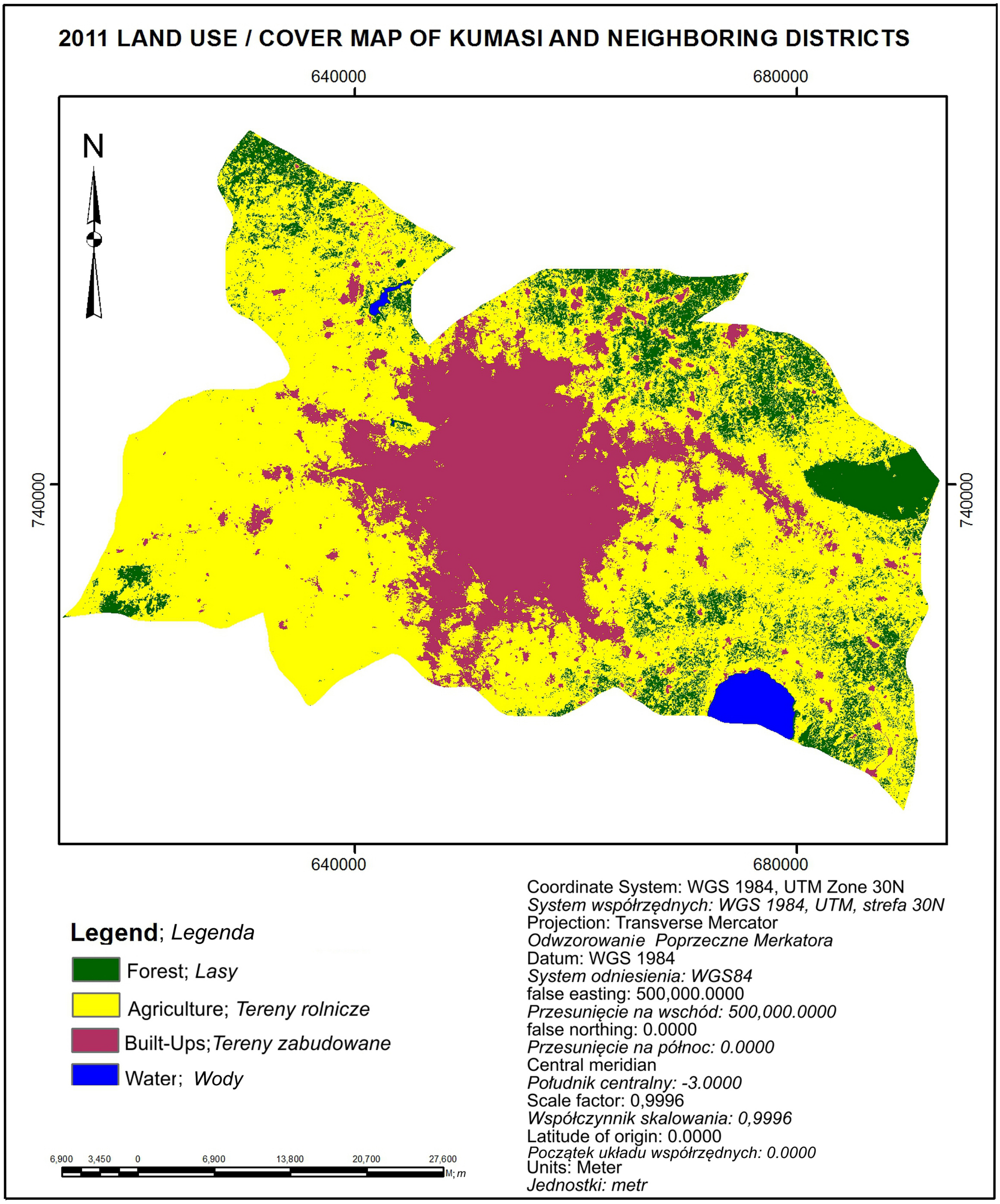

Fig. 10. Land use map Kumasi and fringe districts – 2011.

Ryc. 10. Mapa użytkowania ziemi Kumasi i otaczających okręgów – 2011.

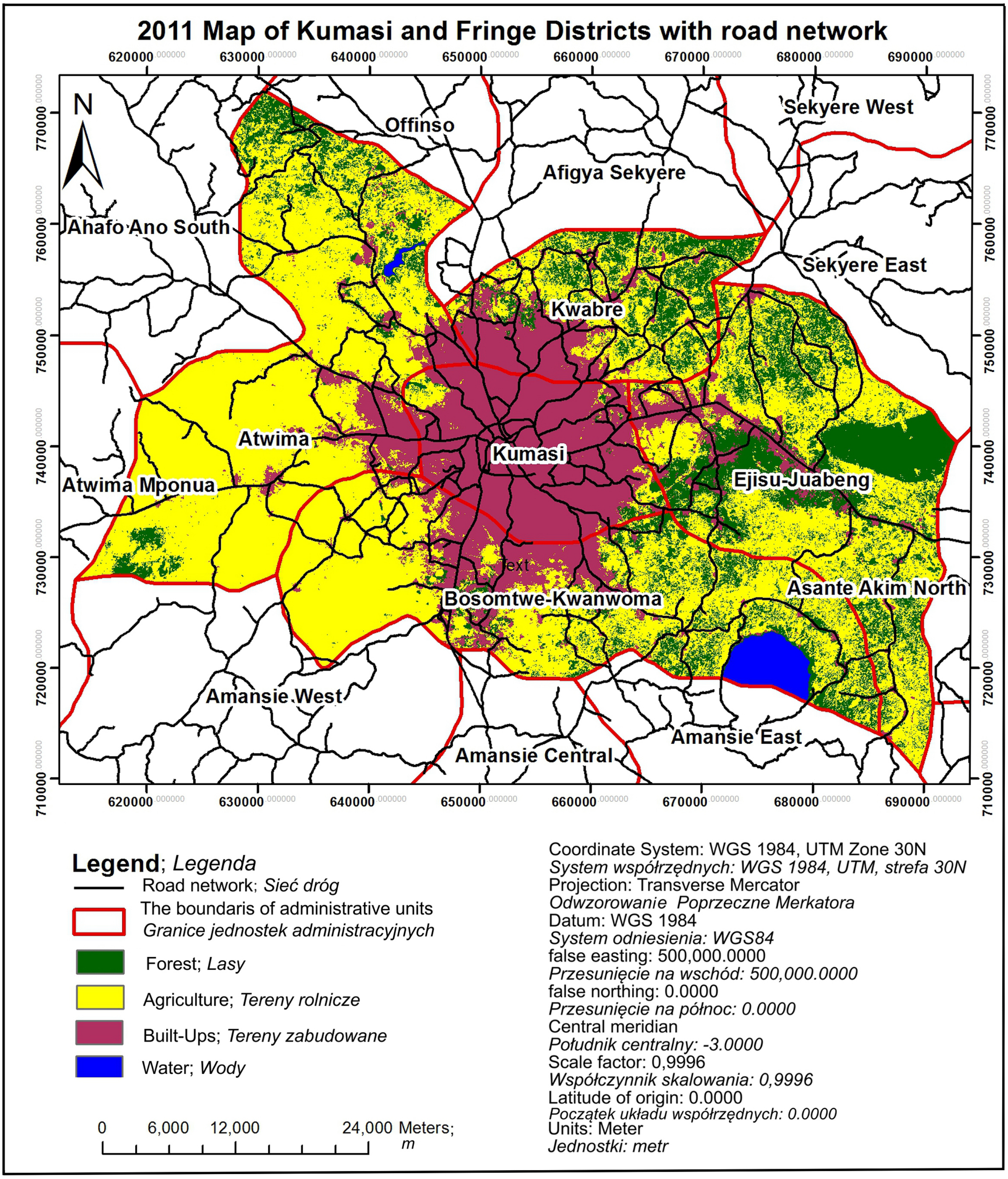

Fig. 11. LULC map with districts and road – 2011.

Ryc. 11. Mapa LULC z granicami administracyjnymi i drogami – 2011.

Atwima districts and Bobri forest in Ejisu-Juabeng districts are intact.

The land use map for 2007 (Figure 8) forest changing places with agriculture. Forest cover has now lost than 30%. Agriculture is now the dominant land use at 50%. Settlements have expanded in all directions. Water remains constant. Figure 9 depicts the Kumasi metropolis Built-ups trippling in size spreading into all the fringe districts. Outskirts of the metropolis which were farmlands and forests have been replaced by human settlemts. The Owabi headworks and surrounding forest reserve is heavily encroahed. In the bordering districts, the Built-ups have also doubled and agriculture remains the prevailing land use. The Barekese headworks in Atwima district is encroached and Bobri forest in Ejisu-Juabeng districts is undisturbed.

The map for 2011 (Figure 10) deforestation and degradation is very prevalent. Forest cover has now been reduce to 13%. Agriculture continues as the leading land use type and has taken much of the forest at 62%. Housing and social amenities (Settlement) have expanded in all directions. Water share of the land cover remains same. Figure 11 describes the Kumasi metropolis Built--ups continuing it sprawling into all the fringe districts. Agriculture and Forests are virtually removed in the Kumasi metropolis. Encroahment of the Owabi headworks and surrounding forest reserve is now dire. The flanking districts, the Built-ups surging is observed. Agriculture is intensified here and remains the prevailing land use at the expense of forest cover. The Barekese headworks in Atwima districts encroached is increasing and the Bobri forest in Ejisu-Juabeng districts is relatively intact.

Change Detection. The table 5 displays the amount of change in the study area of the individual land cover categories. Figure 12 is the graph describing the trends of land cover changes.

Figure 13 depicts the extensive changes that have occurred on 55% of between 1986 and 2007. Forest lost out to agriculture at 63%. Built-up gained at 17% at

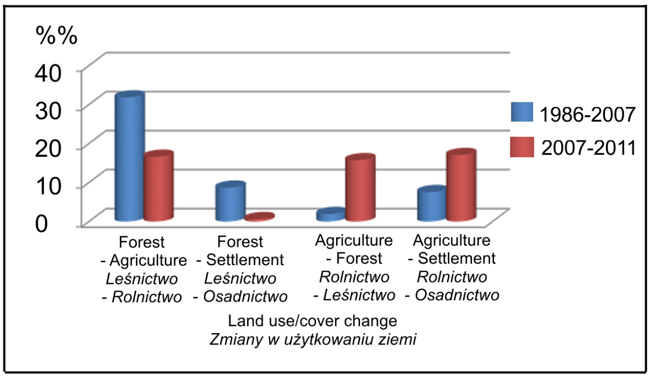

Fig. 12. Change Trajectory of Kumasi and fringe districts in 1986-2007 and 2007-2011.

Ryc. 12. Zmiany użytkowania ziemi w Kumasi i otaczających okręgach w latach 1986-2001 i 2007-2011.

the expense of forest, though Forest slightly increased at the expense of Agriculture at 4%. Agriculture lands were converted at Settlement at 15%.

Figure 14 gives a picture of the changes that have transpired on almost 30% between 2007 and 2011. Forest gave way to agriculture at 33%. Forest lost out slightly to Built-ups at 1.2%, whereas Forest increased its share at the expense of Agriculture at 31%. Agriculture lost to Settlement at 34%.

Discussion

Remote Sensing Application and Land use cover. Satellite remote sensing is a vital tool for studying the dynamic changes in the environment and accompanying ecological factors. The application of remote sensing method guarantees continuity, affordability, and access (Turner et al., 2015). Satellite data offers an essential means in forest change detection and land cover land use studies because of the periodic and coverage of the satellites at relatively short intervals (Mas, 1999).

Table 5. Change detection 1986-2007 and 2007-2010 for Kumasi and its environs.

Tabela 5. Powierzchniowe i procentowe zmiany klas użytkowania ziemi w rejonie Kumasi 1986-2007 i 2007-2010.

Categories *Klasy*	**1986-2007**		**2007-2011**	
	Area *Powierzchnia* ( )	**Area** *Powierzchnia* (%)	**Area** *Powierzchnia* ( )	**Area** *Powierzchnia* (%)
Forest – Agriculture *Las – Rolnictwo*	91868.0742	63,65	26363.0928	33,22
Forest – Built-Up *Las – Zabudowa*	25050.03368	17,36	987.118	1,24
Agriculture – Forest *Rolnictwo – Las*	5607.61155	3,89	24960.9932	31,45
Agriculture – Built-Up *Rolnictwo – Zabudowa*	21810.537	15,11	27058.4556	34,09
Sum *Razem*	144336.2564	100,00	79369.6596	100,00

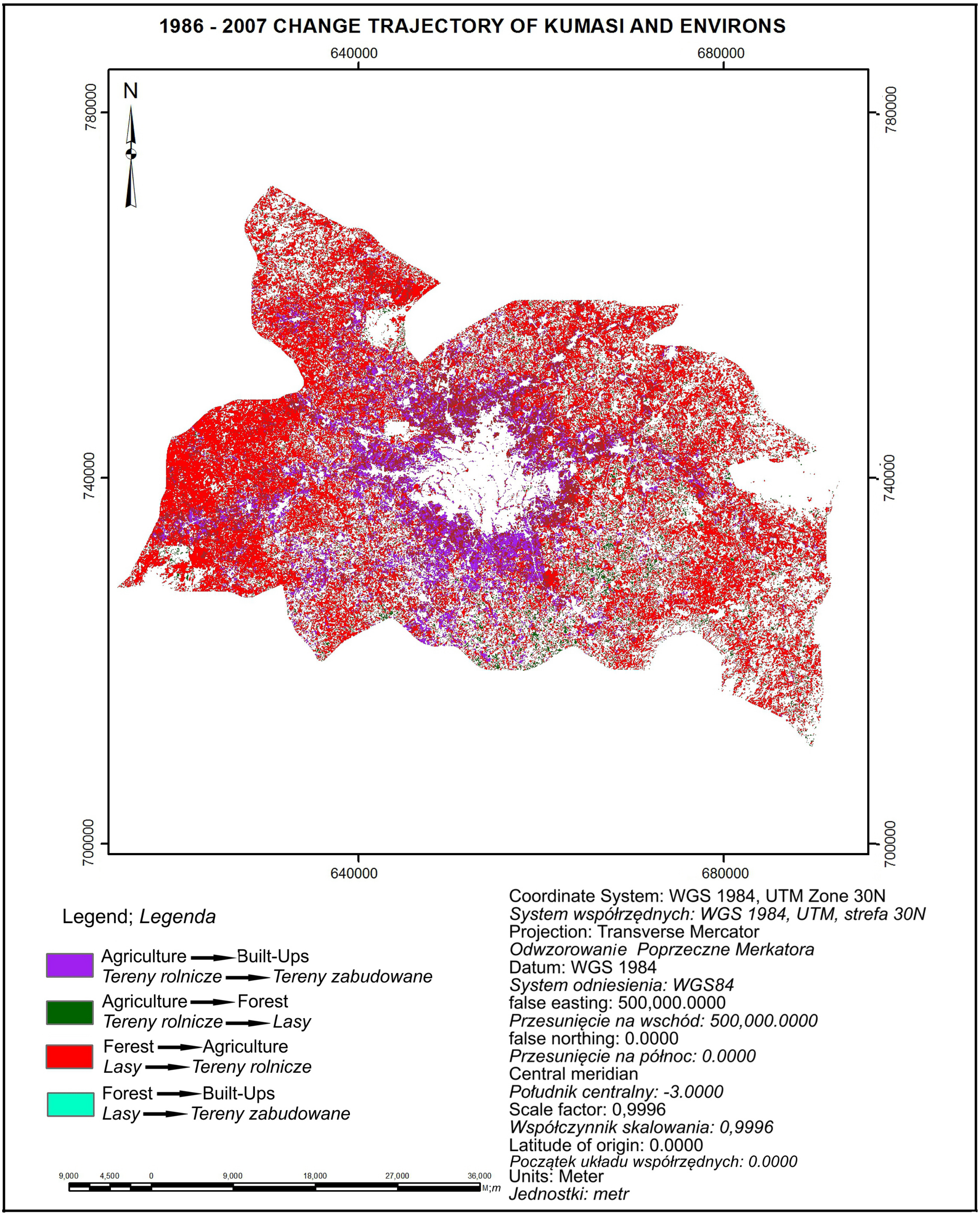

Fig. 13. Change Trajectory 1986-2000.

Ryc. 13. Mapa zmian użytkowania ziemi w latach 1986-2000.

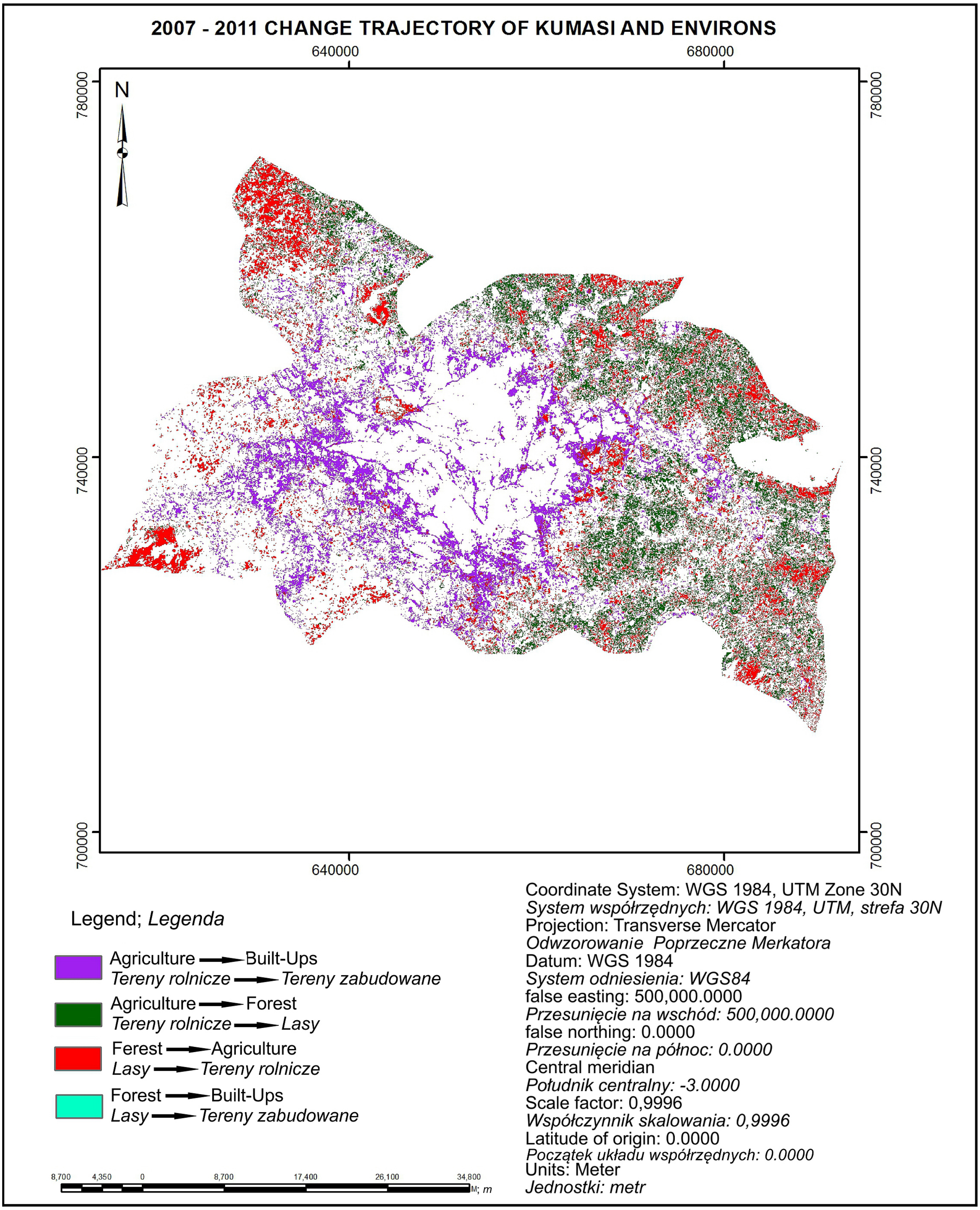

Fig. 14. Change Trajectory 2007-2011.

Ryc. 14. Mapa zmian użytkowania ziemi w latach 2007-2011.

Remote sensing permits cost-effective and time-effectual means studying the management of natural resources, ecosystems, and biodiversity in landscapes (Willis, 2015) ecosystems, and biodiversity. This review synthesizes and recommends best practice change detection methods for land management groups to monitor chief ecological change indicators currently monitored in United States protected areas. The indicators frequently monitored via change detection and reviewed here include: land use/land cover, disturbance, and phenology. Landsat data products are recommended for monitoring land use/land cover and disturbance, due to their continuous data accessibility free of cost since 1972. Data from the Moderate Resolution Imaging Spectrometer (MODIS.

Exploiting remote sensing data for land cover land use studies over large areas is very efficient, quick and reasonably economical when compared with other approaches of land use land cover studies. Nevertheless, in sub-Sahara Africa procuring the necessary remote sensing data (satellite) for such studies is an enormous challenge principally as a result of high cost. Studies via this method consequently depend mostly on Landsat images (available free on line) and donor sponsored programs (Koranteng & Zawila-Niedzwiecki, 2015).

Assessing accuracy of image classification validates the results. There are several assessment techniques, error matrix of classification is the most commonly used (Foody, 2010; Lillesand et al., 2008). An error matrix is an effective technique involving a square matrix that presents the overall accuracy of the classification, the producer and user accuracy of each class. Error matrix was used for the assessments of image classification accuracy for this study. This is a standardized procedure allowing verification of classification results (Congalton, 1994). The overall accuracy and overall kappa statistics obtained for land use cover maps 85% and 0.75. The accuracy very high for a terrain that, had many mosaic agricultural land ranging from tree crops such as cocoa, cashew, citrus, Palm; shrubs and herbaceous plants. Stratified random samplings employed ensured that, all the mosaic substrata were all duly represented and classified accordingly.

The land use/cover for 1986, 2007 and 2011 showed surging deforestation and degradation. Kumasi metropolis has more than quadrupled within the 25 year period. Agriculture and Settlements are the big gainers as the years go by.

Causes of the land use land cover trends. Kumasi and its fringe districts have undergone dramatic increase of built-up areas and agricultural intensification as revealed by the land cover change analyses. The sum of land cover change substantiates the trend and extent of urban growth resulting in sprawling unto the outskirts and additional densification in the inner parts as well. The upsurge of built-up and agriculture (mostly in the neighboring districts) have impacted negatively on forest cover and other open spaces. Essential service such as water supply from the Owabi and Barekese Headworks are under serious threat owing to wanton destruction of natural vegetation for human settlement and agricultural purposes (Koranteng & Zawila-Niedzwiecki, 2014).

The driver for deforestation and degradation is clearly anthropogenic in this study. The Ashanti Region has the largest population in Ghana and the fastest growing population (GSS, 2013). The surge in population has direct consequence on the environment and the forests in particular. The rapid urbanization growth in study area is the consequence of natural increase in population, and migration (GSS, 2013). Ghana's population was 24,658,823 in 2010. 6,726,815 was recorded in 1960 and increased to 18,912,079 in 2000. Between 1960 and 2010, a period of fifty years, the population more than tripled. The Ashanti Region had the highest population in all the census years and most of the population in Ashanti Region resides in the urban centers (GSS, 2013).

The factors enumerated in table 1 all apply in the study area. This unfortunate situation necessitates a quick and a well thought out plan to salvage what is left.

Conclusion

Remote Sensing (Landsat multi-temporal images and DMC) and GIS techniques were used to analyze and compute the land cover changes (amount, trend and location) that had transpired for the period of 1986 and 2011. Reliable digital remote sensing classification techniques were employed to produce land use/cover maps by a hierarchical level I land use and land cover classification which consists of Forest, Agriculture, Water and Built-up. The final image classification accuracy was deemed to be good by means of standardized accuracy assessment procedures.

Urbanization is frequently deliberated upon as a local issue. Nevertheless, this study illustrates that the direct effects of urban growth on biodiversity hotspots and carbon pools would be significant and would affect the whole world. Meanwhile the full environmental consequence will not be restricted to urban boundaries but will largely be felt elsewhere.

Limitations. There were challenges with satellite data availability for the study due to cost and cloud covering. The authors had no choice but to make use of what was available. Cloud free satellite images for the study area would have been preferred to make comparisons proper and at regular intervals.

Demographic data for the respective districts and metropolis was difficult to come by as a result of frequent re-demarcation of old and existing administrative districts by the central government. A precise population growth data covering the administrative districts and metropolis for the respective years would have been very much appreciated.

The investigation was restricted to spatial resolution of satellite remote sensing data with 30 m and temporal resolution of about 21 years (1986-2007) and 4 years (2007 – 2011). It would have more revealing to assess the effect of scale (lesser) in the appraisal of these metrics and their efficiency in mapping the patterns.

Recommendations. The twenty five year time span, 1986 – 2011, deliberated in this study is comparatively a short increase of time in a long-drawn-out history of land use underlying forces. To have forests in the foreseeable future in the Ashanti Region, major intervention and deliberate steps must be taken place to reclaim what is left of our forests. All efforts must be spent at salvaging what is left of our forest. Population growth must be curbed at all cost.

Remote Sensing when used in combination with existing norms and practices can facilitate land-use planning to acknowledge the landscape dynamics.

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