URBAN GROWTH AND LAND USE CHANGE FROM 1975 TO 2015 IN SAMARA CITY, RUSSIA

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This study illustrates the spatio-temporal dynamics of urban growth and land use changes in Samara city, Russia from 1975 to 2015. Landsat satellite imageries of five different time periods from 1975 to 2015 were acquired and quantify the changes with the help of ArcGIS 10.1 Software. By applying classification methods to the satellite images four main types of land use were extracted: water, built-up, forest and grassland. Then, the area coverage for all the land use types at different points in time were measured and coupled with population data. The results demonstrate that, over the entire study period, population was increased from 1146 thousand people to 1244 thousand from 1975 to 1990 but later on first reduce and then increase again, now 1173 thousand population. Built-up area is also change according to population. The present study revealed an increase in built-up by 37.01% from 1975 to 1995, than reduce -88.83% till 2005 and an increase by 39.16% from 2005 to 2015, along with the increase in population, migration from rural areas owing to the economic growth and technological advantages associated with urbanization. Information on urban growth, land use and land cover change study is very useful to local government and urban planners for the betterment of future plans to sustainable development of the city.

Keywords: Urban growth, land use/cover; remote sensing; change detection analysis and GIS

1. Introduction:

The official foundation date of Samara is 1586. That time small fortress was built at the confluence of the Volga and Samara rivers. It was protecting the eastern borders of the Russian state from nomads. After building the quay, Samara settlement became the economic and diplomatic center of Russia. In 1780, the town became the capital of Simbirsk region. The economy of Samara was growing quickly at the end of the 19th and beginning of the 20th centuries (bread trading and milling business). The population of Samara at the beginning of the 20th century was about 100,000. It was large trade and industrial center of the Volga region of Russia [1].

Urban sprawl is defined as an inefficient urban development often linked to sparse building density over rural areas [2, 3]. Only 3 present earth surfaces covered by urban area [4] but due to urbanization, population growth, economic development and unplanned development are the main cause of environmental and social problems in modern cities. Urban areas are faced with distinctive, or ‘systemic’, issues arising from their unique social, environmental and economic characteristics [5]. Some glitches such as health risks including air pollution, occupational hazards, traffic injury, risks caused by dietary and social changes [6] as well as destruction of vegetation, agricultural lands, population of underground and surface water sources and climate change [7] are associated with urban expansion. These parameters are decreasing the quality of life in urban and rural societies. In developing cities, information about unplanned settlements is often unavailable. It is critically important to properly characterize urban expansion before developing a comprehensive understanding of urbanization processes [8, 9]. To know the spatial patterns of Samara city urban growth over in a timeframe, city must be systematically mapped, monitored, and accurately assessed using satellite images with conventional ground truth verification data. This type of analysis work provides a scenario of where growth is occurring and helps to identify the environmental and natural resources threatened by such development and suggest the likely future directions and patterns of growth.

2. Material and methods

The specific satellite images used were Landsat MSS (Multi-Spectral Scanner) for 1975, Landsat TM (Thematic Mapper) for 1985-1995, Landsat ETM+ (Enhanced Thematic Mapper plus) for 2005 and 2015, an image captured by a different type of sensor. Digital image processing was manipulated by the ArcGIS software. The scenes were selected to be geometrically corrected, calibrated and removed from their dropouts. Other image enhancement techniques like histogram equalization are also performed on each image for improving the quality of the image. Some additional supporting data were used in this study. Digital topographical maps, 1:50,000 scales were used for image georeferencing for the land use/cover map and for increased accuracy of the overall assessment.

After preprocessing, first use unsupervised classification and get maximum possible classes on the basis of grave levels. Then used supervised classification method with maximum likelihood algorithm in ArcGIS 10.1 Software. Maximum likelihood algorithm (MLC) is one of the most popular supervised classification methods used with remote sensing image data. Ground verification was done for doubtful areas. Based on the ground trothing, the misclassified areas were corrected using recode option in ArcGIS. The error matrix and Kappa methods were used to assess the mapping accuracy. Four land use/cover types are identified in the study area viz., (i) Forest (ii) Grassland (iii) Built-up (iv) Water body.

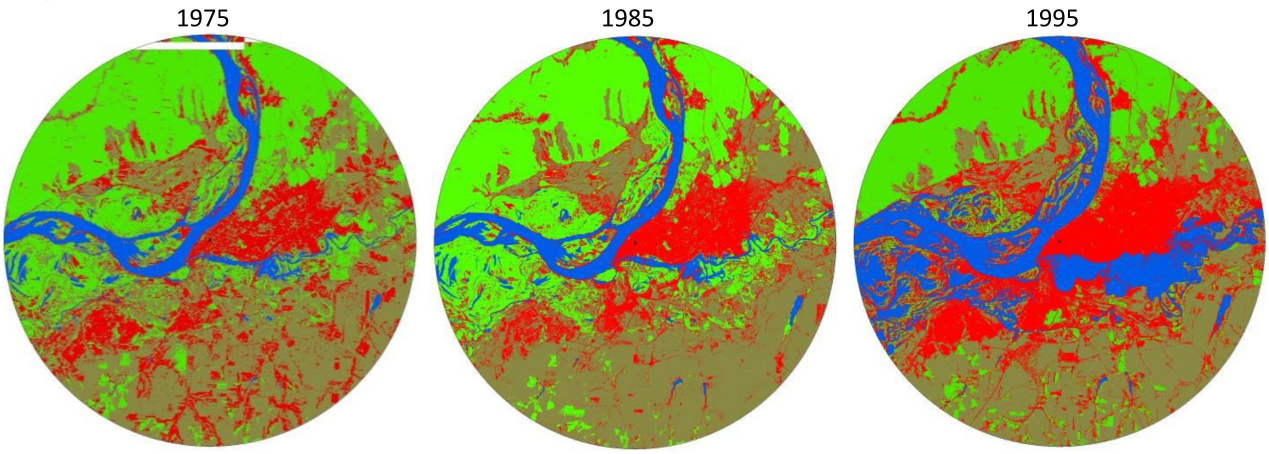
We use following formula to know the intensity of urban expansion called annual urban growth rate (AGR):

$$\text{AGR} = \frac{UA_{n+i} - UA_i}{nTA_{n+i}} \text{ X } 100\%$$

where TA$n+i$ is the total land area of the target unit to be calculated at the time point of $i+n$; UA$n+i$ and UAi the urban area or built-up area in the target unit at time $i+n$ and i, respectively and n is the interval of the calculating period (in years).

3. Results and discussions

Accuracy assessment of the land use/cover classification results obtained showed an overall accuracy is more than 90% for all images. These data reveal that in 2015, about 31.38% (616.14 km^2) area of Samara block was under forest, 36.85% (723.49 km^2) under grassland, 8.30% (162.91 km^2) under water body and 460.87% (23.47km^2) under built-up land. During 1975 the area under these land categories was found about 31.81% (624.56 km^2) under forest, 44.03% (864.50 km^2) under grassland, 7.17% (140.85 km^2) under water body and 16.99% (333.50 km^2) under built-up land (Table 1). First unban area was increase till 1995 then reduce but later on again increase due to increased population. Initially forest area was decreased and later on increase due to governmental protection. Grassland class cover highest area in the study area, it was increase and highest in 2005 but in last radiuses. Water class is stable with small variation (Fig. 1).



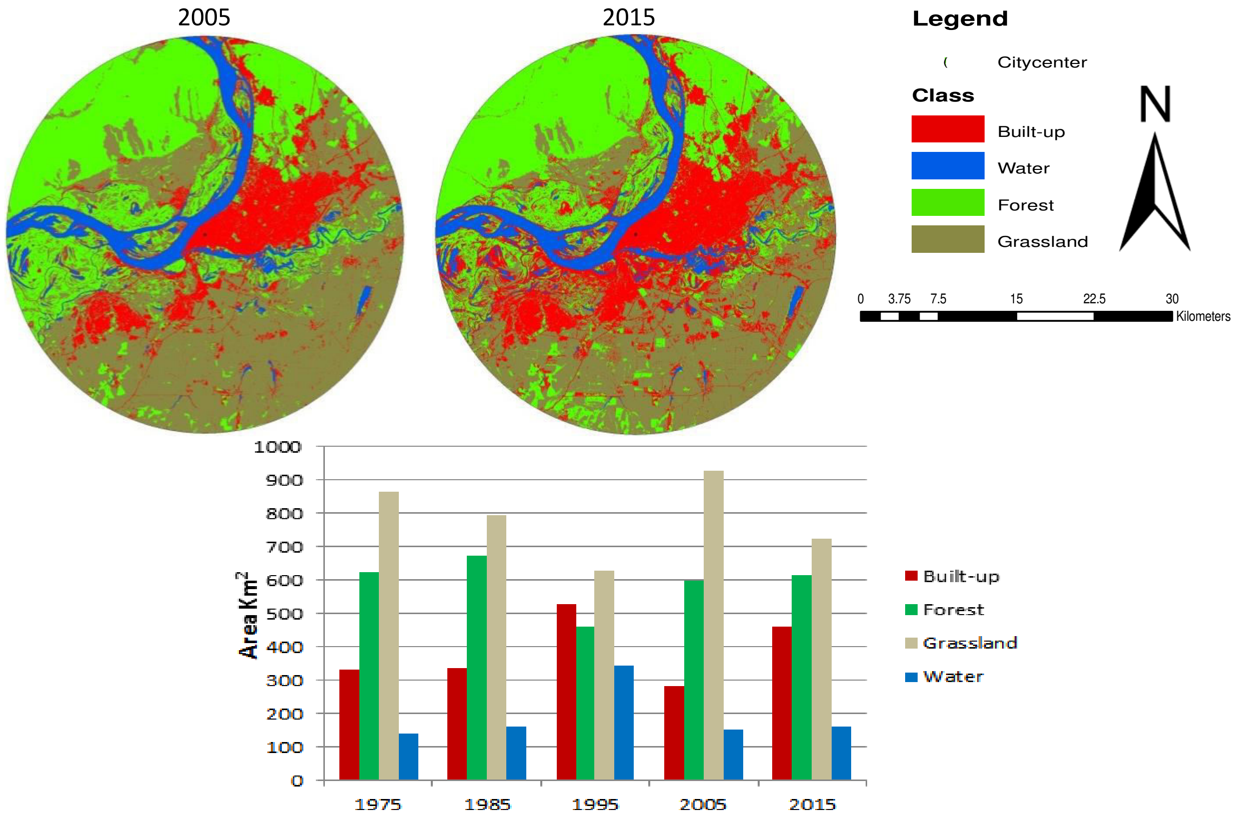


Fig. 1: The land use and land cover map of Samara in 1975, 1985, 1995, 2005 and 2015.

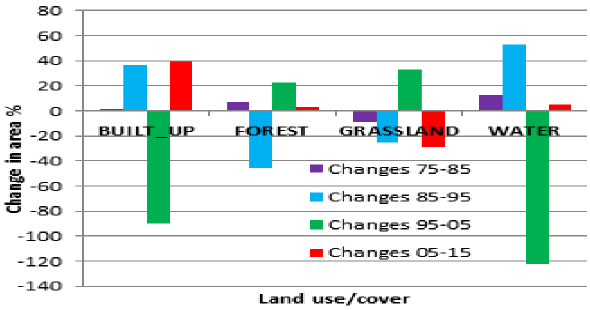
Table 1 shows land use land cover change matrix from 1975 to 2015. Data registered in table 1 and figs. 1 reveal that both positive and negative changes occurred in the land use/cover pattern of the Samara block. During the last four decades the grassland in the study area has decrease from 864.50 km^2 in 1975 to 723.49 km^2 in 2015 which accounts for -19.49% of the total study area. The forest has slightly decreased from 624.56 km^2 in 1975 to 616.14 km^2 in 2015 which accounts for -1.36%. The built-up area has increased from 333.50 km^2 in 1975 to 460.87 km^2 in 2015 which accounts for 27.63%. The water body has been increased from 140.85 km^2 in 1975 to 162.91 km^2 in 2015. This increase in water body accounts for 13.54%. Cross tabulation is a means to determine quantities of conversions from a particular land cover to another land cover category at a later date. The change matrices based on post classification comparison were obtained and are shown in tables 1 and fig 1. Built up area covered 333.5 km^2 in 1975 and 336.59 km^2 in 1985, while the grassland covered an area of 792km^2 in 1985 and 629.68 km^2 in 1995. 383.83km^2 of the forest area which was forest in 1995 was still forest cover in 2005. From 2005 to 2015 149.10 km^2 grassland and 60.50km^2 forest convert in built-up. During the same period, 115.29km^2 grassland had been converted to forest area (table 1).

Table 1: Land use/cover change matrix from 1975 to 2015.

2005-2015					
CLASS	BUILT_UP	FOREST	GRASSLANI	WATER	Total
Built-up	245.14	5.00	18.41	10.32	278.87
Forest	60.50	496.84	42.42	0.32	600.08
Grassland	149.10	115.29	662.95	4.16	931.49
Water	5.56	0.40	0.00	146.78	152.74
Total	460.30	617.53	723.77	161.58	1963.19
Change rate %	39.41	2.82	-28.69	5.47	
1995-2005					
CLASS	BUILT_UP	FOREST	GRASSLANI	WATER	Total
Built-up	216.68	88.07	224.33	1.16	530.25
Forest	4.36	383.83	74.63	0.04	462.86
Grassland	26.17	51.46	551.93	0.20	629.76
Water	31.49	76.83	80.71	151.34	340.37
Total	278.71	600.19	931.60	152.74	1963.24
Change rate %	-90.25	22.88	32.40	-122.84	
1985-1995					
CLASS	BUILT_UP	FOREST	GRASSLANI	WATER	Total
Built-up	227.05	15.53	52.54	42.26	337.37
Forest	114.36	385.95	62.90	111.00	674.22
Grassland	187.79	61.34	514.24	29.13	792.51
Water	1.04	0.04	0.00	157.98	159.06
Total	530.25	462.86	629.68	340.37	1963.16
Change rate %	36.37	-45.66	-25.85	53.26	
1975-1985					
CLASS	BUILT_UP	FOREST	GRASSLANI	WATER	Total
Built-up	151.21	20.51	157.05	4.28	333.05
Forest	31.93	526.99	60.97	4.66	624.55
Grassland	145.54	120.89	573.31	24.87	864.60
Water	7.92	4.89	0.92	127.14	140.87
Total	336.59	673.28	792.25	160.95	1963.07
Change rate %	1.05	7.23	-9.13	12.47	

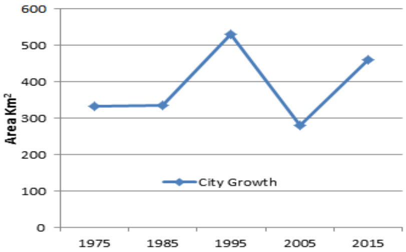
Class	1975	%	1985	%	1995	%	2005	%	2015	%
Built-up	333.50	16.99	336.48	17.14	529.48	26.97	280.40	14.28	460.87	23.47
Forest	624.56	31.81	673.94	34.32	462.69	23.57	600.57	30.59	616.14	31.38
Grassland	864.50	44.03	792.86	40.38	628.54	32.01	928.97	47.31	723.49	36.85
Water	140.85	7.17	160.13	8.16	342.70	17.45	153.47	7.82	162.91	8.30
Total	1963.41	100.00	1963.41	100.00	1963.41	100.00	1963.41	100.00	1963.41	100.00

CLASS	BUILT_UP	FOREST	GRASSLANI	WATER
Changes 75-85	1.05	7.23	-9.13	12.47
Changes 85-95	36.37	-45.66	-25.85	53.26
Changes 95-05	-90.25	22.88	32.40	-122.84
Changes 05-15	39.41	2.82	-28.69	5.47



The urban area of Samara city expanded from 333.50 km^2 in 1975 to 460.87 km^2 in 2015 at annual average rate of 0.69 km^2/year (fig.2).

Year	Area SqKm	Growth Rate	Annual GR	Population (Thousands)
1975	333.5			1146
1980	334.99			1221
1985	336.48	0.89	0.08	1241
1990	432.98			1244
1995	529.48	36.44	3.64	1208
2000	404.94			1173
2005	280.4	-88.83	-8.88	1140
2010	370.63			1164
2015	460.87	39.16	3.91	1173



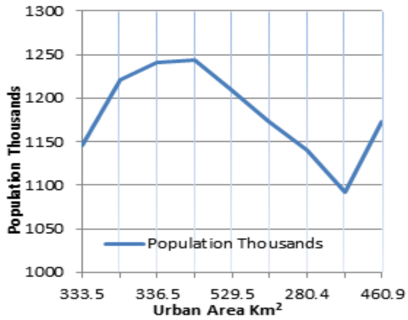


Fig. 2: Temporal change of urban area with population.

Samara Region has highly developed industry and a diversified economy structure. Industry accounts for about 40% of the gross regional product including: automobile manufacture, air and spacecraft manufacture, which account for up to 35% of the total volume of shipped production of processing industries; enterprises with high degree of processing: chemical and metallurgical. The region manufactures 30% of new passenger cars made in Russia, 31% of polymer materials for floor, wall and ceiling coatings, 23% of anhydrous ammonia, 16% of sanitary products made from ceramics, 13% of ceramic floor tile, 7.7% of automobile gasoline and 9% of diesel fuel, 8.5% of plastics in primary forms, 7.3% of beer, 5.0% of confectionery products and 4% of mineral fertilizers.

4. Conclusions

This research work examined the urban growth of Samara city, Satellite data and census data were used to monitoring the dynamic phenomena of urbanization. Samara land expansion is based on Samara and Volga River and social factors such as population growth, migration and economic development. Conversion of vegetation and orchards to built-up area, however, has been a more recent phenomenon. The study reveals that the major land use in the study area is vegetation. The area under vegetation has decreased by 7.66% (149.43 km^2) due to afforestation work during 1975 to 2015. The second major category of land in the study area is built-up area which was increased by 6.48% (127.37 km^2) due to conversion in forest and grassland. Thus, the present study illustrates that remote sensing and GIS are important technologies for temporal analysis and quantification of spatial phenomena which is otherwise not possible to attempt through conventional mapping techniques.

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