

Urban and natural transformations of agricultural lands in Moscow oblast

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1 ABSTRACT

Moscow region (oblast) is a territory that surrounds Moscow, the capital of Russian Federation. Together they occupy the territory larger than Belgium or Netherlands and have the population about 18-21 million people. Urban usage of the territory of Moscow oblast has been radically transformed during the last 10-15 years. The whole region – about several thousand sq.km – is now in a state of rapid urbanization, caused by processes of centralization, which are typical for modern Russia. Urbanization includes expansion of old cities and appearance of new living and commercial development on rural lands.

According to the national statistic in 1990-s about 30-35% of Moscow oblast was used for agricultural purposes. In last 15 years we have observed both processes of rapid housing construction around Moscow on all the areas not covered with forest and the decrease of agricultural production.

The goal of this study was to detect the changes in usage of agricultural lands in Moscow oblast and to classify the discovered changes.

Space images of the Moscow oblast territory have been analyzed and compared at the dates of 1990-1992 and 2005-2007 in order to determine how agricultural lands have transformed over this period.

Two coverages of this region were collected using images of Landsat-5 TM and Landsat-7 ETM. The coverage of 1990-1992 images was classified on forest, natural grassland, agricultural, rural, urban and undefined territories. The buffer zones around roads, railroads, water objects and settlements were preliminarily excluded. Then coverage of 2005-2007 was classified on the same classes. The spatial resolution of space images was 30 meters per pixel and the accuracy of classification was accepted to 2-4 hectares. The classification of 2005-2007 images was made more accurately by using space images of IRS 1C/1D/P-6 sensors with spatial resolution increased to 6 meters per pixel.

As we were analysing detected changes, we have discovered three main types of transformation of agricultural lands:

- Urbanization. The 30-50 kilometres wide area around Moscow was radically transformed into urban territory.
- New agricultural territories. New territories that can be used as arable lands appeared on the place of shrublands or open canopy forest.
- Natural growth. Many fields which were desolated and aren't cultivated any more as a consequence have naturally transformed into shrubland or forest.

2 INTRODUCTION TO THE PROBLEM

2.1 Reasons for urban growth in Moscow region

Moscow oblast is the region of Russian Federation. According to 2002 census its resident population is 7–7,5 million citizens. The Russian capital - City of Moscow - is another region of Russian Federation. The city is located in the centre of Moscow oblast. Official population in Moscow is about 11 million citizens, however in fact more than 14 million people are living permanently in the largest city of Eastern Europe. City of Moscow together with Moscow oblast form Moscow metropolitan area that accumulates 15 % of Russia's population and about 25% of its GDP.

At the beginning of XX century Moscow region had about 1 million of rural and about 3 millions of urban population. 100 years later this region has the same 1 million rural population and about 17-18 millions of urban population.

City of Moscow has a form of ellipsis with own diameter about 35-40 kilometres. All the territories outside Moscow adjacent to main radial highways and railroads are connected in a continuous agglomeration 30-50

kilometres wide around city's border – Moscow Ring AutoRoad (MCAD) and form the largest metropolitan area in Europe.

Reasons for agglomeration growth:

- Moscow attracts new citizens from all over Russian Federation and former USSR countries by workplaces with high salaries and prospects to make a career. Being the capital of USSR Moscow also was very attractive for everybody but the state had put strong restrictions on the population growth in the capital city. Restrictions for living in Moscow are still working. It is a special kind of registration in Russia called «propiska».
- Extremely high housing prices and lack of free sites for civil construction in Moscow. As a result civil construction in Moscow oblast have become more profitable for investors.
- Natural environment together with possibilities for distant working raise the value of Moscow oblast as a place for permanent living for rich and middle classes of Moscow citizens.

2.2 Land use changes in rural lands

More important reason for agglomeration growth –changes in landuse legislation. When in 1990-s the Soviet period of Russian history had ended there were no private property and the territory of Moscow State region was divided into four land categories: 1) forest lands 2) agricultural lands 3) military or special territories 4) urban lands.

At the beginning of private property period the principal of preservation of agricultural lands and forests was declared. Until 2002 any changes of agricultural and forest lands into the other types of lands were prohibited by law. Since 2002 transformation of agricultural lands into the other types of lands (urban or industrial) became possible in accordance with urban planning documentation. The process of transforming of agricultural land plots into the other type is very difficult as the landowner or municipality have to prove the preferences of non agricultural usage of every plot. This is one side of the problem. On the other side, industrial and population growth require more and more lands for new settlements.

In 90-s post soviet collective farms' (kolhoz) lands were distributed among former kolhoz members in the form of "land shares". During last 10 years shares were consolidated by investors and collective farms were transformed into joint stock ventures owned by financial companies. List of most valuable landowners in Moscow oblast you can find on website <http://www.ezem.ru/info/uchast/1235563115/>. New owners have various ideas of using their land property for recreation, logistic, warehouse and housing purposes and very few of them consider possibilities for agricultural use.

2.3 Example of "new city" project

In 2007-2008 more than a dozen of new satellite cities projects were designed for Moscow oblast. "New cities" have various projected population – from 40 up to 500 thousand people, and diverse locations both close to Moscow border and 50-70 km far from the centre of metropolitan area. All cities were projected on agricultural lands.

Those projects developed before crisis came do not represent the whole process. Numerous investment companies – owners of agricultural lands on frontier territories of Moscow oblast and neighboring Ryazan, Kaluga and Tula oblast's haven't transformed their rural development ideas into designs yet.

One of the projects – City of new Stupino – was designed for a 1200 hectares land plots located 70 km to the south of Moscow. At first the project of new city with the population of 60000 people was designed by Canadians (Hopewell residential communities). Economics of the project was evaluated by Ernst & Young.

Project was redesigned by NIPI of Urban planning (Moscow) and finally both projects were combined by architectural group ADEC (Moscow). The work was completed in September 2008.



Fig. 1: Location of land parcels in rural surroundings and the project of New Stupino, designed by ADEC

The project represents the typical approach of pre-crises land development. Probability of implementation of such kind of projects in current circumstances is very low. However, the tendency of transformation agricultural lands into living areas is still of present interest in Moscow oblast.

2.4 Tasks of the study

Understanding necessity of evaluating current tendencies and probable consequences of land transformation processes the Government of Moscow oblast formulates following questions as a task for our study:

- How the territories that may be used for agricultural production were changing since 1990?
- What are the territories that are really uses for agricultural production now?
- What are the territories that were irrevocably lost for agricultural production?

3 ANALIZING AND CLASSIFYING SPACE IMAGES. CHANGE DETECTION OF AGRICULTURAL LANDS FOR THE 1991-2007 PERIOD

3.1 Agriculture in Moscow oblast

According to the information from Moscow oblast' government approximately 40% of it's territory is used for agricultural purposes. The northern, western and eastern frontiers are the least involved in agriculture. In the southern part of the region, especially to the south of the Oka river, 60 % of the territory are used in agriculture. Agriculture tends to have suburban specialization. Plant growing is developed in the southern part of the region. The most part of cultivation area (more than 3/5) is occupied by fodder crops. Considerable areas are occupied by grain crops such as wheat, barley, oats and rye. Potato growing also plays an important role. Greenhouse vegetable growing is widespread, for example in town Moskovskiy the largest greenhouse complex in Europe is situated. Plants and mushrooms are also planted. Livestock sector prevails over plant growing by the volume of gross output and it is mostly directed to meat and dairy production. Except cattle chickens and pigs are bred.

Geographically Moscow oblast is situated in the zone of risky farming.

3.2 Theoretical background of agricultural lands detection on the base of remote sensing data

Agricultural lands in Moscow oblast are mostly used for plant growing. Gardening takes place only on the lands of gardening cooperative.

As a consequence the most part of agricultural lands are occupied by cultivated plants which have their special rates of absorption and reflection in different parts of the spectrum. In the red spectral band (0,6 – 0,7 mcm) lies the maximum of solar radiation absorption performed by chlorophyll of vascular plants. In infra-red spectrum lies the maximum of reflection performed by cellular construction of a leaf. High photosynthetic activity (which is usually connected with dense vegetation) leads to less reflection in the red spectral band and more reflection in the infra-red.

Besides that vascular plants usually have more green biomass with especially high water saturation which allows to distinguish them from plants with natural vegetation cycle using another spectral channels located in near and middle infra-red band.

3.3 Identification of different types of territory using combinations of spectral channels

In this study archive data from satellites Landsat 5 TM / Landsat 7 ETM+ were used for analysis. Images from satellites ASTER, IRS 1C/1D, IRS P-6, SPOT 2/4, MODIS were used as supplementary data.

Two coverages of Moscow region were collected. Landsat 5 TM data for the period of 1988-1993 were analyzed for identification of initial state of the territory and Landsat 5/7 TM/ETM+ data for the period of 2005-2007 were analyzed for identification of it's contemporary state.

The buffer zones around roads, railroads, water objects and settlements were prior excluded. The accuracy of space images was 30 meters per pixel and the accuracy of classification was accepted to 2-4 hectares. The classification of 2005-2007 was made more accurate by using space images of IRS 1C/1D/P-6 sensors reduced to 6 meters per pixel.

3.3.1 Principles of identification of the territories used for agricultural purposes.

During image processing every pixel of the image was rated as one of model subclasses. According to the results of processing the analysis of pixel contiguity was made. After it pixels were combined into areas with similar spectral characteristics. Using combining and generalization these areas were reduced to the one of model classes as of 1991 and 2007 years. Each area was analyzed in order to correlate it with one of model classes at the beginning and in the end of the specified period to identify if that territory was used for agricultural purposes. Identification of agricultural lands' borders changes was made in the same way.

Following model classes were distinguished:

1. Water – water objects and wet dark forests which can't be distinguished from them
2. Forest – areas covered with forests
3. Bush - bushes or perennial herbs
4. Urban_High – dense stone building of populated points or industrial and warehouse territories
5. Urban_Low – rural scarce building where the area of green spaces is much more than the area occupied by buildings.
6. Agr – agricultural vegetation
7. Ground –territories of open soil. They include arable lands and less territories of open pits, construction sites etc.
8. PPA (Populated areas) – territories inside settlement borders not covered with buildings. This class also includes highways and main railroads.

Geological, soil and climatic conditions allow to use the whole territory of Moscow oblast for agricultural purposes. It means that only the territories which are not suitable for agriculture can't be used for agricultural purposes.

All areas were finally referred to one of three metagroups:

1. Territory used for agricultural purposes or suitable for agriculture.
2. Territory which is not suitable for agricultural purposes, that include following land categories:
 - Water objects of all classes
 - Swamps and peatbogs
 - Forests
 - Small glades in forest far from forest border
 - bushes or perennial herbs
 - Urban territories
 - Gardening cooperatives

- Open pits and dumps
- Paved roads, railroads
- Territories of airports
- Green spaces in settlements
- Vegetation on wetlands.

3. Territories which are difficult or impossible to refer to one of the previous metagrops by results of the remote sensing data analysis. For example it may be fields which has not been used in agriculture for 4-5 years. After this period natural meadow vegetation has similar spectral characteristics with not irrigated fields or haying meadows. After 5-7 years such fields begin to overgrow with shrub vegetation and their spectral characteristics begin to change. Also similar spectral properties have dense natural vegetation along river banks or another water objects with dense cultivated vegetation, corn for example.

3.3.2 Results of the analysis

Main characteristics of Moscow oblast's territory in 1991:

- the area of the whole territory without city of Moscow area was 45 740 km²
- the area occupied by railroads and paved highways – 900 km²
- the area of settlements – about 5100 km²
- the area of forests - 22540 km²
- the area of water objects, swamps - 2500 km²
- Other territories which are not suitable for agriculture form about 12%-15% of the left Moscow oblast's territory.
- Territories suitable for agriculture and occupied by grass vegetation or arable lands – about 12 300 km² that was 27% of the whole area.

Changes detected by 2007:

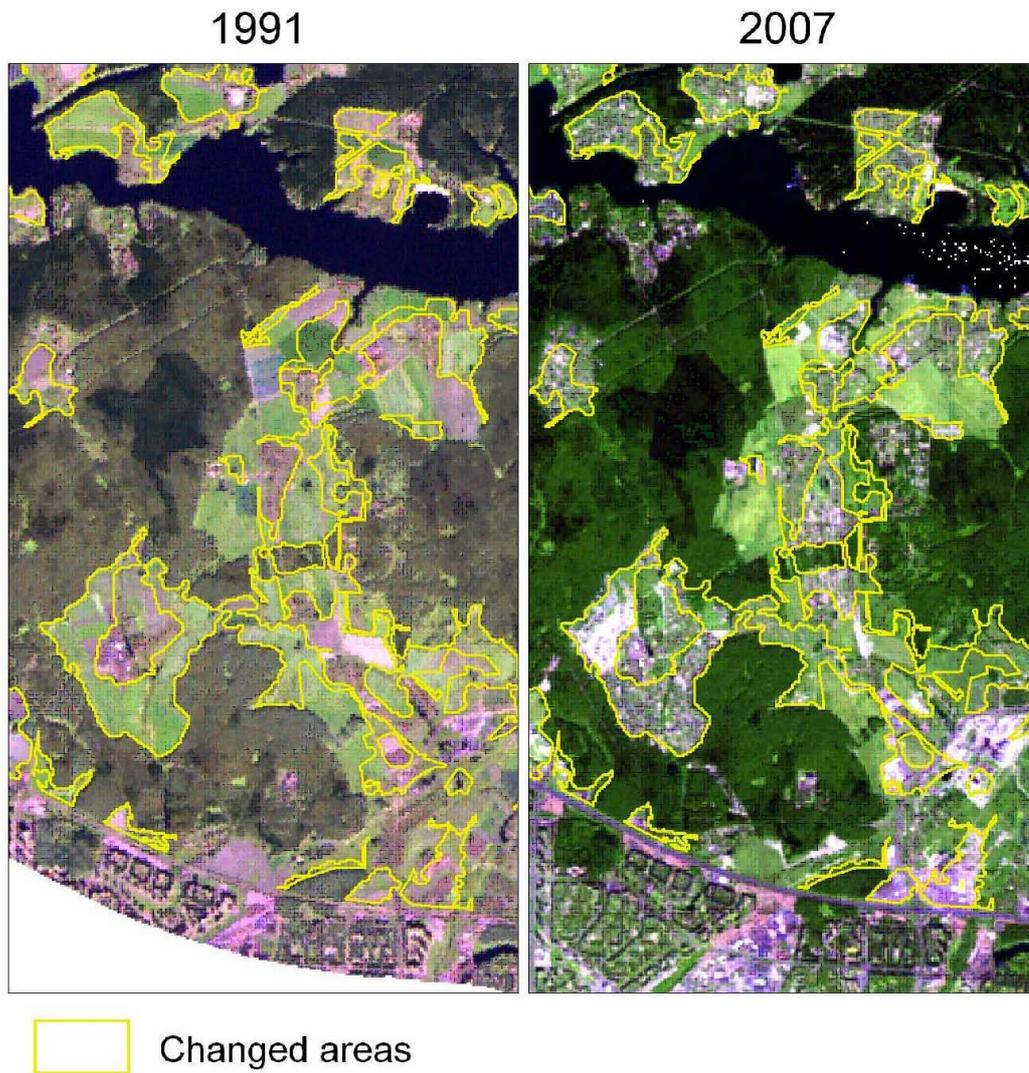
- Moscow oblast's area hadn't changed;
- the area of highways and railroads had increased by 10% because of broadening and reconstruction. The number of roads hasn't changed considerably;
- the area of forests had decreased by 10% generally because of appearance of new glades inside the forest. In some districts of the region the area of shrublands had increased. In some cases areas of herbaceous vegetation appeared on the place of forests;
- the area of water objects almost hadn't changed. In some cases new ponds had appeared but their area is less than 0,1% of the total area of water objects. Since 1991 a part of peatbogs's area had been used by gardening cooperatives;
- the area of other territories which are not suitable for agriculture almost hadn't changed.

During the period from 1991 till 2007 areas of lands suitable for agriculture were decreasing in two different ways – urbanization (90% of changes) and naturalization (10%):

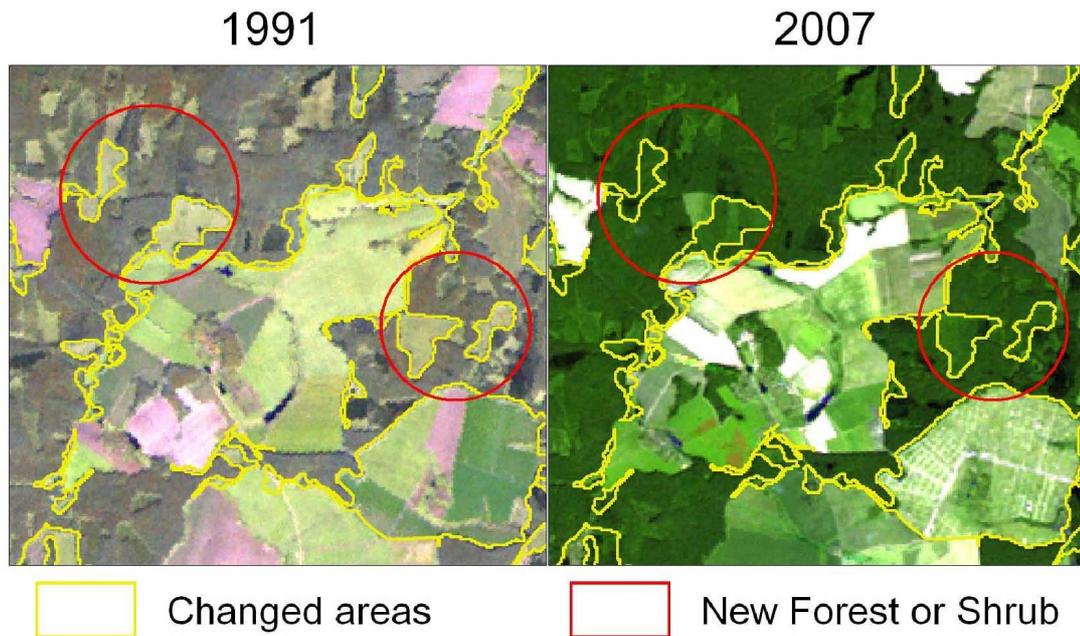
1. The area of lands suitable for agriculture had generally reduced in favour of urbanized territories in the following way:

- lands within borders of main oblast' cities (with more than 80 thousand citizens) like Podol'sk, Domodedovo, Balashikha, Khimki etc. have decreased by 30-60%.
- lands on territories neighboring to Moscow (in a radius of 3-8 km from MCAD) had decreased by 30-90%. Lands of Krasnogorskiy and Lyuberetskiy districts almost entirely were occupied by new urbanized territories
- 10-15% of lands in a radius of 10-20 km from Moscow border were occupied by new urbanized territories.
- 15-60% of lands adjacent to main lakes and reservoirs in a radius of 2-5 km were occupied by urbanized territories.

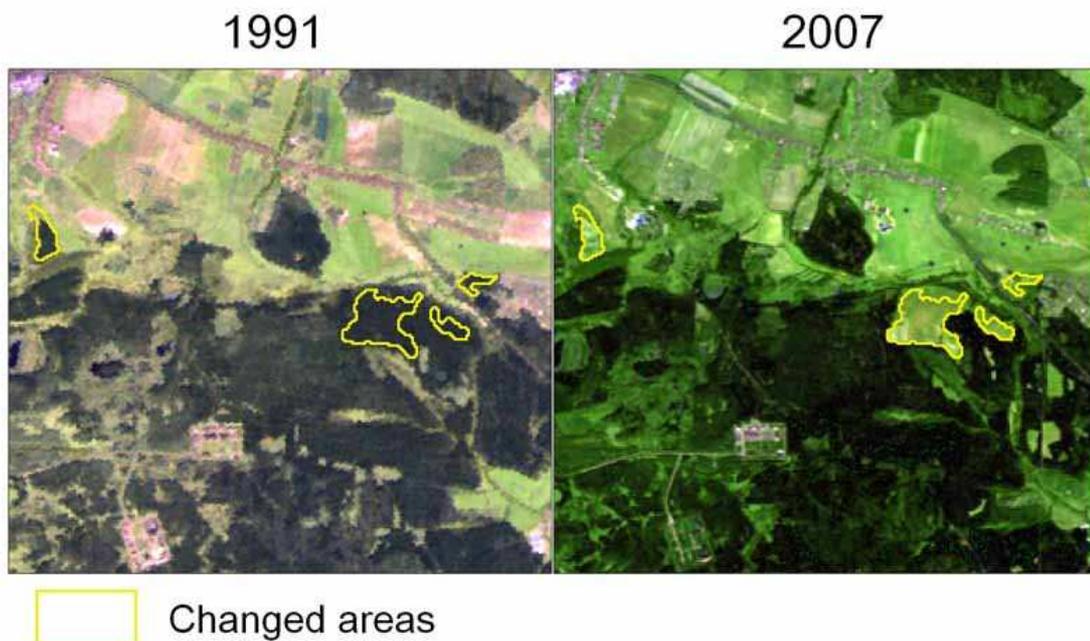
- in the rest of Moscow oblast the area of lands used for agricultural purposes has decreased 5-7% because of appearance of new urbanized territories. In some districts area of lands suitable for agriculture has even increased as a consequence of cutting down forested territories.



2. Some of areas suitable for agriculture have naturalized to forest or shrub:



In some districts area of lands suitable for agriculture has even increased because of cutting down forested territories:



4 CONCLUSION

One of the most important results of the study was that we finally have identified contemporary area of agricultural lands in Moscow oblast. It decreases 21% comparably year 1991 and is about 9 950 km²

As we analyse detected changes, we have discovered three main ways of changing of agricultural lands:

- Urbanisation. The 30-50 kilometers wide area around Moscow was radically transformed into urban territory.
- New agricultural territories. New territories that can be used as arable lands appeared on the place of shrublands or open canopy forest.
- Natural growth. Many fields which were desolated and aren't cultivated any more as a consequence have naturally transformed into shrubland or forest.