

LAND USE/COVER CHANGE IN RUSSIA WITHIN THE CONTEXT OF GLOBAL CHALLENGES

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Land use/Cover Change in Russia within the context of global challenges. The paper presents the results of a research project on Land Use/Cover Change (LUCC) in Russia in relations with global problems (climate change, environment and biodiversity degradation). The research was carried out at the Faculty of Geography, Moscow State University on the basis of the combination of remote sensing and in-field data of different spatial and temporal resolution. The original methodology of present-day landscape interpretation for land cover change study has been used. In Russia the major driver of land use/land cover change is agriculture. About twenty years ago the reforms of Russian agriculture were started. Agricultural lands in many regions were dramatically impacted by changed management practices, resulted in accelerated erosion and reduced biodiversity. Between the natural factors that shape agriculture in Russia, climate is the most important one. The study of long-term and short-term LUCC dynamics permits the analysis of the present status and trends of evolution of natural and anthropogenic landscapes. A feasibility study had been undertaken for scale-dependent landscapes applications and study of land cover dynamics under ongoing changes in Russia.

1. STUDY AREA

1.1. Land use structure in Russia

The structure of lands in Russia (total area 1,720.8 mill. ha) has a significant geographical diversity: most of the country is located in the forest and tundra zones and considered at high-risk for agricultural development (permafrost, insufficient growing degree days and much moisture) (Fig. 1).

The forests occupy about half (46%) of the country territory. The large areas of the original forests are located in the northern part of European Russia, the south of the boreal zone in Siberia, and in the southern part of the Russian Far East (RFE). Conifers represent the dominant forest type (larch, pine and spruce). The current state of the forests is characterized by the decreasing of the share of coniferous species and relative increase of less valuable small-leaved species. A considerable area is covered by oligotrophic marshes that are absolutely dominant in the northern regions. Water bodies (4.2% of the country) include lakes, rivers, streams and man-made reservoirs. Reindeer pastures are located mostly in East Siberia and RFE (30% of all reindeer pastures in Russia are concentrated in the Sakha Republic, Yakutia). A considerable part of reindeer pastures continues to deteriorate, mainly through overgrazing, fires and technogenic contamination. Built-up lands have maximum expansion in the Central European region (4.8%). The lands damaged by human activity are that under mining work, geological prospecting, etc. The largest such areas are situated in the Ural region, Western Siberia and in the Far East. Agricultural lands occupy 13% of total country area.

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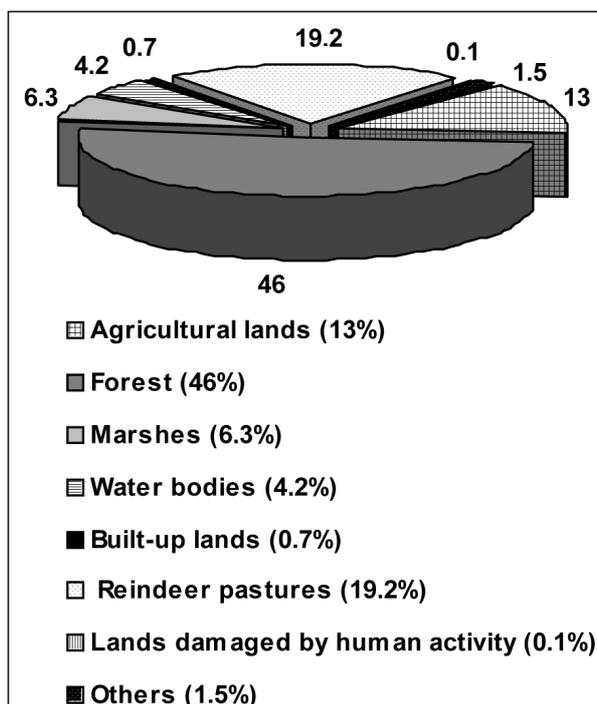


Fig. 1 – Land use structure in Russia.

1.2. Agriculture as major driver of land cover and biodiversity change

a) *Agricultural lands*

According to the Russian Federal Land Register Service, more than 220 million ha, that is close to 13% of the total territory of the Russian Federation, are designated for agricultural use. Approximately 53% of the agricultural area (7% of the Russian territory) is used for growing grain crops (average yield 2.15 tons/ha) and is divided between winter (30%) and spring (70%) crop varieties. Winter crops usually have higher yields, up to 40% of the total grain harvested in Russia. The climate of wheat growing regions resembles that of Canada, the United States, and Argentina, with smaller yield, which trails Canada's by about 10%. Other important crops include sugar beet, flax, sunflower, potatoes, and vegetables, feed roots, grass and legumes, and fruits. The yield of potatoes, sugar beet and feed crops by far lower than in North America than for grains. Better management and improved technology might result in a modest yield increase, higher efficiency, reduced post-harvest losses, bringing significant economic gains.

The structure of agricultural lands presents significant geographical differentiations. In the northern and north-eastern part of the country, the agriculture (primarily grasses and cereals for fodder) is limited by permafrost and insufficient growing degree days. In the south, agriculture is limited by arid and semi-arid climatic conditions. The best agricultural lands in Russia are located in the steppe zone, inside a 1,500 km wide zone south of 55°33' N latitude, between the broad-leaf forested landscapes (oak-lime and pine forests) and the semi-desert zone, extending farther south in Kazakhstan and Mongolia (Fig. 2). Between these two areas of limited or no agricultural use, grain crops prevail in the forest-steppe and steppe zones, with increasing share of land under cash crops, such as sugar beet and sunflower along the north-south gradient. In the RFE region significant areas are cultivated with soy beans.

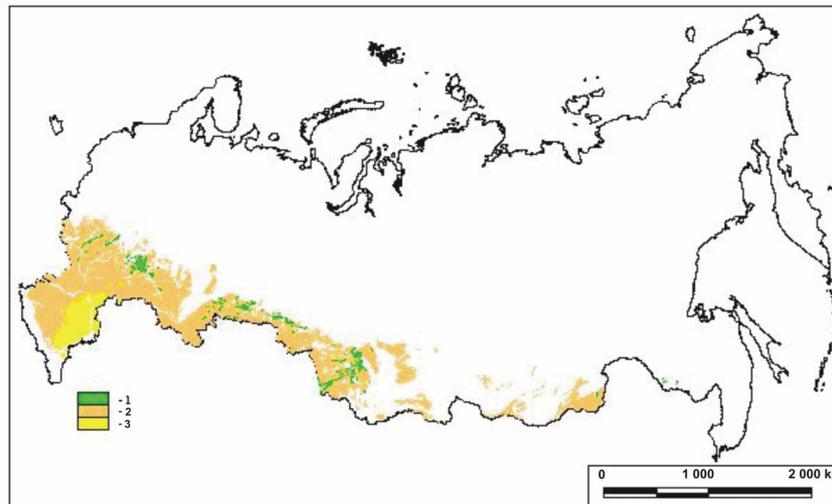


Fig. 2 – The steppe and forest-steppe zones in Russia.
1. forest-steppe; 2. typical steppe; 3. steppe/semidesert.

According to physical geography, a steppe (temperate grassland) is generally treeless plain (apart from those near rivers and lakes). In West Siberia, the steppe zone is much narrower and generally represented by forest-steppe stripe. In Central and East Siberia, the steppes are situated mostly in montaine depressions and on the lower part of slopes.

The world's largest steppe zone in Eurasia extends over the lower regions of the Danube and in a broad belt over the South and Southeastern European and Central Asian Russia, stretching eastwards to the Altai and southwards to the Transbaikal and Manchurian plains. The term is sometimes applied to the corresponding temperate grasslands of Hungary (Puszta), the prairies of the United States, the pampas of South America, and the high veld of South Africa.

The steppe is similar to a prairie, although a prairie is generally considered as being dominated by tall grasses, while short grasses are said to be normal in the steppe. The term is also used to denote the climate of regions too dry to support a forest, but not dry enough to be a desert. The climate of mid-latitude steppes features hot summers and cold winters, averaging 250–500 mm of rain or the equivalent in snowfall per year.

The agricultural belt of steppes plays an important food supplier in Russia. More than 40% of the agricultural production is produced in the steppe zone of the country where more than 30% of the agricultural population is concentrated. As a result of human activity, especially in the 20th century, they steppes irrevocably lost in many areas. During the last 25–30 years the steppe landscapes have been degrading (for example, only in Saratov oblast humus losses are of 30% – 50%). Ploughed lands are abandoned or turned into grazing lands. There are only fragments of the steppe vegetation and they occur mostly in territories unsuitable for development. Only in natural reserves (*zapovednik*) the biodiversity of steppe landscapes is under conservation.

Along the north-south transect, the steppe zone changes from forest-steppe in the north to typical steppe subzone in the south. In the forest-steppe, tree stands alternate with open grasslands. In the European part of the country, these tree stands are represented by oak and other broad-leaf species, but nowadays they are largely cleared for agriculture. In the west of Siberia, the forest-steppe with birch and aspen is a common occurrence.

Farther south, the forest-steppe is replaced by steppe grasslands on fertile chernozem soils. Here, the annual amount of precipitation is 250–400 mm vs. 400–500 mm in the forest-steppe. Smaller precipitation limits the tree species to forested ravines and valleys. Originally, the steppe subzone was

almost exclusively used for grazing, however currently tillable lands are almost entirely under cultivation. On non-tillable lands, especially those in the Caspian Sea area, the annual amount of precipitation is less than 250 mm, the area being rather similar to semideserts. These lands have a limited use for grazing: even though the soils are relatively fertile under irrigation, the total irrigated area being less than 5% of the total agricultural area of Russia. Water shortage is the dominant factor, limiting irrigation in the country as the rivers of the southern slope have already exhausted their water reserves.

Until the 18th century, agriculture in Russia was limited to the forest zone. Agricultural practices in the forest zone demanded extraordinary efforts from the peasants providing very limited and highly variable yields due to the short growth seasons. An acceptable yield could be guaranteed only if sufficiently fertilized with cattle manure which, in turn, required a sizable livestock. On the other hand, the extremely long (over 200 days cold period) would have demanded a sizable amount of silage for cattle overwintering. This fatal correlation between yield and forage had not been resolved until Russian peasants started to relocate into the rich chernozem soil lands of the forest-steppe and steppe zones.

b) Land use policy

Reforming Russian agriculture began in 1991–1993 with the changing of property rights. Up until that time, the land had been under federal ownership; now the farmers received a partial ownership, however, little change in land use followed: similar to the Soviet practice, Russia's agriculture is still dominated by the former collective farms. Relatively a small part of the land was granted to individual farmers and that changed significantly. Agricultural production on individual plots of land is considerably higher than in collective farms. Even though the total agricultural area individually owned is only 13 to 24% (depending on crop), its contribution to agricultural production is disproportional higher. Frequently, property rights for farmland are being acquired (usually through leasing) by large investors, such as the oil companies or banks. During the denationalization process, lands (usually grasslands and ranges) were also allotted to municipal entities and are owned by rural administrations. In total, 62% of agricultural lands are either in private or municipal property.

Two laws regulate the use of agricultural lands. In 2001, the new Land Code came into force. The Land Code regulates the transfer of state-owned lands to private property; however, its applicability to agricultural lands is limited. A separate Federal Law on the Circulation of Agricultural Lands was adopted in 2002. The Law regulates the ownership, usage, and purpose of land designated for agricultural use. The Law limits the use of agricultural lands only for agricultural production.

The transformation of the Russian society and economy over the past fifteen years brought significant changes in land use, especially in the agricultural belt of steppes. The cropped area has decreased for all food crops, with the exception of potatoes and vegetables; the latter are grown mostly on individual farm land. Among cash crops, the area cultivated with sunflower has increased significantly, replacing sugar beet and cereals. The collapse of livestock production has reduced the fodder area, especially where dairy farming is a traditional occupation. The areas with marginal agriculture and those specializing in sheep breeding experienced little decline of grasslands and ranges. Considerable arable areas were abandoned or left for grazing due to land degradation (e.g., up to 50% of the soil humus is lost in some areas), impacting biodiversity and leading to rural depopulation (Milanova 2005). This land cover and land use change in the agricultural regions of the forest-steppe and steppe vegetation zones are usually driven by extensive farming (e.g., up to 90% of lands in some areas are converted to crop production), industry (such as hydropower plants on lowland rivers), and by urban sprawl. Furthermore, these drivers are steered by the social and economic transition: changes in ownership, stagnation of agriculture, re-industrialization, infrastructure development, and others.

c) Agriculture and biodiversity

The steppes are characterized by a high level of biodiversity which considerably decreases (from 1,400 to 400 plant species) from west to east and from north to south.

Agricultural intensification creates new threats to biodiversity. That includes plowing of all tillable lands, which increases the rate of soil erosion, overgrazing, which increases pasture degradation, landscape fragmentation by fields and infrastructure, etc. Degradation affects more than 70% of agricultural land in some regions of European Russia, such as Chernozem region in south-central Russia, Volga region, Kalmukia Black Lands, and the plains of North Caucasus. In the Asian part of the country, land degradation is particularly severe in the Republics of Altai, Tuva and Buriatia.

On the other hand, easement programs run on agricultural lands provide an opportunity for biodiversity conservation. The role of agricultural lands in preserving steppe biodiversity is of particular importance, nearly $\frac{1}{4}$ of the entire steppe zone has already been converted into semi-natural agricultural landscapes: meadows, pastures, hay-fields, and fallow land. Many species live predominantly or exclusively on these lands. That includes more than 6,000 species of plants, about 100 species of mammals, 150–180 species of birds and thousands of species of insects and other invertebrates found in the steppe grasslands (Smelansky 2003). These and other species may be endangered if current agricultural management is changed. As an example, many species of eagle, included in the IUCN Red List of Threatened Species live in the ranges of the steppe zone of European Russia and Southern Urals; the change of land use would threaten their habitat (Smelansky 2003).

Although the monetary value of biodiversity is rarely taken into account, maintaining biodiversity is important for both agriculture and the well-being of local communities. Semi-natural and natural fodder fields in Russia represent more than 70 million ha (including 26 million ha in the steppe and forest-steppe), or 32% of all fodders, and provide more than \$2 billion in hay and other phytomass (Smelansky 2003). Another example of the economic importance of biodiversity is bee-keeping, with wild plants growing in steppe lands converted to agriculture serving as melliferous herbs. Other examples include medicinal plants, edible plants, and mushrooms. Semi-natural landscapes are also important for ensuring the preservation of plowed field fertility and self-recovery of territories. During the agricultural crisis of the 1990s, 10 million ha of agricultural land in Russia was abandoned, with the fallow area ranging from 3–4% in Rostov oblast and Altai krai to 70% in Tuva; the flow of seeds and resettlement of soil invertebrates from the adjacent natural and semi-natural lands had ensured quick recovery of these lands.

2. GLOBAL CHALLENGES AND THEIR INFLUENCE ON LAND USE IN RUSSIA

The global challenges, which have influenced land use/cover change, are well-known and include climate change, biodiversity decrease and degradation. To study climate change in Russia simulations of five different Global Circulation Models (GCMs) were used (CGCM2, CSIROmk2, ECHam4, DOE PCM, and HadCM3) for three pre-set time periods: 2020s, 2050s, and 2080s. IPCC report (IPCC 2007), combining the results of the general circulation models, placed the upper limit of the expected temperature increase within the next seven decades at more than 5°C. All climate change scenarios show a significant increase of temperature and a moderate increase of precipitation. Since the effect of global warming is even more profound at high latitudes, northern countries, like Russia, can reasonably expect even a higher temperature rise. There is no doubt that such a great impact will significantly affect the agricultural sector, but at what rate, or if negatively or positively, is still under research. The reason for that is that the effect of global warming is at least two-fold. On the one hand, higher temperatures will increase the length of the vegetation period and reduce the risks connected with spring and winter frosts. On the other hand, increasing temperature with decreasing precipitation augment the probability for summer droughts. Taking into account that the steppe zone of Russia is

the principal agricultural producer of grain for domestic and export needs, any research of climate change impacts should include changes in the risk of droughts.

In the 2020s the annual temperature is estimated to increase by 1.8°C through Russia and by 1.6°C (compared to 1961–1990 baseline temperature) in the main agricultural steppe zone. Annual precipitation increase by 32 mm on average, with small increase or decrease in the difference between potential evapotranspiration (PET) and precipitation (P), a value that provides information on moisture deficit. For the areas of high and considerable development of agriculture, there are smaller changes in temperature, yet precipitation increase is also smaller. In the 2050s, the annual temperature is simulated to rise by 3.4°C all over Russia and by 3.1°C in the main agricultural zone of the country. Precipitation increase by 14 to 65 mm i.e. by 3 to 13%, compared to the baseline climate. The increasing water deficit leads to aridization, which affects most of North Caucasus and Low Volga and threatens conventional farming. The 2080s climate simulation shows negative change to accelerate in the main agriculture zone. The annual temperature increases on average by 4.7°C in the agricultural regions (5.2°C for all over Russia). Precipitation in agricultural regions is projected to increase by 44 to 70 mm, with lower increases or a decrease even, in the most productive area in the south-European part of Russia. This results in a sharp decrease of water availability for the rain-fed agriculture of the North Caucasus, Low and Middle Volga and Chernozem regions.

3. RESEARCH METHODOLOGY

3.1. Present-day landscape approach

The landscape approach to the environment as a combination of hierarchically subordinated geosystems (present-day landscapes) was used for the realistic understanding and study of land use/land cover dynamics and changes in steppe regions. It provides a basis for the perception of the world as a system of interrelated territorial samples with different combinations and close interaction of the natural and socio-economic components (Fig. 3).

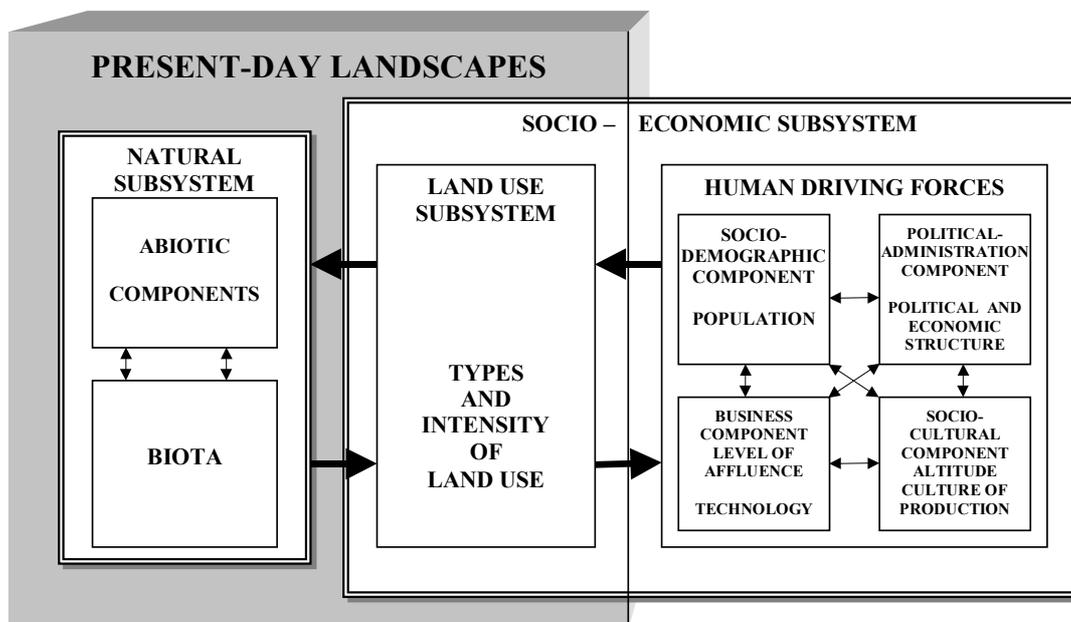


Fig. 3 – Natural and socio-economic subsystems of present-day landscapes.

The landscape analysis represents a holistic view on man-made and natural surroundings and attempts to bridge the gap between natural and human subsystems. Within the framework of Present-Day Landscape mapping it will be possible and relevant to investigate how regulatory tools at various political or administrative levels, addressing different parts of the systems, will influence the environment and how sensitive different parts of the landscape are to human driving forces as to regulatory instruments (local, regional, national, or international). The reason for the complexity of the systems needs further investigations to ensure that more simple analytical approaches will not suffice. A likely outcome is that the systems are complex due to the fact that social, economic, technical and ecological processes operate on a wide spatial and temporal scale.

Before defining and describing land-use types, initial consultations are conducted, comprising an inventory and analysis of so-called fundamental references to the socio-economic and physical situation of the land evaluation area. This is a time-consuming activity, which should be initiated in the very early stage of land evaluation.

The most important items of these fundamental references are:

- the terms of land evaluation references. In some cases preliminary land-use types relevant to the study area are given in a global description;
 - the actual situation of the region, regarding in particular actual land use, population, infrastructure, income, and technology;
 - the formal development objectives regarding ecology, economy, employment, education, research, etc.;
 - the time period for which the results of the land evaluation study are expected to remain valid.
- Land use will change in time, so that adaptation is essential;
- the socio-economic conditions of land, for instance, ownership, location, size, etc.;
 - the general physical conditions of land (scape).

3.2. Classification of Land Cover Transformation Degree

All present-day landscapes of the steppe zone in Russia have been classified into two groups, according to their degree of transformation: modal and natural/anthropogenic, the latter being further subdivided into derivative (or secondary) landscapes, landscape anthropogenic modifications and technogeneous complexes (Fig. 4).

Anthropogenic changes of land cover and land use structure in forest-steppe and steppe regions mostly are related to intensive cultivation (up to 90%), large industrial installations (hydropower stations in the Volga basin), and urban areas. Also, these regions are characterized by high mobility of the economic processes that have been taking place during the last decade in Russia, caused by political and economic transition.

Changes in ownership and industrial specialization, stagnation in agriculture, modern development of transport infrastructure – all these causing complex natural – anthropogenic transformations of the steppe landscapes.

The protection of a specific variety and a genofond of the natural steppe flora calls for most urgent decision measures.

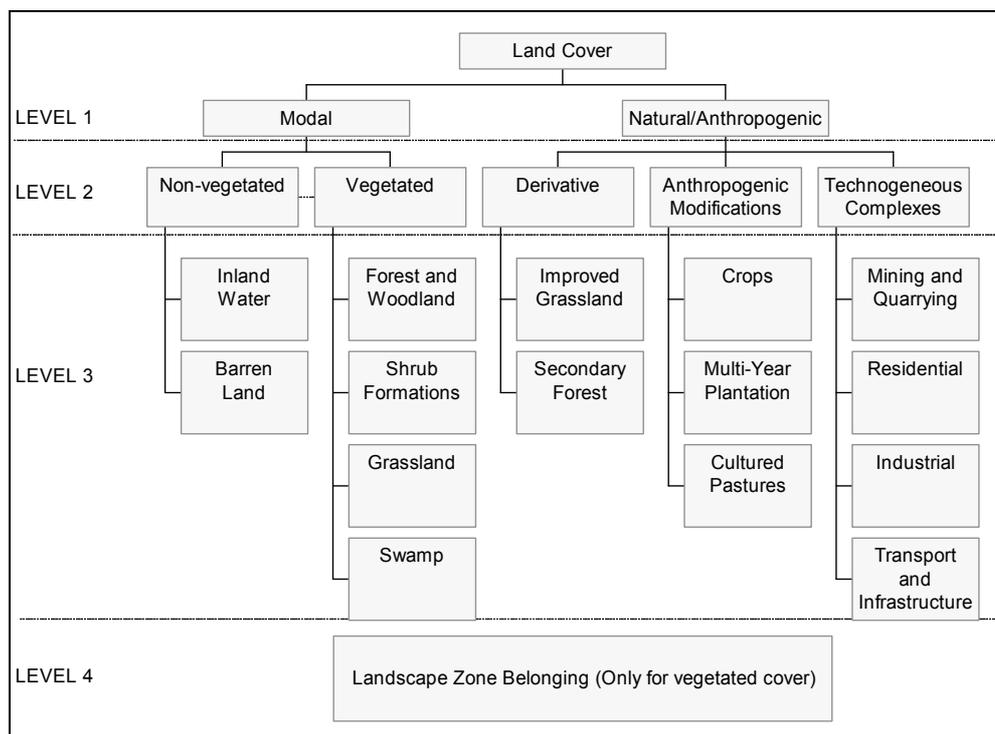


Fig. 4 – Land cover classification based on landscape approach.

4. RESULTS AND DISCUSSION

4.1. Scale-dependent land cover applications through remote sensing technique

The global level of land cover classification and mapping has been implemented by the group of researchers of the Faculty of Geography, Moscow State University – an integrative World Map of Present-Day Landscapes at the scale of 1:15,000,000 has been published in English by “Soyuzkarta” Publishers (1993). The map offers a colourful presentation of the territorial distribution of present-day landscapes in the whole World, and the degree of their transformation under the human impact. The steppe and grasslands zones are shown for different geographical belts (temperate, subtropical and tropical).

The country (macroregional) level of investigation was implemented for the whole territory of the former Soviet Union (40°–80° N, 20°–180° E). The most reliable source of NOAA-AVHRR NDVI images for continental-scale feasibility study was the Global Ecosystems Database (GED), Version 1.0 (on CD-ROM) by EPA Global Climate Research Program, NOAA/NGDC Global Change Database Program (Kineman, Ohrensall 1992). For country level research, a total of 60 images over 1986–1990 period with a 10-km resolution were obtained from the database for the territory of the whole former Soviet Union. Particular attention is given to the analysis of vegetation indices. Around 40 seasonal clusters were produced by a fine classification scenario for each of the images. These clusters were then analyzed to determine land-cover type. Experiments with present-day landscape mapping and classification made on the basis of remote sensing at this macroregional level have shown the following features of steppe natural zonal structure and its anthropogenic transformation (Milanova 1999).

The analysis of vegetation biomass seasonal dynamics, based on the 10 km resolution data set, indicates that zonal stratification of landscapes very often differs from that traditionally drawn on vegetation and landscape maps. For example, the steppe zone should be stratified according to the balance of humidity and warmth (e.g. normal humidity, dry and extra dry). These zones do not actually correspond to the generally accepted structure of vegetation and landscape zones because their differentiation is based on NDVI classification and not on the floristic characteristics of the land cover.

Preliminary experiments in this field show that human activities have changed the pattern of natural zones in many regions of Russia. In the steppe zone, the area of active anthropogenic influence were detected on the NDVI scene, is an area of intensive irrigation in steppe regions north of the Black Sea along the Dnieper and the Kuban river valleys. As far as vegetation activity is concerned, sub-humid landscapes steppe differ here greatly from the drier steppes of the Volga region and Western Siberia, although traditionally they are shown on vegetation and land cover maps as the same natural zone without further subdivision.

Regional level

Two **regional level** case studies were selected for a short-term Land Use/Cover Dynamics study in the forest–steppe and steppe zones of the European part of Russia: the Central part of European Russia (centered in Moscow) and the Middle Volga region.

Case study: Central European Russia

The Central part of the European Russia territory is situated between 33–42° E longitude and 53–60° N latitude with the center in Moscow.

Data from two different sources were used for the regional study – vegetation index data with 10-km resolution and high resolution false colour composite photographic images. Cluster classification methodology was used mainly for data analysis. The data of each of these sources give different information about the vegetation and land use pattern: vegetation index data are most efficient for the study of seasonal phenological dynamics of vegetation and space photographic images are most important when analyzing long-term vegetation and land-use trends.

The Central part of Russia was historically covered by broad-leaf forests, but long-time human impact period on the area was afforested and forests changed to arable lands, secondary small leave forests and steppes.

Two principal satellite imagery sources used for data simulation at regional level over Central Russia were: AVHRR images of 1-km resolution over the whole study-area and high and medium photographic resolution images obtained by KATE-1000, MK-4 and MKF-6 instruments on board the Russian satellites of the RESURS-F1 series and the orbital stations Soyuz and MIR (Milanova 1995). The following four images were chosen for research based on how clear they are from different artifacts and errors described above and how representative they are for seasonal vegetation phenology: April 21–30, 1992, June 1–10, 1992, September 1–10, 1992 and February 21–28, 1993. All five spectral bands were obtained for each image, as well as NDVI.

False colour photographic images offer a new approach land use / land cover classification and definition of natural and economic districts. Preliminary experiments in the Moscow region have shown that land use maps that may be produced by automatic classification of remote images differ a lot from existing vegetation and landscape maps, but at the same time, do not desert with them. New maps are much more detailed and exact in describing real land-use and landscape stratification. Different mathematical methods were used to check the results of automatic classification of remotely sensed data – coefficients, describing the spectral and spatial complexity of resulting classes will be developed and analyzed; basic methods of automatic image recognition will be implemented (if adequate technical possibilities would be available) for automatic determination of economic and natural districts.

Vegetation index data was used to delineate natural and economic landscape units at regional scale and land-use types. Each land-use type can be distinguished by a unique seasonal vegetation change. For example, territories with a high percentage of arable lands have lower vegetation index values in March than the forests, because larger areas are covered with snow. For the Center of the European part of Russia, regions of intensive agriculture may be distinguished based on this – Middle-Russian Height and so-called Vladimir's Opolye (arable land area near the city of Vladimir). Images for July – August may be used to stratify arable lands according to the type of crops (cereals are not growing any more and have values vegetation index low, potato and vegetables are still growing, etc.). Each landscape unit or land-use type has its unique vegetation index pattern that can be used for describing and analyzing. Having vegetation index images for different months of the year we may determine each of these landscape units or land use types; at the same time, having information for different years gives an opportunity to study long-term dynamics of vegetation and land use in the region. This will be used mainly for land use / land cover stratification and analysis of seasonal dynamics.

On regional scale, for the Central part of European Russia, 5 major cluster categories were first determined using 1-km seasonal vegetation activity data from AVHRR by applying unsupervised classification. By visual interpretation and analysis of attribute data and case-studies, these primary clusters were defined as follows: Water bodies, Agricultural lands, Deciduous Forests, Coniferous Forests, Non-Vegetated Areas.

A comparative analysis of land cover data from traditional and remotely sensed sources of each of these natural-anthropogenic regions, the geographical and landscape meaning of determined cluster categories was established.

Finally selected cluster categories were described as follows:

1. Water bodies;
2. Dry well-drained agricultural lands;
3. Dry well-drained secondary deciduous forests;
4. Wet poorly drained mostly coniferous forests and agricultural lands;
5. Low-vegetated urban and rural lands.

The analysis of traditional and remotely sensed data enables the determination of the following, sometimes contradictory, patterns of land use/cover dynamics: Extemporaneous recovery of forests; Anthropogenic recovery of forests; Controlled deforestation around agglomerations and transport channels; Changes in species composition of forests (through clearance of valuable wood); Urban development over agricultural lands; Waterlogging of arable and forest lands next to wetlands.

Case-study: Middle Volga Region

The map depicting the state of agricultural lands in Samara oblast was compiled using the space image received from the MSU-SK/Resurs satellite on June 18, 1998. The image was processed using Erdas-Imagine 8.2 system by the method of classification without training. The results of identifying classes by analysing their spectral curves allowed to determine the areas including agricultural lands in different stages of vegetation cover.

The Middle Volga Region is characterized by climatic variability, hence considerable fluctuations of crop yields. Recurrent draughts caused severe crop failure. One of the severest draughts occurred in 1891, crop failure causing mass starvation in several Volga Region districts. About one-third of arable lands had no crop-shoots. A region's socio-economic development trends in connection with agricultural draughts is shown on the Figure.

In 1921, failure crop effects, augmented by the political situation, resulted in millions of causalities in the Volga Region. In 1946, the whole region suffered from failure of crops caused by drought. The last severe drought in the region occurred in 1998. It had catastrophic effect on crops. About one-third of the arable lands had no crop-shoots.

4.2. Rural population change

The beginning of population decrease in post-Soviet Russia dates back to 1990 and was caused mainly by natural decrease. Since then birth rates dropped to lower levels, while mortality continued to rise.

Rural population change varies in the Russian Federation. Some regions have been faced with a dramatic decrease in rural population, while in others the number of rural residents stays at a constant level or even grows. The situation is reinforced by a continuing migration flow of rural population to cities and towns where the living standard is higher.

In a number of regions the growth of rural population during the 1989–1999 period is due to the administrative reform, whereby a large group of towns have lost their urban status. Within the territories, the growth of rural population is supported by a stable demographic situation. From the economic point of view, in these regions agriculture is much more profitable, thus keeping people from moving to the urban settlements.

CONCLUSION

Russia is a country with a transitional economy, which includes both elements of the free market and an administrative economy, inherited from socialism times. Despite the low level of agricultural specialization, a distinct difference between agriculture in forest and steppe zones is still preserved at national scale. This difference has increased during the past 15 years, when many marginal lands within the forest zone were abandoned. On the other hand, the agriculture of the steppe and forest-steppe zones in the European part of Russia received a boost from investments, including those made by the big, wealthy oil, energy, and mining companies. Aside from the political and economic reforms, bringing new investments into the regions, suitable for large-scale agriculture, climate change is likely to redefine these regions, producing large-scale land use and land cover change. The effect of climate change and global warming will be fairly deep-going, so the country can reasonably expect temperature rise and moisture deficit that will significantly affect the agricultural sector. GCM scenarios simulations show an increase in potential yield in the central and northern regions and a fall in yields, in the currently most productive southern European region of Russia due to ever more frequent droughts. It is likely that the most productive regions will have to cope with increasing crop failure by shifting their strategy from producing crops for export to local consumption. Adaptation to the new climate conditions by shifting agriculture further north will be limited by the shortage of fertile soils. Another adaptation strategy is a major increase in the irrigated area, which, however, will be limited by seasonal water shortage. Any research of climate change impacts in agriculture should include the elaboration of adaptive mechanisms: widening the drought-resistant crop area, development of water-saving technologies and irrigation (according to water resource changes).

The methodology of land use/ land cover classification based on remote sensing data, as well as collection, generalization and analyses of all currently existing data (local and regional maps, satellite imagery, detailed field observations) have allowed to produce an up-to-date land characteristics database and to study land cover/ land use structure and trends of change. The present-day landscape concept could enrich the assessment of land use/cover change and avoid the unfavourable consequences of land degradation. Different spatial levels of the LUCC study help providing an understandable presentation of the geographical distribution of areas with different LUCC trends and degree of land cover transformation.

The results of research have direct relevance to land management and nature conservation, and can help to elaborate recommendations for a rational land-use strategy in Russia. The mapping, monitoring and modelling of land cover / land use in such a vast territory as Russia could also contribute to the study of global environmental change.

REFERENCES

- Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Kineman, J.J., Ohrensall, M.A. (1992), *Global Ecosystems Database. Version 1.0 (on CD-ROM)*. Documentation Manual, EPA Global Climate Research Program, NOAA/NGDC Global Change Database Program.
- Milanova, E.V., Kushlin, A.V., Middleton, N. (eds.) (1993). *World Map of Present-day Landscapes: an explanatory note*, Soyuzkarta, Moscow, State University, United Nations Environment Programme.
- Milanova, E. V. *et al.* (1999), *Land use/land cover change in Russia: mapping and GIS, land use policy*, Elsevier Science, vol. **16**, 3, pp. 153–159.
- Milanova, E. *et al.* (2005), *Landscape approach for Land-Use/Land-cover Classification and Mapping at Different Scales*, in: *Understanding Land-Use and Land-Cover Change in Global and Regional Context*. Enfield (NH), USA, and Plymouth, UK: Science Publishers Inc., Eds. Elena Milanova, Yukio Himiyama, and Ivan Bicik, pp. 233–247.
- Smelyansky, I. (2003), *Biodiversity of Agricultural lands in Russia: Current State and Trends*, IUCN – The World Conservation Union, Moscow.

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