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Landscape Impact Assessment of the Oil and Gas Industry in the Russia using space images interpretation

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Abstract. The experience described in the article was taken in the course of developing the methodology of cumulated landscape impact assessment of the oil and gas industry using space images interpretation. It represents the information about different types of the satellite images applicability depending on the resolution, the number of spectral channels, periodicity of the survey in the purposes of the project and about the possibilities of the different natural and climatic areas impact assessment. It provides a description of the methodology of application of various types of satellite data for interpretation of identified oil and gas industry facilities (well pads, initial treatment facilities, pipeline technical corridors, flares, etc.), infrastructure (roads, borrow pits, etc.) and their direct (deforestation and oil pollution) and indirect (burnt-out forest, changes of water bodies characteristics) impact on the natural landscape. Specific examples of map generation are given for one of the oil production areas: degree of fragmentation of landscapes (by density of linear infrastructure) and pollution (identification of oil polluted areas based on the interpretation of a multispectral satellite image). Conclusions are made about applicability of the developed methodology and the way forward is described to improve the methodology. In the end the benefits are mentioned about the remote sensing imagery use in the oil and gas industry for increasing the environmental transparency and minimizing the impact on the environment.

Keywords: Remote Sensing, GIS, Pollution, Environmental Transparency.

1. Introduction

The activities of the oil and natural gas sector in Russia have had a series of negative effects on the natural landscape (Figure 1). Fires, oil spills and pipeline ruptures from systematic exploration, extraction and transportation activities have wreaked havoc on local ecosystems (Figure 2). The resulting damage has led not only to a fragmented forest landscape, but also to the disruption and erosion of local settlements that depend upon the ecosystems to sustain their communities.

The majority of research conducted in this field lacks a straightforward, accurate and comprehensive methodology. However, as more spatial information becomes available, it is now possible to objectively assess the scale of the environmental footprint of the oil and gas industry on the landscape. Satellite images have always been instrumental to specialists when conducting such assessments. As of recently, however, websites such as earth.google.com have made remote-sensing data available to a much wider audience, thus making the environmental footprint evident to anyone who is interested.

NGO "Transparent World" and R&D Center "ScanEx" with support of World Resource Institute have initiated the development of a methodology to assess the environmental footprint of the oil and gas industry on the Russian landscape using publicly available information, mostly satellite data.

Figure 1. Typical landscape in Siberian oil production area.

Figure 2. Oil polluted area in Western Siberia.

2. Methodology

Creation of the anthropogenic environmental impact maps includes two preliminary stages: mapping of the fields' industrial infrastructure and the identification of the polluted areas.

In the course of creation of the fields industrial infrastructure maps the following elements are identified: well pads, primary processing units, pumping stations, power substations, flares and flaring facilities, roads, pipelines, and other utility corridors.

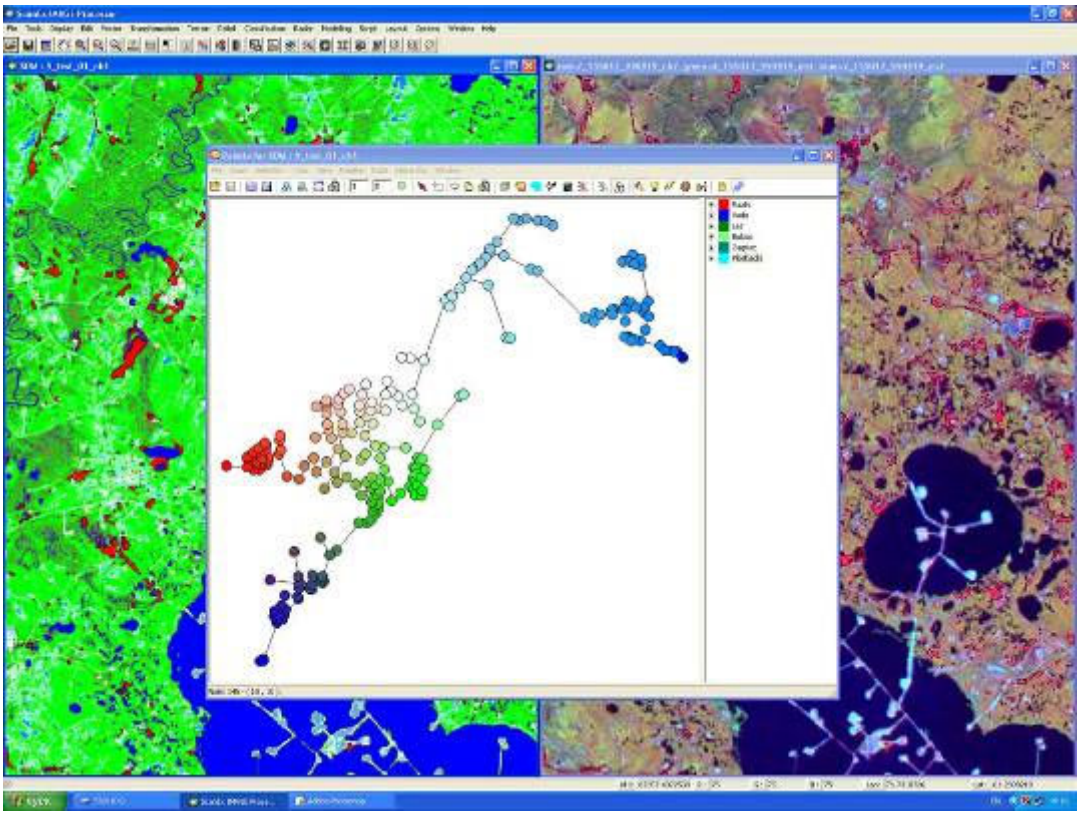

Figure 3. Image classification using Kohonen neural networks analysis algorithm implemented in programme ScanEx Image Processor.

Depending on the type of the area this stage may be conducted with application of the middle and high resolution data. Thus the complex of interpreting attributes typical for each class of objects is used. As a result of this stage the vector layers are created especially for different elements of industry facilities.

The created infrastructure map is the basis for identification of polluted areas caused by oil spills. In this case industrial facilities may be considered as potential sources of pollution. It is a well-known fact, that oil pollution slicks are difficult to distinguish in the visual area of the spectrum from small water reservoirs or wet lands. Nevertheless, the application of infrared spectrum data makes it possible to distinguish the objects with a high degree of accuracy. It is because oil and water absorb solar power in infrared areas quite differently.

A method of automated classification applying a neutral network analysis algorithm implemented in programme ScanEx Image Processor is used to identify areas of pollution (Figures 3-5) The algorithm of classification allows not only to identify the area of pollution but also to estimate the accuracy of the result. As a rule satellite data has the middle resolution as consists of middle and far infrared bands. That is why in case of necessity to

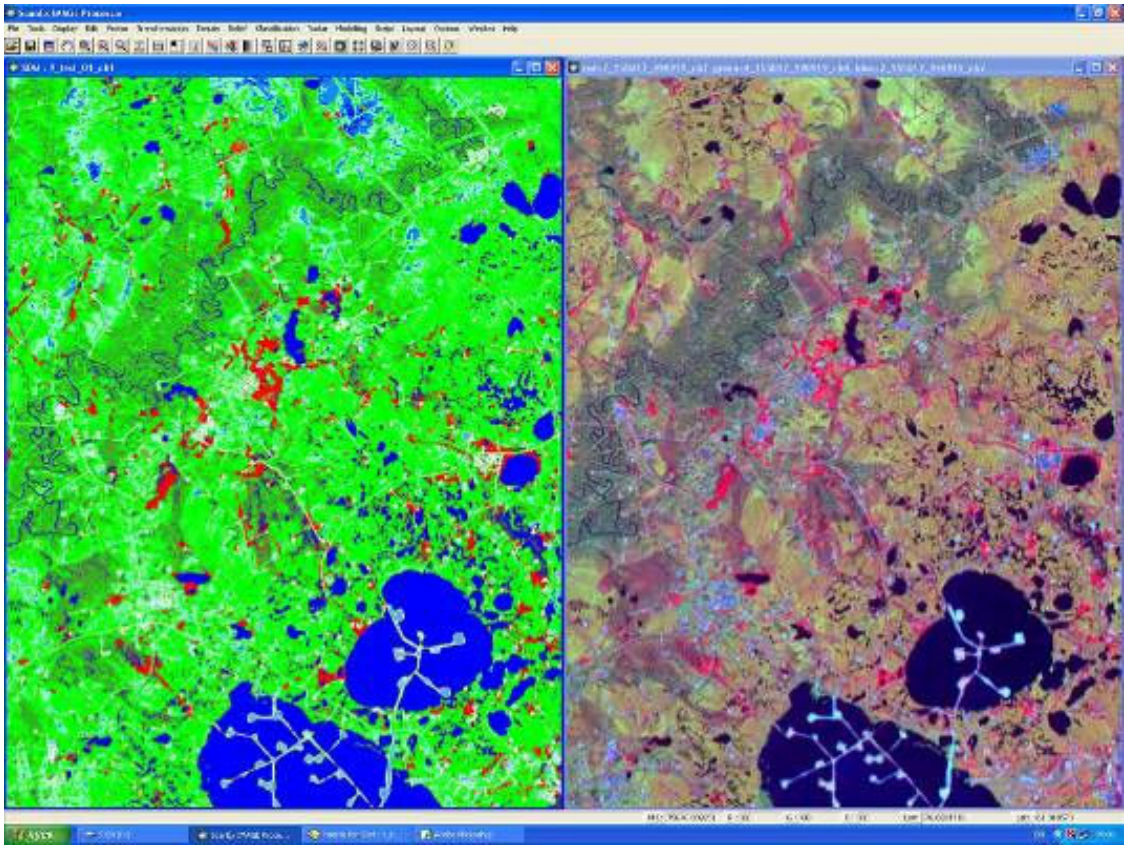

Figure 4. Comparative analysis of the results of the classification and the original image.

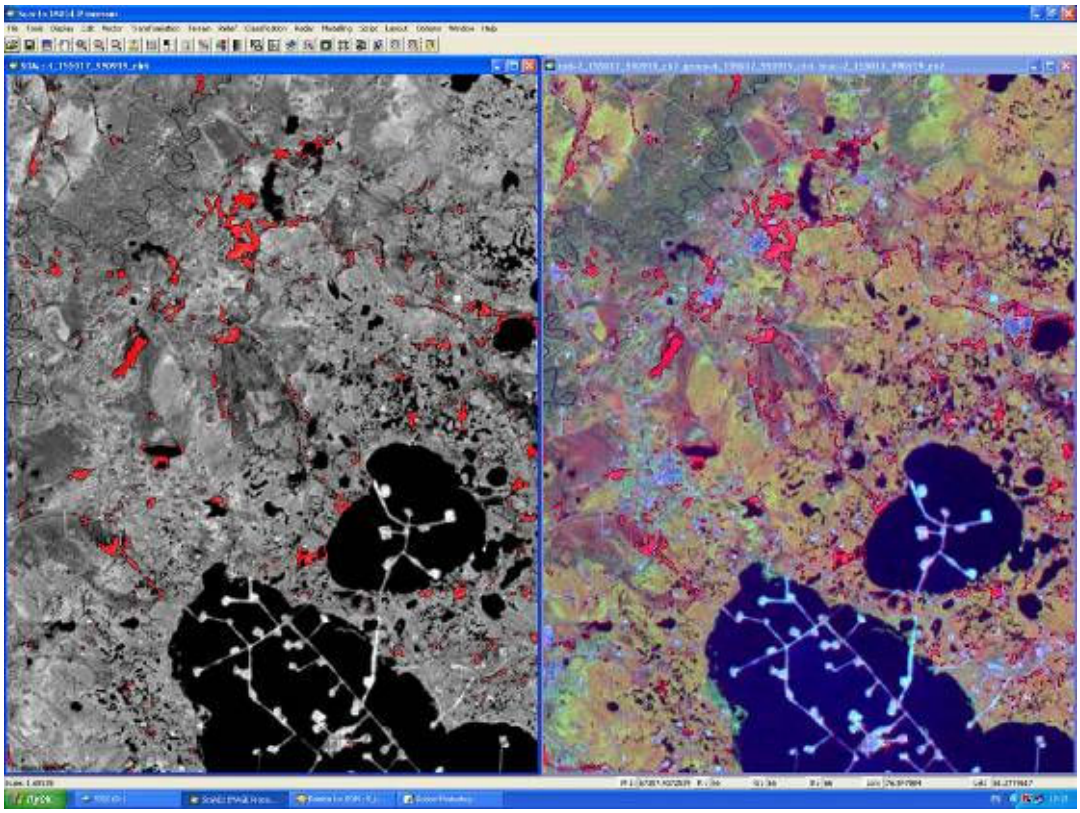

Figure 5. Vectorization of the result obtained and including it in the GIS-project of the investigated area.

obtain more detailed information about the pollution area a "two-step" algorithm of identification with high resolution data may be also applied (Figure 6).

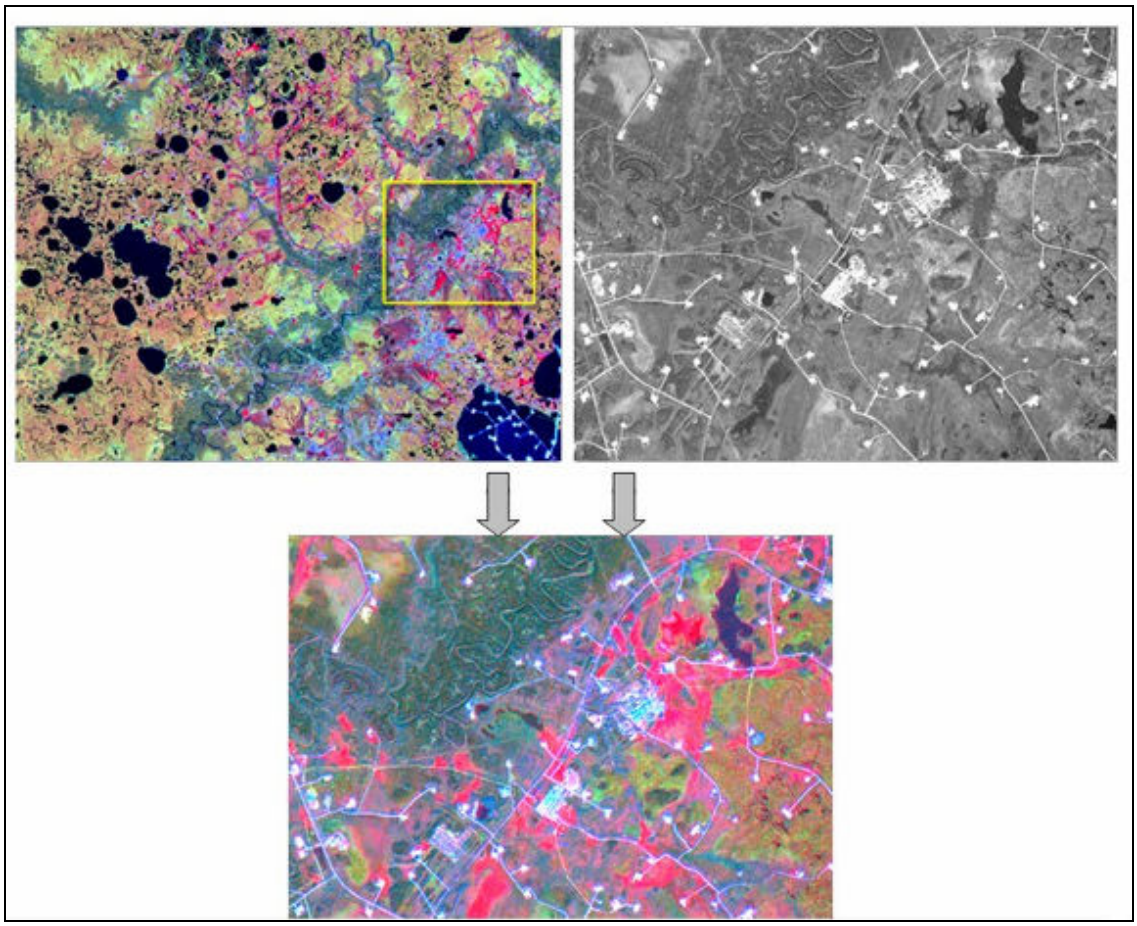

Figure 6. Creation of the merged image with resolution 5,8 m. on the basis of LANDSAT ETM (resolution 30 meters) and IRS 1D PAN (resolution 5,8 meters) images.

The maps obtained are used for the further analysis and for the anthropogenic environmental impact calculation.

3. Results and Discussion

A list of impacts by oil producing facilities on environment has been developed that can be mapped and assessed qualitatively and/or quantitatively with satellite data;

The assessment is conducted for applicability of various types of satellite data for different purposes of the project (Figure 7);

Required modifications of applied methodologies have been identified depending of natural area and the level of development of the area in question;

A methodology of assessment of areal oil and oil products pollution of the oil production territories has been developed and tested (Figures 4-5);

All the methods developed have been tested in the course of the project in various test regions – in Samotlor oil field (Western Siberia) and other oil and gas fields in Orenburg region;

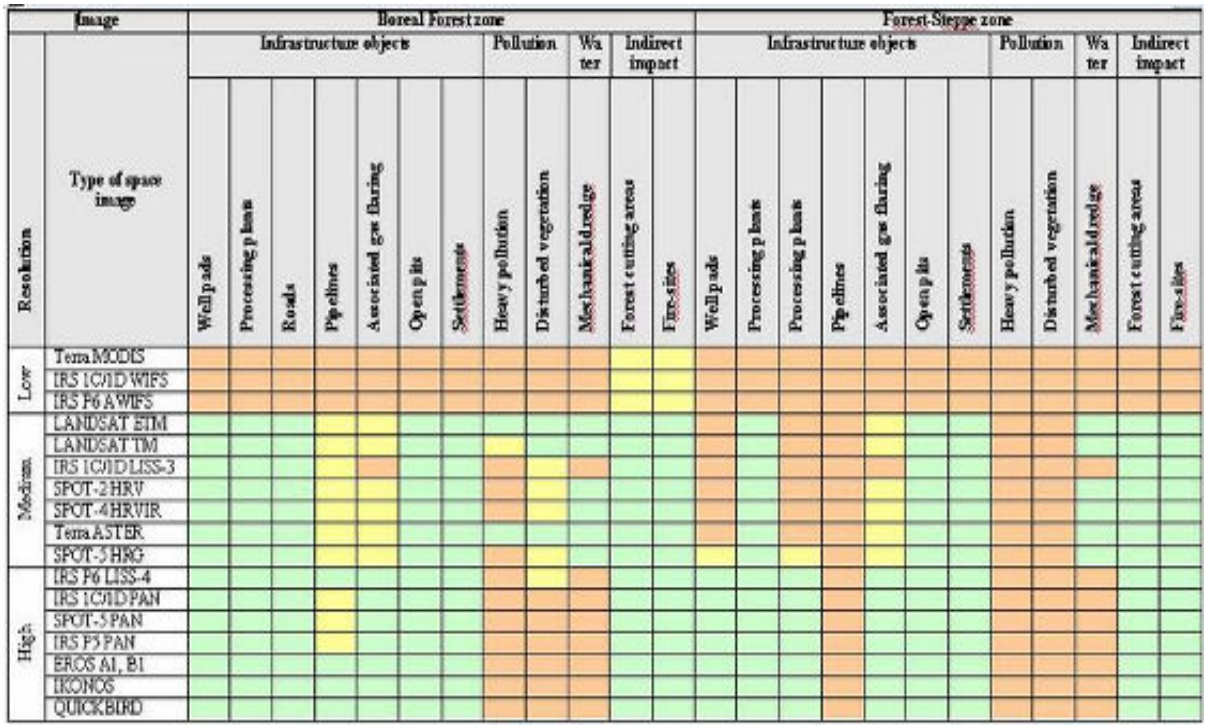

Figure 7. The applicability assessment of various types of satellite data for different purposes of the project: brown color – technical characteristics of the image don't allow meet the goal; yellow color – limited availability; green color –the image is fully applicable for the purpose in view.

The thematic negative environmental impact maps of the oil and gas industry were created on the basis of satellite imagery (Figure 8).

The work on image interpretation, selective field verification and specification of certain sections of the developed methodology was carried out mainly in forest boreal and forest-steppe zones. In the course of the project activities it was noted that the methodology definitely needs further refining in terms of its application in other regions. Thus, for the further methodology development the similar project activities should be conducted in the oil and gas industry's assets in other natural and climatic areas.

4. Conclusions

An objective analysis of the activities of the oil and gas sectors on the Russian landscape has many positive outcomes. Firstly, it sets a baseline against which future impacts can be measured. Secondly, such an assessment assists in prioritizing reclamation activities and efforts to reduce future impacts. In addition, it allows the setting of environmental performance targets (e.g. voluntary commitments). With such work, environmental transparency and social responsibility in multinational corporations currently operating in Russia will be promoted, so securing the rights of local citizens for a responsibly developed landscape.

The data and the methodic solutions obtained in the course of the project may become the important component of the industrial, corporative and public GIS, help in making decisions in the sphere of environmental protection and finally minimize the impact on the environment of the oil and gas industry.

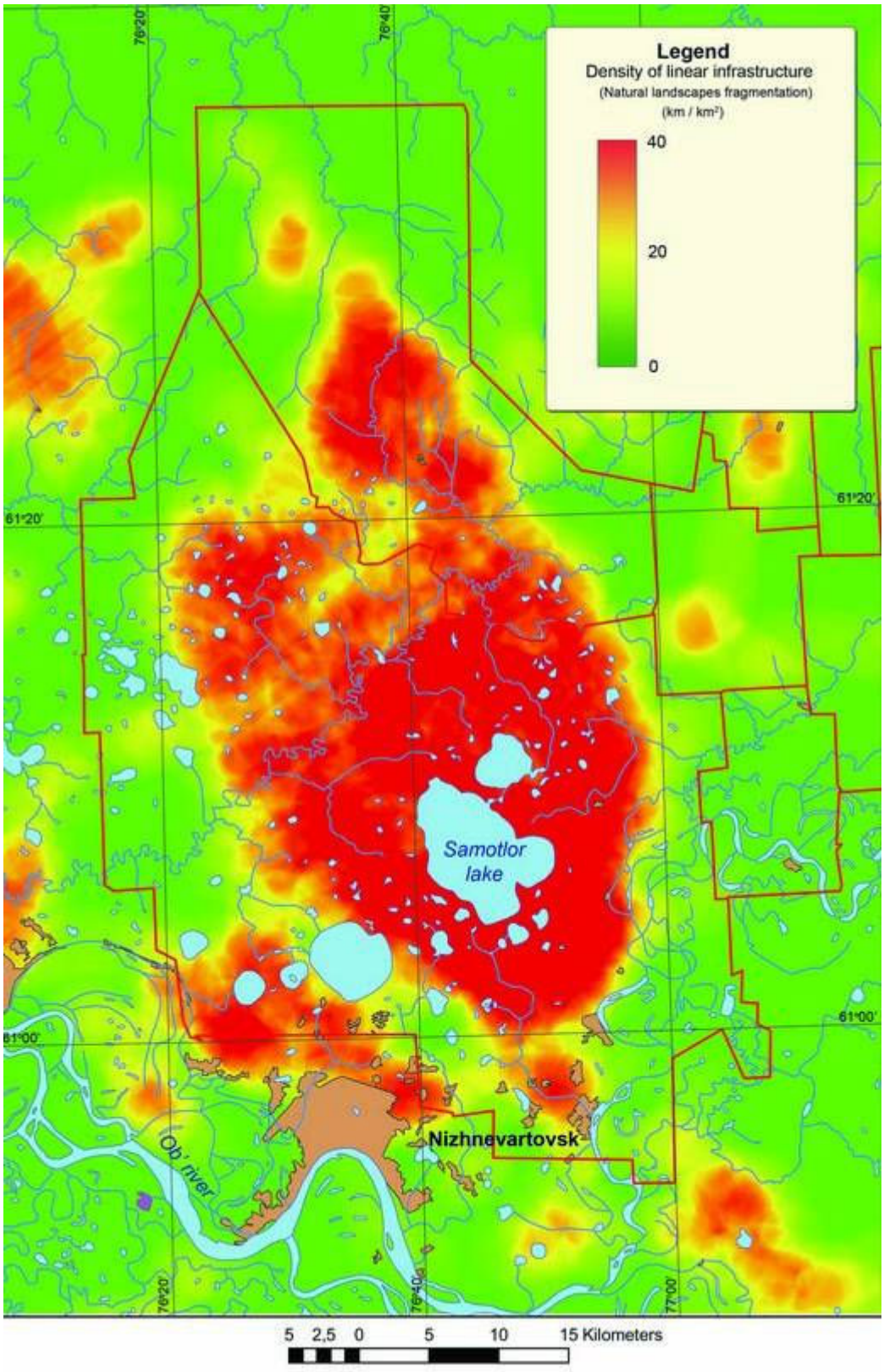

Figure 8. The density of the linear infrastructure (fragmentation of the landscape). Oil production area in Western Siberia.