Classification of restrictions on the use of lands affected by military actions

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SUMMARY

It is emphasized that geographic information systems (GIS) are one of the tools that allow processing and integrating a large volume of analytical and spatial information about land plots. It is noted that GIS can serve as a foundation for monitoring and classifying restrictions on the use of land that have been affected by military actions. A list of sources of information about land resources and land plots subjected to various negative impacts, including those resulting from military activities, is presented. Proposals for classifying information from satellite and optical images depicting the aftermath of negative impacts on land plots due to military activities are provided. Groups and subgroups of spatial analytical information that could be included in the new geographic information system of the state land cadastre are suggested. Proposed are also new types of restrictions on the use of land that have been affected by military actions.

Keywords: geographic information systems, environmental restrictions, planning restrictions, image classification
Introduction

The negative consequences of armed conflicts include the damage and destruction of infrastructure, populated cities, and territories, including land plots designated for economic and societal needs. These areas may become contaminated with hazardous substances, lose their fertility, and become unsuitable for their intended purpose and type of use. According to the Land Code of Ukraine, such areas can be characterized as technogenically polluted lands. Their restoration will require the implementation of appropriate usage restrictions. The classification of such restrictions on the use of land plots affected by armed conflicts necessitates the collection, analysis, processing, and visualization of such a vast amount of information. Geoinformation systems are one of the tools in modern conditions that allow for the processing and integration of such information with spatial data, attribute assignment, and subsequently for the model representation of the territory. The integration of spatial and analytical information related to land resources, as demonstrated by research conducted by members of the scientific community, is noteworthy (Dorosh et al., 2020a, 2020b; Dorosh et al., 2022; Malashevskyi et al., 2022; Ibatullin et al., 2023).

Method and Theory

When applying geoinformation system tools to justify the classification of restrictions on the use of land affected by armed conflicts, a spatial analysis method was employed. This method allows spatial layers associated with various analytical information about the land plot to be combined with each other to obtain new insights about the research subject. This allows assessing the areas of negative factors’ influence and their configuration on specific territories. The methods of theoretical modeling and comparison were employed to explore and enhance the theoretical and methodological foundations of combining various analytical information on negative factors that can arise on land plots. These methods of scientific understanding also enable the consideration of all factors in future classifications of restrictions on the use of land affected by armed conflicts, as well as the deepening of practical aspects.

Results

More than a quarter of Ukraine’s territory is directly affected by armed conflicts. These territories and land plots are subjected to various negative influences, including territory contamination, craters from artillery explosions, soil compaction due to the passage of military equipment, areas with fortifications, land plots with destroyed equipment, and so on. To classify relevant regime-forming objects and their restrictions on land use for further monitoring of the consequences of military actions on land resources as a whole, it is necessary to integrate information from various sources about negative factors. Spatial data sources that can serve as a basis for the subsequent classification of restrictions on the use of lands affected by military actions may include data from governmental institutions, civil organizations, and private initiatives. The main criteria for such information should be reliability, objectivity, accumulation, and systematic representation. Among the sources of information from governmental institutions necessary for building spatial layers, we will include: The State Service of Ukraine for Geodesy, Cartography, and Cadastre, which may contain the following information: a list of registered land plot purposes; type of usage of registered land plots; types of land use of registered land plots; list of agro-production soil groups outside populated areas; registered restrictions on land and land plot use; ownership form; particularly valuable soil groups; degraded and low-productive lands; established limitations on land plot usage. State Agency of Water Resources of Ukraine: river pollution in Ukraine; monitoring of irrigated and drained lands; monitoring of areas prone to flooding and potential consequences of floods leading to submergence and inundation. State Agency of Forest Resources of Ukraine: forests damaged due to military actions, forest fires. Ministry of Environmental Protection and Natural Resources of Ukraine: nature reserve fund affected by military actions; emerald network. Ministry of Reintegration of Temporarily Occupied Territories: list of territorial communities affected by military actions and currently under occupation. State Emergency Service of Ukraine: information regarding the survey of territories that could potentially be contaminated with explosive objects, keeps records of demined areas and territories affected by
fires. State Agency of Ukraine on Exclusion Zone Management: potential territories of radiation contamination, particularly within the exclusion zone. State Institution "Institute of Soil Protection of Ukraine": information on assessing the level of soil fertility in terms of nitrogen (N), phosphorus (P), and potassium (K), as well as the presence of humus in soils based on agrochemical survey tours.

In addition to official resources, there are also public and private initiatives that gather information from official sources and international organizations engaged in monitoring. An example of such an initiative is SaveEcoBot, which is positioned as Ukraine's only environmental chatbot, combining data about pollution, polluters, and environmental protection tools (SaveEcoBot, 2018). Monitoring data about fires on lands are provided by NASA FIRMS (Fire Information for Resource Management System) (NASA FIRMS, 2000). Some separate sources that analyze information about events of military and societal nature that could impact land contamination include: ACLED (Armed Conflict Location & Event Data Project) - a project that collects, analyzes, and maps disaggregated data on the location and events of armed conflicts (ACLED, 2018); Eyes on Russia - a project by the Centre for Information Resilience aimed at collecting and verifying videos, photographs, satellite images, and other media related to Russia's invasion of Ukraine (Eyes on Russia Map, 2022); DeepStateMap.Live is a project that has developed an interactive online map of the military actions in Ukraine. It allows users to track changes in the front line and the progress of military operations. The project operates based on non-commercial OpenStreetMaps (DeepStateMap.Live, 2022); The FloodMap project has developed an interactive online map depicting floods, inundation, and submerged land parcels under various scenarios of rising sea levels, dam failures, and more (FloodMap, 2020).

One layer of information includes satellite imagery, which over time can depict the consequences of military actions on respective territories. One of the major producers of such satellite imagery is Maxar Technologies Inc, along with Sentinel and Landsat, providing optical raster images that, due to their resolution, allow for the identification of potential soil contamination on land parcels. We propose classifying the images based on the following characteristics: Land parcels where the soil cover is disrupted due to the construction of fortifications; Land parcels, particularly those of agricultural use, compacted by the passage of machinery; Land parcels contaminated by the combustion of destroyed equipment; Land parcels contaminated by the impact of explosive devices on the soil. The corresponding division of images in satellite imagery can be done individually for each characteristic or in combination. This division is necessary to identify specific objects that will require the establishment of restrictions on the use of land parcels.

After analyzing the sources of spatial data, we propose the following groups and subgroups of spatial analytical information in the State Land Cadastre:

- **Group 1 - Land Parcels**: Registered land parcels in the State Land Cadastre; Land parcel category; Land parcel purpose; Land parcel purpose type; Types of land use for land parcels; Ownership form; Established restrictions on land parcel use.
- **Group 2 - Soils**: Agrochemical soil groups; Particularly valuable soil groups; Organic matter content in soil; Soil nitrogen (N) content; Soil phosphorus (P) content; Soil potassium (K) content; Degraded land parcels; Low-productivity land parcels.
- **Group 3 - Forests**: Land parcels with forest cover that have suffered damage due to military actions.
- **Group 4 - Nature Reserve Fund**: Nature reserve areas that have suffered damage due to military actions; Nature reserve areas located in occupied territories; Land parcels (territories) of the emerald network.
- **Group 5 - Radiation Contamination of Land Parcels (Territories)**: Contamination of land parcels with Sr-90; Contamination of land parcels with Cs-137.
- **Group 6 - Territorial Communities**: List of territorial communities affected by military actions; List of territorial communities under occupation; List of territorial communities that have been de-occupied.
- **Group 7 - Landmines Contamination**: Land plots (territories) potentially contaminated with explosive devices; Land plots (territories) that have been demined (operational demining);
Land plots (territories) that have been demined (humanitarian demining); Confirmation of hazardous zone.

- Group 8 - Reclaimed Lands: Irrigated lands; Drained lands; River pollution.
- Group 9 - Buildings, Structures, Infrastructure: Buildings; Structures; Infrastructure.
- Group 10 - Satellite Imagery of Land Parcels: Maxar Technologies Inc; Sentinel; Landsat.
- Group 11 - Floods: Floods; Deluges; Inundations; Submersions.
- Group 12 - Military and Societal Events: Acleddata; Eyes on Russia; DeepStateMap.Live; Fire-affected Land Parcels (Territories).

The corresponding scheme of information-analytical layer groups will have the following structure (Figure 1)

![Scheme of Information-Analytical Layer Groups for Classification of Restrictions on Land Use Affected by Military Actions](image)

The intensity of potential land contamination requires the establishment of appropriate types of restrictions on their use. We propose to identify the following types of new restrictions:

- For the first type of restriction, we propose to include land plots where any activity is prohibited due to landmines, the influence of toxic substances, and potential threats to adjacent land plots within a distance of up to 100 meters;
- The second type will include land plots that are restricted in their suitability for use according to their designated purpose and type of usage. This applies to agricultural lands that were within the zone of military operations and occupation. Additionally, until their full restoration, organic farming cannot be conducted. Excessive levels of chemical substances also limit the cultivation of agricultural crops on these land plots;
- The third type of restriction will encompass land plots conditionally suitable for use according to their primary designated purpose and type of usage. These are land plots that do not have direct negative impacts from military actions or whose consequences have been minimized. This type of restriction will require only monitoring of these land plots to minimize the risk of undetected threats from previous surveys of areas affected by military actions.

**Conclusions**

Information about land plots is dispersed across various data sources, lacking integration within a unified information system. This absence hampers the creation of a comprehensive understanding of the research subject. Establishing a unified geoinformation system would enable the assessment of
losses due to military actions, identification of issues in land plot utilization, development of forecasts, and delineation of appropriate restriction zones. The unified geoinformation system will facilitate the implementation of more informed management decisions in the ecological and economic realms of the country, territorial communities, and specific land plots. Furthermore, this system should allow for the expansion of information-analytical groups and subgroups of layers. The establishment of a unified geoinformation system will foster the creation of objective, well-founded proposals regarding appropriate restriction groups for the utilization of land plots affected by military actions.

Taking into account the data from the geoinformation system, three new types of restrictions for the use of land plots affected by military actions are proposed. Specifically, these will include a complete prohibition of usage for the intended purpose and type of use of land plots, land plots limited in suitability for use, and land plots conditionally suitable for use.

References


DeepStateMap.Live (2022) Map of the war in Ukraine. URL: https://deepstatemap.live/


Eyes on Russia Map. (2022) The Centre for Information Resilience (CIR). URL: https://eyesonrussia.org/

FloodMap (2020) Elevation Map, Sea Level Rise Map. URL: https://www.floodmap.net/


SaveEcoBot (2018) The only environmental chatbot in Ukraine that combines data on pollution, polluters and environmental protection tools. URL: https://www.saveecobot.com/ (in Ukraine)