Environmental effects of agricultural activity on the Crimean Peninsula

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Abstract. The article deals with agricultural loads occurring on the Crimean Peninsula. It was determined that distribution of agricultural lands shows a strong asymmetry in this region. At least ⅔ of the whole area is characterized by essential loads on the environment due to intensive agriculture development. Given the fact that the majority of agri-business and concentration of agricultural production can be found on territories with unfavourable natural features, it is getting obvious that the negative natural processes will rapidly accelerate and loads will increase. The study is focused on revealing the geographical distribution of environmental violations caused by agricultural activity. It is considered that variety of consequences caused by intensity of agricultural loads is strongly rooted with landscape features. It was found that the distribution of the contemporary agricultural loads reflects the ways of agrarian developed on the studied territory.

1. Introduction
The Crimean Peninsula is the one of the long-agrarian developed regions, where agricultural impact on the environment is reflected as occurrence of large-scale negative natural processes. Taking into account that this region is considered as a strategically significant area for the development of agriculture it becomes obvious the agricultural loads will rather strongly increase.

The region includes 14 municipal districts, 11 urban districts, and the one federal city (Sevastopol). The total area of the studied region is 26 081 km². Relief and landscapes of Crimea are characterized by variety forms: from north to south low steppe lands are replaced by foothill’s plains, by hilly uplands, and by middle mountains are covered by forest [1]. Climate is running from temperate continental (on low lands and foothill’s plains) to sub-Mediterranean type (along the south coast). Average annual amount of the rainfall gradually falls (from 1500 on the southeast to 300 mm on the northwest). The river network is slightly developed [2]. During the summer period, the water level in the rivers drops significantly, there is a shortage of water for the needs of the population and agriculture [3].

The natural and climatic features allow developing crop production (more than 60% of the region are covered by chernozems), as well as livestock production. Crimea takes a leading position among Russian regions on the grain harvesting, ranks the 3rd place on grape harvest, and is in the top of 10 Russian regions on berries, fruits, and vegetables harvesting [4]. Agricultural lands occupy 1793.5 thousand hectares or 68.7% from the total area of the region. The Russian food embargo slowed down agricultural development in the Crimean Peninsula. Most productive lands were abandoned, processes
of deagrarization were widespread. In 2 years, area of abandoned agricultural lands increased on 115.7 thousand hectares, area of arable lands dropped on 407.3 thousand hectares, areas are under haymaking grew in 4 times (from 2 to 12.5 thousand hectares), and areas are used for pastures reduced on 382.7 thousand hectares [5-7]. Since 2016, it has been observed the opposite tendency – re-agrogenesis, when landscapes return to agricultural use [8;9]. Area of abandoned agricultural lands decreased and reached the values are recorded in 2014 (10.6 thousand hectares), area of arable lands increased in 1.5 times, areas are under haymaking and pastures are also returned to the values of 2014 committed on the National reports on land use in Russia [6].

Crimea is keep going the course for extending the lands of pastures and areas are under crops. In 2021 croplands held 713.2 thousand hectares, areas are under crop increased on 132.2 thousand hectares from 2014 to 2021 [6]. It is important to stress that further agricultural development accelerates appearance of environmental problems on the Crimea Peninsula. Diversity of the environmental impact is connected to natural features and level of agricultural loads. The most widespread loads are linked to agricultural facilities and land use methods applying for crops cultivation. The forms and degree of landscape transformation are determined by the environmental features of the region and the intensity of agricultural pressure both.

The aim of the research is to assess geographical scales and distribution of violations caused by agricultural activity within the Crimea Peninsula by taking into account contemporary natural features, intensity of agricultural loads, and variety of consequences connected with agricultural land use.

Understanding of regularities of geographical location of violation occurring on agricultural lands is a key solving environmental problems arising during agricultural management. To achieve this goal, it was necessary: (1) to collect statistical data, satellite images and cartographic material on the territory; (2) to reveal and to analyze environmental problems; (3) to identify areas are subject to agricultural loads and to classify them on degree of the impact on the landscapes; (4) to assess the agricultural loads depending on natural features. The study has a significant meaning according to the action of the strategic document "Forecast of long-term socio-economic development of the Russian Federation for the period up to 2030" and highlights problems connected to agricultural complex of Crimea. The results of the research were reported at the international conference ESDCA-II-2022.

2. Materials and methods
Guidelines for the conducted study were elaborated at the Institute of Geography of the RAS and are based on the concept of responses of the natural ecosystem’s components to the agricultural impact which has harmful effects on their natural functioning [10]. This general concept was further supplement by approaches to environmental assessments [11]. The conducted study is based on statistical data on land fund of the Crimean Peninsula for the period 2014-2021, reports on the environmental violations, space images and maps of the territory, and data are gathered during personal field research. Statistical, mapping and analytical methods were applied.

On the first step of the research, the most observable violations were ranked by degree of their impact on the landscapes: air pollution (maximum allowable concentration: more than 0.5 - high, 0.8-5.0 - mean, less 0.8 - low), water contamination (phenol, heavy metals, and synthetic surfactants - high, phenol and heavy metals - mean, phenol - low), water pollution (water pollution index: more than 4.0 - high, 2.5-4.0% - mean, less than 2.5% - low), water shortage (more than 60% - high, 25-60% - mean, less than 25% - low), soil degradation (more than 50% - high, 20-50% - mean, less than 20% - low), soil acidification (more than 50% - high, 20-50% - mean, less than 20% - low), soil salinity (more than 50% - high, 20-50% - mean, less than 20% - low), soil contamination by pesticides (more than 50% - high, 25-50% - mean, less than 25% - low), loss of soil fertility (more than 40% - high, 20-40% - mean, less than 20% - low), overgrazing (more than 55% - high, 10-55% - mean, less than 10% - low), loss of pastures (more than 20% - high, 20-10% - mean, less than 10% - low), land cover fragmentation (more than 56% - high, 10-56% - mean, less than 10% - low), reduction of vegetation cover diversity (more than 60% - high, 15-60% - mean, less than 15% - low), erosion occurrence (more than 40% - high, 20-40% - mean, less than 20% - low), deflation (more than 40% -
high, 20-40% - mean, less than 20% - low), ravine occurrence (1 per km$^2$ - high, 0.9-0.6 per km$^2$ - mean, 0.5 per km$^2$ - low), area of karst occurrence (20% - high, 19-10% - mean, 9% - low), loss of bio capacity (20% - high, 19-10% - mean, 9% - low).

On the second step, the features of the agricultural loads were estimated by applying a following formula that reflects the degree of agricultural impact on the environment [10]:

$$Al = \frac{5S_1 + 2.5S_2 + 1S_3}{100}$$  \( (1) \)

Where $Al$ is agricultural load, $S_1$ – area (% of the total territory under the agricultural development) of a high degree of agricultural impact (coefficient is 5 grade), $S_2$ – area (% of the total territory under the agricultural development) of a mean degree of agricultural impact (coefficient is 2.5 grade), $S_3$ – area (% of the total territory under the agricultural development) of a low degree of agricultural impact (coefficient is 1 grade). All calculations were implemented within the municipal districts of the region. The obtained results were integrated to ArcGIS and were attached to relief forms. As a result, the map of the levels of agricultural loads on the environment in Crimea was created.

### 3. Results and Discussion

Environmental violations appearing from agricultural activity.

According to rank of observable environmental violations and evidences about degree of their occurrence caused by agricultural activity on the plains and mountains of Crimea, it was determined a strong asymmetry between territories are placed on low lands, foothill’s plains, and mountains (table 1).

#### Table 1. Environmental violations and degree of their impact on the plain and mountain territories of the Crimea Peninsula arising during agricultural activity.

| Violations                      | Low lands | Foothill’s plains | Valleys and hollows | Middle mountains |
|---------------------------------|-----------|-------------------|---------------------|-----------------|
| Air pollution                   | high      | high              | low                 | low             |
| Water contamination             | high      | high              | low                 | low             |
| Water pollution                 | high      | mean              | low                 | low             |
| Water shortage                  | high      | mean              | mean                | low             |
| Soil degradation                | high      | high              | low                 | low             |
| Soil acidification              | high      | high              | low                 | low             |
| Soil salinity                   | high      | high              | low                 | low             |
| Soil contamination by pesticides| high      | high              | low                 | low             |
| Loss of soil fertility          | high      | high              | low                 | low             |
| Overgrazing                     | high      | low               | mean                | low             |
| Loss of pastures                | high      | low               | mean                | low             |
| Land cover fragmentation        | high      | low               | mean                | mean            |
| Reduction of vegetation diversity| mean       | low               | mean                | mean            |
| Erosion occurrence              | high      | high              | high                | mean            |
| Deflation                       | high      | mean              | low                 | mean            |
| Ravine occurrence               | high      | high              | low                 | low             |
| Area of karst occurrence        | mean      | high              | high                | high            |
| Loss of bio capacity            | mean      | low               | low                 | low             |

The major environmental violations related to agricultural development are currently occurring on the whole territory of Crimea. The natural landscapes of the central and southeastern parts of Crimea are in conjunctions with agricultural activity. Nevertheless, the ecological state of these territories can be described as "satisfactory" [12]. The ecological state of the mountain territories is "favorable" [13].
Agricultural loads on the environment.
Natural landscapes are located on low lands, foothill’s plains, and mountain territories response differently on agricultural impact (figure 1).

Figure 1. Levels of agricultural loads on the environment of the Crimea Peninsula in 2021.

According to formula (1), areas with low agricultural loads lie on the southeastern mountainous part. Agricultural activity is accompanied by chemicals pollution of soils. Long-term use of soils for crop production led to humus decrease on 25-35%. Copper content in soils exceeds 1-1.5 of the maximum allowable concentrations (MACs) [7]. The majority valleys and hollows arable lands are subject to water erosion. On the territories with mean agricultural loads there is water shortage. Rivers are exposed to pollution by contaminated waters flowing from farmlands and dumping of irrigating waters. Irrigated lands include 397.3 thousand hectares, 179.3 thousand hectares of them are in "good" condition, 183.3 thousand hectares of them are in "satisfactory" condition, and 34.8 thousand hectares of them are in "non-satisfactory" condition [6]. Wind erosion is also widespread: 25% from the total area are subject to erosion of high degree, nearly 35% is characterized by mean degree, and 10% are qualified by low degree of erosion. Soil acidification is observed on 30% of the territory. Over 40% of agricultural lands are subject to soil salinity. Soil contamination by pesticides is mean (40%); loss of soil fertility achieves 20%. Values of deflation and karst occurrence are mean; loss of bio capacity obtains 20%. The most common violations on areas with high agricultural loads are subject to water contamination. Effective cleaning and drainage system are weak. Water in personal wells doesn’t meet the quality standards for drinking water according to sanitary and epidemiologic norms 1.2.3685-21. Presence of Fe, B, Li, Mn, Al, Ag, Ba in water exceeds 2.5 MACs [14]. Protection of small rivers from pollution and depletion is practically not performed at the appropriate level [15-16]. The level of air pollution is well above than 1 MACs [17]. Loss of pastures is 25%. Land cover fragmentation achieves 70%, reduction of vegetation cover diversity is about 60%. Deflation and erosion are observed on 40% on areas with high agricultural loads.
Instability of the landscapes to agricultural loads. Conducted research allows the author to assess ecosystem instability to agricultural pressure depending on landscape features and landscape condition (figure 2).

![Figure 2. Profile of ecosystems resilience to agricultural loads on the Crimea Peninsula.](image)

The most naturally instable landscapes prevalent on middle mountains [18]. However, agricultural loads on such territories are low, for this reason ecosystems are not subject to high level of instability. In turn, the landscapes of low lands are affected by high and mean agricultural loads. Natural stability of these ecosystems is low or mean owning to local impact of the agriculture. It should be pointed out that southeastern areas are also under technogenic and urbanized loads [19-20]. In fact, such disproportion of ecosystems resilience to agricultural loads can be explained by the differences of landscape features and landscape condition leading to an asymmetry towards the agricultural loads.

4. Conclusion
Crimea is strongly involved in agricultural use for a long period of time. The economy of the region is open to domestic market and highly integrated to the production system of the Russian regions. There seems to be, agriculture will develop and negative processes affecting the environment will broadly occur here. The findings of the study indicated the following patterns: (1) agricultural land use is not strongly integrated in the natural landscapes thus environmental violations have been accelerating rapidly since 2014; (2) types of agricultural loads deal with relief forms of the landscapes and water supply: from north to south agricultural loads are increasing; (3) intensity of agricultural loads is higher in steppe lowland central areas, in mountain valleys, in hilly territories lying along the mountains. The results of the conducted research can be used as a basis for elaboration of proactive management program of land resources in the Crimean Peninsula.

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