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THE VULNERABILITY AND ENVIRONMENTAL RESILIENCE OF ECOSYSTEMS IN YAMAL, RUSSIAN ARCTIC

Аннотация: представленная работа рассматривает актуальные экологические проблемы на п-ове Ямал, на севере центральной части России, ЯНАО. Этот регион, уникален по своим природными и экологическими условиям. Физико-географически, территория представлена распространением покрова мохово-лишайниковых тундр в условиях вечной мерзлоты. Глобальные экологические изменения и климатические вариации, способствуют деградации окружающей среды тундры, в частности увеличивает активность криогенных склоновых процессов (криогенные оползни). Данная статья представляет обзор локальных экологических аспектов, вызванных процессами планетарного изменения климата на п-ве Ямал, в т.ч. анализ воздействия склоновых геоморфологических процессов на окружающую среду тундры. Так, участки растительно-почвенного покрова, где имели место криогенные оползни, испытывают медленное и затрудненное восстановление в условиях крайнего Севера, что связано со спецификой температурно-почвенного режима. В работе подчеркивается необходимость бережного и щадящего внешнего (в т.ч. антропогенного) воздействия на окружающую среду в условиях тундры, благодаря крайне специфическим экологическим условиям местной природы, имеющей природоохранную ценность планетарного масштаба.

Ключевые слова: Ямал, тундра, экология, почвенно-растительный покров.

Abstract: the research paper focuses on the environmental problem of Yamal region, geographically located in the Russian Yamal-Nenets autonomous region, northern-central Russia. This region is characterized by the unique nature and environmental conditions, combining two physical-geographical regions: sub-Arctic and Arctic moss-lichen tundra and permafrost conditions. The recent changes in global climate and overall warming highly contribute to the degradation of the tundra environment and increases cryogenic slope processes. This paper focuses on the investigation of the ecological aspects of the global climate change in Yamal peninsula, and analysis the development of slope processes on the local tundra environment.

Keywords: Yamal, tundra, ecology, land cover types.

The Russian Arctic tundra is a very specific ecoregion of our planet, highly important for the world environmental heritage. Lots of tundra species have only circumpolar spread. Arctic ecosystems have complex structure with functional linkages between soil and plant communities, highly adapted to the polar climatic and environmental conditions. Thus, the biodiversity in Yamal tundra is in general low, with limited taxonomic diversity of plant communities [9]. There are only 26 mammal species, 32 species of valuable fishes (with up to 70% of Russian salmon) and 186 species of mostly Arctic spread birds [4]. Major role in the functioning of Yamal ecosystems plays reindeer, lemmings and arctic fox.

The Yamal peninsula occupies low plain, so that the relief of the region is almost completely flat with dense river network, which leads to the seasonal river flooding and active erosion processing that intensify local landslides formation. The adjusting shelf area of Kara Sea is also shallow: almost 40% of the continental shelf is no deeper than 50 meters, and the sea coasts are mostly flat, flooded during the high tide [5]. Located in the area of permafrost distribution, the soils in the region are frozen for the most of the year, with the depth of the frozen soil reaching up to 0.2 m in the north and 2 m in the south [5]. In such conditions the processes of superficial cryogenic landslides are especially active. The distribution of the permafrost serving as a shear surface for sliding highly contributes to the landslide formation. Therefore, the cryogenic landslides developed on the fine-grained, saline marine sediments, occupy almost 70% of the area [15].

The ecosystems of the region are highly adapted towards specific environment of Arctic. The development of permafrost results in scarce vegetation coverage in general and landslides also change local landscapes and vegetation cover. Thus, several years after the landslide formation the vegetation coverage changes gradually, being dominated by grass, moss, lichen and shrub, then by sedge and finally by willow meadows [16]. As a result, landslide-affected areas of bare slopes are usually occupied by willow shrubs, which can serve as an indirect, yet reliable, indicator for former landslide processes, which happened in this area [13]. Moreover, different stages of the vegetation coverage may provide additional information about the possible age of the landslides. Thus, early-stage vegetation, such as primitive mosses or lichens, could indicate recent landslide formation on this surface, while distribution of meadow and willow shrubs with high canopy points to the final stage of the landslide activities. Besides type and age of vegetation coverage, the salinity of ground waters as well as sediment chemical content indicates the relative age of the landslides.

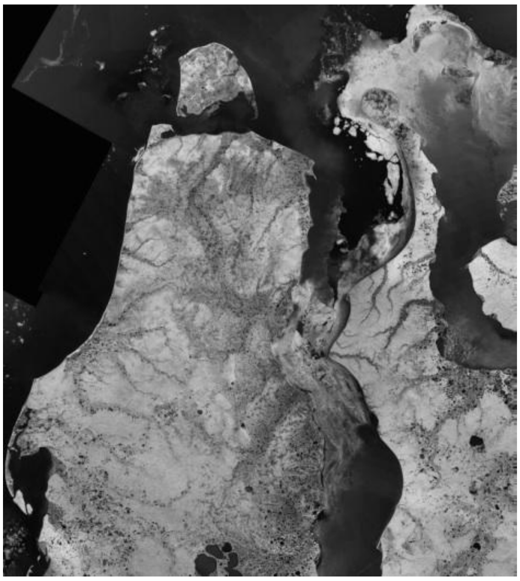

Fig.1. Yamal Peninsula: a mosaic of color composites of Landsat TM satellite images

The sustainable functioning of such unique ecosystems is highly adjusted towards climatic-environmental settings. Recent changes in the climate patterns may result in serious alterations in the structure of tundra ecosystems. The environment in the Kara Sea area is mostly influenced by the Arctic climate conditions, which had several fluctuating changes since past time [1], [11]. Nowadays, the processes of global climate warming have severe threats to the tundra environment [2], [3].

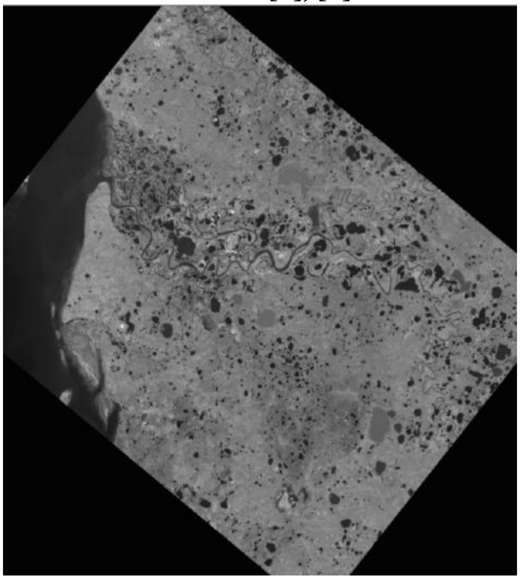

Fig.2. Illustration of the tundra wetlands: a view from space (Landsat TM scene)

Since early 1980s the processes of Arctic warming activated and included meteorological changes (precipitation level, permafrost and snow cover depth) and increase of greenhouse gases percentage in the atmosphere [8]. This naturally triggered certain changes in the vegetation coverage. Namely, climate change causes "greening" effect in Arctic, i.e. unnatural increase in vegetation growth, primarily of willow (*Salix lanata L.*). The significant increase in willow growth, height, cover, abundance and shrub ring width is detected in the last 60 years, which perfectly correlates to the overall increase in summer temperatures for the same period [6]. Similar results are reported by [14], demonstrating that growth of the willow shrubs and air temperatures are closely connected, so that the shrub growth serves as a good indicator of the climate change in Russian Arctic. Besides natural factors, the anthropogenic activities, mostly connected with exploration of hydrocarbons [12], contribute to changes in tundra ecosystems. The continental shelf of Kara Sea is the largest Russian national reserve of hydrocarbons, primarily oil and gas [10]. Therefore, the anthropogenic pressure on this region is high, and Arctic complex ecosystems are highly susceptible to the industrial and technological impacts, as well as to the climate change.

At the same time, the environment of the high north has high environmental vulnerability, low resilience towards external impacts, as well as low capacity to respond to the external environmental impacts [7]. Namely, specifically for the Arctic region, the natural recovery of the damaged landscapes becomes a very slow and difficult process, due to the above mentioned climate factors. Thus, seasonal thawing of the permafrost triggers dangerous geomorphological processes, e.g. thermokarst, thermoerosion, solifluxion and erosion. As a result, the impacts of socio-technological negative processes on the Yamal landscapes become reinforced by the natural factors in Arctic climate, which finally leads to the drastic changes of tundra landscapes. Consequently, it may have serious consequences for the overall sustainability of polar tundra ecosystems. Needless to say that careful, recovering and responsible use of natural resources in the Russian Arctic tundra should be the priority way of anthropogenic activities in this unique region of our Earth.

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