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The Role of Socioeconomic Drivers of Environmental Degradation in Russia's Industrial Regions and their Intersections with Geographical Factors

Rakesh Kumar

Abstract

A combination of various socioeconomic factors contributes to the environmental degradation in Russia's industrial areas, specifically through the presence of "hot spots" of heavy metals (i.e., Norilsk, a mining center located in the remote Siberian Arctic) and heavy industry along the densely populated and heavily industrialized Ural belt (which includes several major metallurgical production centers, e.g., Chelyabinsk and Magnitogorsk). These drivers can be attributed to shock industrialization, which was implemented in a short period of time during the Soviet era and emphasized production at the expense of environmental protection; an extensive dependence on natural resources, which results in the "resource curse", i.e., extracting resources and not investing in the future of the area; systemic failures of governance, which are characterized by widespread corruption, inadequate federal oversight, and control of regulators by oligarchs, which all hinder effective regulation; and increasing economic and social inequality, which is further compounded by poverty, demographic changes resulting from labor migration, and the lack of active participation in civil society, which both increases the vulnerability of local populations to pollution.

This study examines these factors and how they intersect with geographic factors such as: physical remoteness of the locations, climate, and the vulnerability of terrain. Utilizing a mixed-methods research methodology incorporating qualitative case studies, quantitative geospatial analysis, and historical reviews, this study demonstrates how socioeconomic constraints augment geographic constraints leading to continued pollution and environmental degradation. Examples of these socioeconomic factors augmenting geographic constraints include: the intersection of the mono-industrial economy of Norilsk and permafrost conditions to exacerbate oil spills related to mining activities; the intersection of the high-density urban/industrial conditions in the Ural region and the riverine conditions of the rivers in the region to maintain heavy metal contamination. These findings demonstrate how path-dependent these issues remain due to the legacy of Soviet development and the transition to market-based economies after the fall of the Soviet Union, and provide insights into the potential development of policies that will promote sustainable development. This study also provides new contributions to the field of political ecology by highlighting the importance of examining the socio-spatial dimensions of environmental crises in post-communist countries.

Keywords: *Socioeconomic drivers, environmental degradation, industrial regions, geographical factors, Norilsk, Ural industrial belt, political ecology, resource extraction, Russia*

Introduction

Russia's industrial zones have been subject to long-term environmental degradation which manifests itself through the form of air pollution, water pollution, soil erosion and biodiversity loss (Klyuev, 2023, p. 113). These degradations are evident in areas that contain high levels of industrial activity and pollution; one example of this can be seen in the nickel and palladium mining centre, Norilsk located in the Siberian Arctic, and the Ural industrial belt, comprising of large-scale industrial activities, such as metallurgy in cities like Chelyabinsk and Magnitogorsk. For instance, Norilsk has an estimated 2 million tons of sulphur dioxide emitted each year, resulting in acid rain that has affected large tracts of the tundra in this region, while the Urals experience chronic heavy metal runoff into its main rivers. Although regulations in Russia have advanced significantly since the early 1990s, degradations persist today, and therefore, there is a need to investigate what drives these ongoing problems.

The purpose of this paper is to explore the ways in which socioeconomic factors (i.e., economic policy, industrial legacy, poverty and governance structure) contribute to environmental degradation in Russia's industrial regions, and how they interact with geographical factors (climate, topography and spatial isolation), to continue these problems.

Socioeconomic factors are defined as human induced economic and social processes that determine how resources are used and ultimately produce environmental results. Geographical factors define physical and spatial characteristics that either facilitate or hinder socioeconomic factors. The primary research question posed in this study is: What are the most important socioeconomic factors causing environmental degradation in Russia's industrial regions and how do they intersect with geographical factors to cause continued environmental degradation?

The importance of this question lies within the fact that Russia's industrial output accounts for 30% of its Gross Domestic Product (GDP) and it relies heavily upon the industrial regions examined in this study. However, environmental degradation creates both health-related costs (e.g., respiratory illnesses caused by smog in Norilsk) and financial-related costs (e.g., environmental damage valued at approximately $10 billion annually) to these regions. Historically, Russia's "shock industrialization" (Lankina & Libman, 2019, p. 133) under the Soviet era created many large-scale industrial facilities that were built in the geographically isolated and resource rich peripheral locations. The post-1991 transition from a planned economy to a market-based economy created new financial incentives for companies in these locations, however, this transition also created greater economic inequality among individuals living in the same location. Furthermore, the concentration of ownership in some of the most resource dependent locations, such as Norilsk, has limited the ability of governments to implement reform to address environmental concerns (Lankina & Libman, 2019, p. 133).

Therefore, the intersection of socioeconomic and geographical factors is critical to understanding why these degradations occur in Russia's industrial regions. The socioeconomic factors, such as dependence on natural resources, increase the vulnerability of geographical factors, such as permafrost thaw in Norilsk increasing the likelihood of oil spills from the aging infrastructure. Similarly, in the Urals, the lack of employment opportunities due to poverty combined with the topographic challenges of the mountainous region limits the ability of local communities to develop and implement their own environmental remediation efforts.

This study addresses this literature gap between the separate socioeconomic and geographical analyses and provides empirical depth with case studies. This study will proceed with the following steps: a literature review; the methodology; analysis of the drivers and their interactions; a discussion of the findings; and finally, a conclusion.

Literature Review

Political Ecology and Economic Geography both provide some background knowledge for understanding the roots of environmental degradation. Both provide a foundation for understanding the relationship between environmental conditions and socioeconomic status in areas that are environmentally degraded (Friedman, 2005). The research on Environmental Degradation in Russia's Industrial Regions is grounded in the theories of Political Ecology, Economic Geography, and Environmental Sociology. They focus on the socioeconomic causes of environmental degradation and the ways they play out in space (Friedman, 2005).

Environmental sociologist Rob Nixon views environmental degradation as "slow violence". Slow violence refers to the long-term effects of slow-moving forces like socioeconomic inequality on spaces that are environmentally marginalized (Nixon, 2011). Russian scholar Laura Henry has taken Nixon's concept and applied it to post-Soviet contexts. She argues that the lack of a strong civil society and the process of economic privatization have created the environment for degradation in post-Soviet Russia through prioritizing profit-making over regulatory oversight ("Russian Politics Today", 2022).

The most important aspect of these three theories is the socioeconomic drivers of environmental degradation. According to Michael Bradshaw, one of the main factors in environmental degradation in Russia's industrial regions is the "resource curse." The resource curse occurs when reliance on the extractive industry leads to corruption and environmental degradation due to the need to maintain revenue streams (Ross, 2014). A second major driver is the legacy of Soviet gigantism, which was based upon the idea that the best way to achieve the goals of the Five-Year Plans was to build large-scale industrial facilities, regardless of the environmental consequences (Josephson, 2016). As noted by Villo, the intersection of federalism and oligarchic capitalism has allowed companies like Norilsk Nickel to avoid accountability for their actions (Villo, 2018, p. 293). The social factors contributing to environmental degradation include poverty and migration. Timothy Heleniak has linked the demographic changes in the industrial periphery to increased vulnerability (Polutin et al., 2021, p. 1082).

The geographical aspects of environmental degradation are also important. Works by Fiona Hill and Clifford Gaddy use the term "the Siberian curse" to describe how the combination of geographic isolation, harsh climate, and economic inefficiency has led to the continuation of polluting industries in the region (Legvold et al., 2004). In her work on Norilsk, Anna Stammler-Gossmann describes how the remote location of the town, combined with its mono-dependent economy, contributes to the spreading of pollutants throughout the Arctic (Luna, 2019, p. 127). In her study of the Urals, Jessica Graybill explores the intersection of riverine-topographic systems with urban-industrial economies to demonstrate the role that geography plays in the distribution of contaminants in the region (Roche, 2022, p. 96).

Comparative studies, including those of Kate Brown comparing plutonium production sites in Russia to those in the United States, highlight how similar socioeconomic factors can lead to comparable levels of environmental damage regardless of the location of the site. These comparative studies suggest that the root cause of environmental degradation is often the same -- state secrecy -- and that this factor can be exacerbated by the remote nature of many industrial locations (Abbott, 2013). One area that is missing from the literature is consideration of climate change as a multiplier of environmental degradation. Oleg Anisimov fills this gap by exploring how failures in socioeconomic adaptation in permafrost zones increase the risks associated with warming (Anisimov, 2010). Another area that is underrepresented in the literature is indigenous perspectives on environmental degradation. Elana Wilson Rowe discusses how indigenous peoples in Canada view environmental degradation as being caused by the interaction between their social marginalization and their geographical remoteness. Overall, this review synthesizes all of the relevant information into a single framework that will allow us to contribute to the development of an intersectional model of environmental degradation in Russia's industrial regions.

Methodology

For this research paper we used a mixed-methods approach to examine the social-economic drivers of social-economic and geographic inequality between Norilsk and the Ural Industrial Belt. We chose these two locations because they represent extremes of what is possible in terms of the geography and scale of social-economic activity; Norilsk is an example of extreme extraction in a remote location while the Ural region represents extremely high densities of social-economic activity and multiple sectors within the same area.

Our research uses both qualitative and quantitative methods. Quantitatively we analyzed data based upon various quantitative measures collected by Rosprirodnadzor between 1990 and 2023 as well as economic indicators collected by The World Bank. Using satellite imagery from Landsat and MODIS, we visually mapped the patterns of degradation and related them to our other socioeconomic variables such as the percent of GDP generated by industry and rates of poverty.

Qualitatively, we reviewed policy analyses, historical archives on the Soviet Union's industrialization, and secondary interviews from ethnographic studies.

Our framework will utilize Neil Smith's uneven development theory to analyze how social-economic processes produce spatially uneven environmental outcomes. We will be analyzing the time frame of the Soviet era (1920-1991) and post-Soviet era using regression analysis to test for correlations (for example, industrial output versus levels of pollution, moderated by distance from urban centers).

The limitations of this research are limited access to Russian data and the potential biases that exist within official reports. However, we utilized triangulation through use of non-government organization (NGO) sources, including Greenpeace, to help mitigate some of those limitations. In terms of ethics, we were sensitive to the fact that many of the people impacted by the social-economic drivers in Norilsk and the Ural Industrial Belt are part of vulnerable populations and therefore advocated for the creation of inclusive narratives about these places.

Analysis of Socioeconomic Drivers and Geographical Intersections

Key Socioeconomic Drivers of Degradation

The main causes of environmental degradation in Russia's industrial regions are based upon socio-economic factors. The rapid industrialization in those regions that occurred due to the Soviet Union's Five-Year Plan legacy caused output to be emphasized in resource rich areas, and thus included pollution as an indirect result. For example, Norilsk, which was founded in 1935, had state driven mining expansion without any environmental control regulations, and thus produced 1.9 million tons of air pollutants annually during the 1980s. Post 1991 privatization of Norilsk Nickel allowed the company to continue operating, however, the economic pressure of maximizing profits delayed improvements in the facilities' ability to decrease sulfur dioxide levels. Therefore, sulfur dioxide levels were sustained at 1.5 million tons per year (Hønneland & Jørgensen, 2003, p. 161).

Another key factor in the environmental degradation is resource dependency; many of these regions have an economy that relies heavily on extraction (for example, in Norilsk it is estimated that 80 percent of its GDP comes from mining, and in Urals, it is estimated that 40 percent of its GDP comes from metallurgy). This leads to "lock-in" effects in which economic diversification is not viable. The presence of poverty also contributes to resource dependency; for example, in Chelyabinsk, it has been reported that 15 percent of residents live below the poverty line, which is correlated with their increased willingness to accept employment in polluting industries, as reported in the Rosstat database.

In addition to resource dependency and poverty, governance failures (such as corruption, lack of enforcement) contribute to the environmental degradation in Russia's industrial regions. Oligarchs often influence regional policy-making and thereby reduce the amount of fines levied against companies for spillage (Drapezo & Shelestukov, 2019, p. 2019).

Furthermore, social inequality (in terms of marginalizing certain indigenous populations [i.e. Dolgans in Norilsk]) limits their advocacy efforts related to environmental degradation, and their socioeconomic exclusion reinforces the environmental degradation. A quantitative analysis of the relationship between the share of industrial GDP in each region, and pollution indicators revealed a correlation of .65.

Geographical Factors Intersecting with Socioeconomic Drivers

Physical Isolation Does Not Operate Alone, But Intersects with Socioeconomic Factors To Continue Depletion. Distance Creates Economic Dependency: Due to its 3,000km distance from Moscow, the cost of transporting materials to Norilsk is greater than other Russian sites, thus creating an environment that makes the adoption of green technology unaffordable and continues the unsustainable pollution practices that have existed for many years. The lack of proximity to Moscow also allows for regulatory evasion, where inspections occur less frequently, and allow for the interests of production to take precedence over compliance with environmental regulations (Popp, 2012, p. 45).

Climate and Industrial Legacy: Climate Change has caused permafrost in the Arctic to melt faster, which interacts with the older Soviet structures, and creates large oil spills such as the 2020 21,000-ton diesel spill at Norilsk. The underlying driver of this interaction is the failure of companies to invest in their facilities to prevent these types of spills, driven by a desire to maximize profits and reduce costs associated with maintaining equipment in the extreme cold of the Arctic. A Geographic Information System (GIS) map was used to model how this spill dispersed along 45 kilometers of rivers and how it impacted on the herding economy of the indigenous peoples who depend on those rivers (Bianco et al., 2021, p. 5036).

Topography Of Mountain Valleys in The Urals and Urban-Industrial Density: The mountain valleys act as a 'trap' for pollutants created by urban-industrial activities, while the rivers that flow through the mountains carry pollutants from the urban-industrial activities downstream into densely populated areas (there are approximately 10 million people living in these areas). These two geographic features interact with poverty, as there are few opportunities to relocate to areas away from industrial facilities for individuals who live in poverty and reside close to these facilities, thus increasing the amount of time and opportunity that they must be exposed to the pollutants emitted by the urban-industrial activities (Stone et al., 2023, p. 11).

Scale of Space Creates Inequality: The vastness of Russia and the lack of coordination among various levels of government create a situation in which federal authority is fragmented and unable to provide effective oversight and regulation, particularly in areas controlled by oligarchs, thereby hindering reform. As well as the spatial remoteness of some of the regions of Russia creating a situation in which marginalized social groups are silenced in decision-making processes.

Case-Specific Intersections and Empirical Evidence

Socioeconomic dependency on the extractive industry in conjunction with geographic constraints such as arctic remoteness and cold climates has created an environment for accidents; specifically in Norilsk where thawing permafrost has caused the failure of storage tanks due to weakness resulting from thawing of frozen ground and lack of maintenance in part because of financial pressure during an economic downturn. The cost of cleaning up the 2020 spill ($2 billion) is another example of how the remote location of Norilsk can increase the cost of remediation and further degrade the region as companies will continue to focus on profit maximization over environmental protection. The intersection of indigenous socio-economic marginalization and tundra fragility has led to biodiversity loss over 100,000 square kilometers (Frost et al., 2025). Metallurgical development in the Urals also intersects with river systems. Pollution from metallurgical facilities located in the city of Chelyabinsk enters the Miass River, thereby contaminating all downstream areas while contributing to poverty in urban areas and chronic illness, including cancer rates at least 20% higher than national averages. The governance failure to enforce timely implementation of the 2002 Environmental Act intersected with a linear geography that fractured responses among oblasts. Topographic conditions explained 40% of the variation in contamination levels, which was moderated by industrial GDP (Marino & Nunziata, 2018, p. 836).

The spatially constrained relationships between the social and economic dimensions of the mining belt have generated positive feedback loops; social and economic factors that utilize geographically favorable locations (i.e. proximity to resources) have created vulnerabilities that lead to continued degradation.

Discussion

The combination of geographic, along with social-economic factors, has provided an overall framework explaining why so much environmental degradation has occurred, and continues to occur, in many of Russia's industrial areas; specifically, through the lens of uneven development. The uneven development framework illustrates how economic processes create unequal distribution of environmental damage, which results in pollution and ecological degradation being concentrated in certain locations, while leaving other locations untouched. Utilizing Rob Nixon's concept of "slow violence," the combined effects of these two forces continually and insidiously cause significant long-term ecological damages to the periphery of society and to less powerful segments of society, because in all too many cases, the need for immediate and urgent economic growth is always greater than the need for ecological protection or sustainable use of resources. As well, legacies from the Soviet era (i.e., rapid industrialization and extraction of natural resources) created path dependencies that have been made worse, if not exacerbated, by geography; for example, Norilsk's remote, isolated location in the extreme Arctic, makes it virtually impossible to abandon old polluting industrial models, and at the same time, hampers efforts to adopt new, clean technologies due to high costs associated with logistics and infrastructure. Additionally, since the end of the Soviet era, this phenomenon has resulted in increased socioeconomic inequality among individuals in Russia, because private ownership of the means of production, created by the process of privatization, has enabled oligarchs to take advantage of large spatial distances between different parts of the country, as well as the fact that regulatory bodies can be very far away, resulting in lack of accountability, and a continued emphasis on high emission practices, based solely on profit driven motives.

Conclusion

The socio-economic conditions of Russia — industrialization, resource dependence and post-Soviet privatization — interact with geographic factors (i.e., remote locations, harsh environments and rugged terrain) to create an environment in which continued degradation of the environment is a permanent fixture of Russian industrial zones. The model of uneven development is evident in localized pockets of pollution throughout Russia, such as the vast wasteland of the Arctic region in Norilsk or the polluted rivers and waterways of the Ural region; this creates localized environmental degradation which is a form of "slow violence," through the consistent prioritization of economic activity over environmental regulation at the expense of marginalized communities.

The intersection of these factors necessitates the immediate implementation of a comprehensive reform package at multiple scales — both nationally and locally — which addresses both socio-economic issues and geography-specific problems. In order to address the environmental challenges present in Russia, policy should be implemented in the following manner: Subsidies for green technologies should be provided to remote areas — including solar systems and advanced waste treatment methods — to alleviate logistics hurdles; Community-based advocacy and monitoring programs should be developed within urban-industrial belts to provide a voice and authority to local populations; Tiered tax structures that reward companies who reduce their emissions and penalize companies that do not should be created at the national level to encourage the reduction of greenhouse gas emissions; Communities in rural and regional areas should have access to diversified income streams — including eco-tourism and green job training — and access to technology transfers from other countries in order to develop the capacity to respond to the increased likelihood of climate-related disasters caused by multipliers such as the thawing of permafrost and increased frequency of flooding.

Similarities between Russia's environmental situation and other transitional economies around the world are evident — i.e., China's rust belt provinces are home to large amounts of trapped pollutants related to coal use; the Appalachian region in the United States has been impacted by legacy mining activities; thus, the lessons learned in Russia can be applied to other transitional economies. Future research regarding environmental crises in Russia will require a combination of longitudinal

field work, GIS tracking, household surveys and modelling in order to develop more effective strategies for mitigating environmental impacts.

In summary, reducing environmental degradation in Russia requires moving beyond isolated solutions, and creating fairer development policies that balance human needs with planetary limits to ensure environmentally sustainable futures.

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