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Legal regime for Antarctic governance: Challenges and opportunities

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Abstract

The Antarctic Treaty System, a cornerstone of international cooperation, faces increasing challenges as the 21st century unfolds. This study examined the effectiveness of Antarctic Treaty System in addressing contemporary issues such as marine environmental protection, bioprospecting, and climate change. It analysed the strengths and weaknesses of the treaty, identified gaps in its coverage, and assessed its adaptability to future challenges. This study employed an interdisciplinary approach combining legal analysis, policy analysis, comparative analysis, and critical analysis, and delved into the treaty's provisions, limitations, and potential for reform. The findings of the study showed that although the Antarctic Treaty System plays a vital role in preserving the Antarctic as a global common, its ability to withstand new threats is limited. The study emphasised the need for a comprehensive system of marine protected areas, stricter regulations on bioprospecting, and stronger enforcement mechanisms. Key conclusions included the need for mandatory environmental impact assessments, the expansion of marine protected areas, sustainable tourism management, and effective climate change mitigation strategies. In addition, the article recommended strengthening the inspection regime, promoting international cooperation, recognising the rights of indigenous peoples, and intensifying scientific research. By addressing these issues and implementing the proposed reforms, the Antarctic Treaty System can continue to protect Antarctica's unique environment and ensure its long-term sustainability

Keywords:

Antarctic Treaty System; marine conservation; climate change; bio prospecting; indigenous peoples' rights; international cooperation

Introduction

Antarctic Treaty System (ATS) established in 1959, it has been instrumental in preserving Antarctica as a natural reserve devoted to peace and science to this day. However, the increasing human activities in the region, driven by scientific research, tourism, fishing, and potential mineral resources, pose significant challenges to the existing legal framework in its effectiveness. Special advanced icebreaking technology and satellite

navigation have opened areas previously inaccessible to human activity. This has led to increased pressure for resource extraction, tourism, and scientific research, often at the expense of environmental protection. These factors necessitate the examination of the Antarctic Treaty System in addressing this issue, and therefore this study aimed to assess whether this treaty can address these issues.

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Technology has transformed access to previously unreachable areas of Antarctica. Advanced icebreaking technology and satellite navigation systems have facilitated human activities in remote regions, intensifying pressures for resource extraction and tourism. According to S. Kakareka & S. Salivonchyk (2022), while scientific research stays a primary focus, it often comes at the expense of environmental protection. M. Howard (2023) stated that, with more researchers venturing into these fragile ecosystems, the potential for ecological disruption grows. Moreover, remote sensing and resource exploration technologies have emerged as double-edged swords. On one hand, they provide essential tools for monitoring environmental changes, enabling scientists to gather critical data on climate impacts and ecosystem health. On the other hand, these technologies have also ignited interest in exploiting untapped mineral and fossil fuel deposits. The allure of economic gain poses a severe threat to Antarctica's pristine environment, challenging the very principles upon which the ATS was founded.

The fishing industry has also evolved dramatically with the advent of modern technology. Fishing vessels equipped with advanced sonar and GPS capabilities have intensified fishing activities in Antarctic waters (Hughes *et al.*, 2022). This escalation has led to overfishing of key species like krill, which is crucial for maintaining the marine ecosystem. The decline of krill populations disrupts the food chain, negatively affecting predator species such as seals and penguins (Wauchope *et al.*, 2019). The consequences of overfishing extend beyond immediate ecological concerns; they threaten the long-term sustainability of marine life in the Southern Ocean. Additionally, some technologies associated with fossil fuel extraction and transportation contribute to greenhouse gas emissions. According to A. Purich & E.W. Doddridge (2023), these emissions accelerate climate change, leading to more rapid ice melting, rising sea levels, and ocean acidification in the Antarctic region.

The interconnectedness of these issues underscores the urgent need for a comprehensive assessment of the ATS's effectiveness in addressing contemporary challenges and its adaptability to future threats. Considering these mounting pressures, it is crucial to evaluate the capacity of the Antarctic Treaty to mitigate these changes. The ATS was designed to promote international cooperation and peaceful scientific inquiry while protecting the unique environment of Antarctica. However, its provisions require updates to stay relevant considering modern advancements and emerging threats. One area that necessitates reevaluation is the management of scientific research activities. While

scientific inquiry is essential, it must be balanced with environmental protection measures. Generally, all these contemporary changes necessitate a comprehensive assessment of the Antarctic legal regime in terms of its effectiveness in addressing the contemporary issues and its adaptability to future challenges. This study aimed to assess the capacity of the treaty to prevent such changes and to recommend areas of the treaty that need to be changed to address these advancements appropriately.

Materials and Methods

Considering the specific purpose and objective of this study, various methods of cognition were employed, which helped to contribute the most significant and meaningful scientific findings. This study primarily applied normative research methodologies, focusing on four methods, such as legal and policy analysis, literature review, critical analysis, and comparative analysis. The legal analysis method was employed to review the Antarctic Treaty¹ and its protocols², examining their provisions, limitations, strengths, and potential for adaptation. In addition, arguments and interpretations that were not explicitly stated are supported by references to relevant case law and legal opinion.

On other hand, the study employed policy analysis method to analyse various policies and regulations related to Antarctic governance, identifying their strengths, weaknesses, and implications for environmental protection and scientific research. In addition, the study employed a comparative analysis method, which was particularly useful for comparing the ATS with other international regimes, such as those governing the Arctic or the high seas. This helped to identify the best practices and lessons learned. The study applied the literature review methods to examine the existing academic literature on Antarctic governance. This allowed for the consideration of pivotal debates and nascent trends within the field, as well as consulting sources such as reports (British Antarctic Survey, 2017) to gain a more comprehensive understanding of the topic. Finally, the critical analysis method was employed to highlight the limitations of the current legal framework, identifying gaps in its coverage of emerging issues such as climate change, marine conservation, and bioprospecting, as well as to assess the effectiveness of the ATS in achieving its objectives, particularly considering the changing circumstances and arising challenges. Based on the analysis, potential solutions and reforms were proposed to strengthen the ATS and ensure the long-term protection of Antarctica.

This study covered a range of international regulations concerning the investigated subject, including the Antarctic Treaty System³ and Madrid Protocol to the

¹ The Antarctic Treaty. (1959, December). Retrieved from https://documents.ats.aq/keydocs/vol_1/vol1_2_AT_Antarctic_Treaty_e.pdf.

² Madrid Protocol to the Antarctic Treaty. (1991, October). Retrieved from <https://www.antarctica.gov.au/about-antarctica/law-and-treaty/the-madrid-protocol/>.

³ The Antarctic Treaty. (1959, December). Retrieved from https://documents.ats.aq/keydocs/vol_1/vol1_2_AT_Antarctic_Treaty_e.pdf.

Antarctic Treaty¹, United Nations Convention on the Law of the Sea (UNCLOS)², Convention on Biological Diversity³ (CBD), United Nations Fish Stocks Agreement⁴ (UNFSA), FAO International Guidelines (FAO, 2008). The study was informed by a range of secondary sources, including legal and scientific literature, journal articles, reports, and government publications. Furthermore, it presented a comprehensive analysis of the rate of Antarctic devastation and conducted a thorough review of the existing literature on the subject.

Results and Discussion

Analysis of the Antarctic Treaty System. The Antarctic Treaty⁵, a cornerstone of international cooperation, has established Antarctica as a global common dedicated to peace and scientific exploration (Alexander *et al.*, 2019). Article I of the treaty explicitly designates the continent as a “zone of peace”, prohibiting any military activity. This ground-breaking provision transformed Antarctica from a potential arena of geopolitical conflict into a sanctuary for international collaboration⁶. Central to the treaty’s ethos is the freedom of scientific investigation. Article II enshrines this principle, encouraging open exchange of scientific data and personnel. By fostering international cooperation in research, the treaty has facilitated ground-breaking discoveries in fields ranging from climate science to astrophysics. Article III outlines the procedures for the exchange of information regarding scientific programmes and has proved to be a pivotal instrument in the coordination of research activities and the avoidance of replication within the region.

To ensure unimpeded scientific inquiry, Article IV guarantees free access to Antarctica for all nations. This provision has been essential for maintaining the continent as a global laboratory, open to scientists from around the world. Recognising the complexities of territorial claims, Article V⁷ effectively set aside these disputes for the duration of the treaty, creating a stable environment for cooperation. Preserving Antarctica’s pristine environment has been a paramount concern. Article VI explicitly prohibits nuclear explosions and the disposal of radioactive waste, safeguarding the continent from the devastating effects of nuclear contamination. To uphold the treaty’s principles, Article VII establishes a robust inspection regime, allowing parties to verify compliance and deter potential violations.

Beyond its impact on Antarctica, the treaty has broader implications for international relations. Article VIII encourages cooperation between Antarctic Treaty Parties and other states on matters related to the continent. This provision has fostered a spirit of global partnership in addressing challenges such as climate change and marine conservation.

The Antarctic Treaty Consultative Meetings (ATCMs), established under Article IX⁸, serve as the primary forum for decision-making and cooperation within the treaty system. These meetings have been instrumental in developing measures to protect the Antarctic environment and manage human activities on the continent. To ensure the treaty’s adaptability, Article X outlines the amendment process, requiring unanimous agreement among the parties. Article XI provides for the establishment of a Secretariat to support the work of the ATCMs. This administrative body plays a crucial role in facilitating information exchange and coordinating activities. Article XII outlines the entry into force of the treaty, while Article XIII allows any state to accede to its provisions, expanding the treaty’s global reach. The Antarctic Treaty is a testament to the power of international cooperation. By establishing a framework for peaceful coexistence, scientific collaboration, and environmental protection, the treaty has ensured that Antarctica stays a pristine wilderness for generations to come.

The need for environmental protection in Antarctica (in-depth investigation). Antarctica, the southernmost continent, spans approximately 14 million km², with a mere 0.18% of its landmass being ice-free. This remote and largely uninhabited region is surrounded by the Southern Ocean, which boasts a rich and diverse array of marine species (Rodger, 2014). The continent itself serves as a crucial breeding ground for various bird and marine mammal species, contributing to significant biodiversity distributed across 16 recognised ice-free bioregions. As one of the Earth’s least visited and least understood continents, Antarctica holds immense intrinsic value. Its pristine environments are not only vital for the species that inhabit them, but also represent a unique opportunity for scientific exploration and understanding. (British Antarctica Survey, 2017)

The scientific significance of Antarctica cannot be overstated. Each year, researchers produce a wealth of information on various aspects of life, earth, and

¹ Madrid Protocol to the Antarctic Treaty. (1991, October). Retrieved from <https://www.antarctica.gov.au/about-antarctica/law-and-treaty/the-madrid-protocol/>.

² United Nations Convention on the Law of the Sea. (1982, December). Retrieved from https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf.

³ Convention on Biological Diversity. (1992, June). Retrieved from <https://www.cbd.int/doc/legal/cbd-en.pdf>.

⁴ Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. (1995, September). Retrieved from https://www.un.org/oceancapacity/sites/www.un.org.oceancapacity/files/files/Projects/UNFSA/docs/unfsa_text-eng.pdf.

⁵ The Antarctic Treaty. (1959, December). Retrieved from https://documents.ats.aq/keydocs/vol_1/vol1_2_AT_Antarctic_Treaty_e.pdf.

⁶ Ibidem, 1959.

⁷ Ibidem, 1959.

⁸ Ibidem, 1959.

physical sciences related to this unique environment. The continent offers unparalleled opportunities for monitoring and researching processes that are significant both globally and regionally. This tradition of scientific inquiry dates back to the International Geophysical Year, which marked a turning point in collaborative scientific efforts focused on Antarctica (Makanse, 2024). Since its discovery around 1820, Antarctica has undergone a series of transformations, particularly driven by human activities such as sealing, whaling, and fishing. These commercial exploitations have continued into the present day, particularly with the ongoing fishing activities in the Southern Ocean (Wauchope *et al.*, 2019). The early years of exploration were often characterised by a dual focus on exploitation and scientific discovery. Following World War II, there was a marked increase in scientific interest in the continent, culminating in significant collaborative efforts during the International Geophysical Year (IGY) from 1957 to 1958. This period coincided with heightened geopolitical tensions during the Cold War, leading to an increased perception of Antarctica as a “continent for science” (Alexander *et al.*, 2019).

As of 2022, over 100 research facilities operate in Antarctica, including 40 year-round stations and numerous seasonal stations. These facilities support research conducted by approximately 30 countries engaged in various scientific endeavours. However, alongside the growth of scientific research, tourism has also seen exponential growth over the past two decades. Currently, around 40,000 tourists visit Antarctica annually, primarily landing at a limited number of sites concentrated mainly on the Antarctic Peninsula and nearby offshore islands during the austral summer months from November to March (Kakareka & Salivonchyk, 2022). The duration of the summer tourism season is gradually expanding, resulting in prolonged pressure on already vulnerable environments. The development of infrastructure to support both scientific and tourism activities is becoming increasingly prevalent. This includes the construction and expansion of airstrips, research stations, and wharfs, often situated on scarce ice-free land. While these developments facilitate valuable research and economic activity, they also pose significant risks to the fragile Antarctic ecosystems (Guzeva, 2024). These human activities have had profound impacts on Antarctic environments – terrestrial, freshwater, marine, and ice systems have all been affected. Disturbances or displacements of wildlife are common consequences of increased human presence. Habitat destruction is another critical issue, as infrastructure development encroaches upon natural habitats essential for various species' survival. Furthermore, environmental pollution from human

activities poses a serious threat to these pristine ecosystems (Samari, 2015).

The introduction of non-native species is another pressing concern. As human activity increases in the region, so does the risk of invasive species establishing themselves in Antarctic ecosystems, potentially outcompeting native species and disrupting existing ecological balances. Additionally, over-exploitation of marine resources continues to be a significant threat. Illegal, unreported, and unregulated (IUU) fishing contributes substantially to the global catch of certain fish species, such as toothfish. This illegal activity not only depletes fish stocks but also leads to incidental mortality among seabirds and other marine life. The cumulative effects of these human activities underscore the urgent need for effective environmental protection policies in Antarctica. Considering that human activity is likely to continue intensifying and diversifying in the region alongside the rising pressures from external activities, Antarctica faces mounting conservation challenges (van den Hoff, 2024). These challenges necessitate prompt development and implementation of robust environmental policies aimed at safeguarding this unique environment.

In conclusion, the need for environmental protection in Antarctica is more pressing than ever. As human activities continue to encroach upon this pristine environment through scientific research, tourism, and resource exploitation, the potential for irreversible damage increases. To safeguard Antarctica's unique ecosystems and ensure their resilience against future challenges, as later discussed in this article, comprehensive environmental policy must be developed and implemented through international cooperation. Protecting this vital region is not only an ethical responsibility but also essential for maintaining global ecological balance.

The Antarctic: International legal frameworks for environmental protection. The Antarctic, a region of immense ecological significance, is primarily governed by the Antarctic Treaty and its associated agreements. However, several other international legal frameworks, while not explicitly addressing the Antarctic, have indirect implications for the preservation of its ice and marine ecosystems (Madani, 2023). The United Nations Convention on the Law of the Sea¹ establishes a legal framework for the oceans, including the Southern Ocean surrounding Antarctica. While not mentioning Antarctica directly, the UNCLOS provisions on marine pollution, marine scientific research, and the conservation of marine resources have relevance to the Antarctic region. For instance, Article 92 of UNCLOS prohibits the discharge of pollutants into the sea, which could harm Antarctic marine life and ice. Additionally, the Convention's provisions on marine scientific research

¹ United Nations Convention on the Law of the Sea. (1982, December). Retrieved from https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf.

could contribute to understanding the impacts of climate change on the Antarctic ice (Article 103).

The UNFSA¹ focuses on conserving fish stocks in the high seas, including those potentially found in Antarctic waters. While the Agreement does not specifically address Antarctic fisheries, its principles of sustainable fishing and conservation measures could be applied to any fisheries operating in the region. The FAO Code of Conduct for Responsible Fishing also provides guidance on sustainable fishing practices, which could help protect Antarctic marine ecosystems and the ice they depend on (Section 5). Another significant international instrument is FAO (2008) International guidelines for the management of deep-sea fisheries in the high seas, which offer specific guidance for managing deep-sea fisheries, which are increasingly important in the Southern Ocean. These Guidelines emphasise the need for precautionary measures and ecosystem-based management, which are crucial for protecting Antarctic marine ecosystems and the ice they sustain. The FAO (2008) International Action Plan to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) addresses the problem of illegal fishing, which can have devastating consequences for marine ecosystems, including those in the Antarctic.

The Convention on Biological Diversity² aims to conserve biological diversity and ensure its sustainable use. While it does not explicitly mention Antarctica, the CBD's principles of sustainable development and biodiversity conservation are relevant to the region. The Convention's focus on ecosystem-based management and the protection of threatened species could help protect Antarctic marine ecosystems and the ice they depend on. The Convention on Migratory Species addresses the conservation of migratory species, which are often found in Antarctic waters. The CMS could contribute to the protection of Antarctic marine ecosystems by addressing the conservation needs of migratory species, such as seabirds and marine mammals³. The Madrid Protocol⁴ to the Antarctic Treaty⁵, while focused on environmental protection in Antarctica, also has implications for the preservation of ice. The Protocol in Article 7 prohibits any activities that could harm the Antarctic environment, including those that could contribute to climate change and ice loss. Additionally, the Protocol establishes a system for environmental impact assessment, which can help identify and mitigate potential threats to Antarctic ice. In conclusion, while

these international legal frameworks may not explicitly address the Antarctic ice, they have indirect implications for its preservation. By promoting sustainable fishing practices, protecting marine ecosystems, and addressing issues like pollution and climate change, these frameworks can contribute to the conservation of Antarctic ice and the unique ecosystems it supports.

Gaps and shortcomings of the current legal framework. The Antarctic Treaty System (ATS), a landmark achievement in international cooperation, faces increasing challenges as the 21st century unfolds. While the treaty effectively prohibits military activities and nuclear threats, as discussed above, its capacity to address emerging issues is becoming increasingly strained. One of the most pressing concerns is the lack of a comprehensive framework for Marine Protected Areas (MPAs). Although the Convention on the Conservation of Antarctic Marine Living Resources⁶ has made great strides, a more integrated approach within the ATS is necessary to safeguard marine ecosystems. This requires addressing issues such as sustainable fishing practices, marine pollution, and the impact of climate change on Antarctic waters.

The potential for bio prospecting, the exploration of Antarctic organisms for commercial purposes, poses another significant challenge. As scientific understanding advances, the economic value of Antarctic biodiversity grows, necessitating clear regulations to prevent overexploitation and ensure equitable sharing of benefits (Giménez *et al.*, 2024). The effectiveness of the ATS is also hindered by the lack of participation by some key states. While the treaty has garnered widespread support, there are still countries that have not joined the agreement. This limits the treaty's global reach and influence, potentially undermining its ability to address transnational challenges. It is imperative that a more robust environmental impact assessment (EIA) process be implemented to mitigate the environmental impact of human activities in Antarctica. While some consultative processes exist, a standardised EIA requirement would ensure that potential risks are systematically identified, assessed, and addressed before projects commence. This is crucial for large-scale infrastructure projects, such as research stations and tourist facilities (Tiwari, 2017).

The rapid growth of tourism in Antarctica poses major threats to the fragile ecosystem (Fan *et al.*, 2021). While the Protocol on Environmental Protection has

¹ Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. (1995, September). Retrieved from https://www.un.org/oceancapacity/sites/www.un.org.oceancapacity/files/files/Projects/UNFSA/docs/unfsa_text-eng.pdf.

² Convention on Biological Diversity. (1992, June). Retrieved from <https://www.cbd.int/doc/legal/cbd-en.pdf>.

³ Convention on Migratory Species. (1979, November). Retrieved from <https://www.cms.int/en/convention-text>.

⁴ Madrid Protocol to the Antarctic Treaty. (1991, October). Retrieved from <https://www.antarctica.gov.au/about-antarctica/law-and-treaty/the-madrid-protocol/>.

⁵ The Antarctic Treaty. (1959, December). Retrieved from https://documents.ats.aq/keydocs/vol_1/vol1_2_AT_Antarctic_Treaty_e.pdf.

⁶ Convention on the Conservation of Antarctic Marine Living Resources. (1982, April). Retrieved from https://documents.ats.aq/keydocs/vol_1/vol1_12_CCAMLR_CCAMLR_e.pdf.

established guidelines, more stringent regulations are needed to manage visitor numbers, control their impact, and protect sensitive areas. Implementing a licensing system for tour operators, establishing visitor quotas, and designating specific tourist zones could help minimise disturbance to wildlife and habitats. Climate change is rapidly transforming the Antarctic environment, affecting ice shelves, sea levels, and marine ecosystems. While the ATS has recognised climate change as a threat, the treaty itself lacks concrete mechanisms to address its impacts. Strengthening the ATS's capacity to coordinate international efforts to mitigate and adapt to climate change is crucial. This could involve developing joint research programmes, sharing data, and implementing cooperative measures to reduce greenhouse gas emissions. The ATS primarily focuses on environmental protection and scientific research, with limited consideration for the rights and interests of Indigenous peoples who have historical and cultural connections to the region. While not explicitly recognised in the treaty, the rights of Indigenous Peoples should be acknowledged and respected. This could involve consulting with Indigenous communities on Antarctic-related matters, incorporating traditional knowledge into research and conservation efforts, and ensuring that their cultural heritage is protected. To address these challenges, the ATS must evolve to meet the demands of the 21st century. This requires strengthening international cooperation, adopting a more proactive approach to environmental protection, and ensuring that the treaty stays relevant in the face of rapid global change. By addressing these issues, the ATS can continue to safeguard Antarctica for future generations.

Potential reforms and opportunities. To address the gaps in the Antarctic Treaty System, a multifaceted approach is essential. First and foremost, implementing mandatory Environmental Impact Assessments (EIAs) for all human activities in Antarctica is crucial. These assessments will ensure that potential environmental impacts are thoroughly evaluated, fostering transparency and accountability through public consultation. Additionally, expanding Marine Protected Areas (MPAs) and establishing no-take zones in critical habitats will serve to safeguard biodiversity, while robust monitoring and enforcement mechanisms will deter illegal activities. Moreover, developing a sustainable tourism management plan is vital. This plan should include visitor quotas and strict regulations for tour operators, minimising ecological impacts while promoting environmental education among visitors. In conjunction with this, it is imperative to integrate climate change considerations into all Antarctic activities. Supporting research on the impacts of climate change and facilitating international collaboration to reduce greenhouse gas emissions will be essential in preserving the integrity of this fragile environment.

Strengthening the inspection regime is another key recommendation. Leveraging advanced technologies such as satellite imagery and drones can enhance compliance with treaty obligations, while establishing a dedicated enforcement unit will bolster monitoring efforts. Furthermore, acknowledging Indigenous Peoples' rights and enhancing their participation in decision-making processes will enrich governance frameworks and ensure that diverse perspectives are considered. In addition, prioritising capacity building for developing countries is vital to ensure equitable participation in Antarctic governance and research. This will help create a more inclusive environment where all nations can contribute to the stewardship of Antarctica. Research efforts should also focus on critical issues such as climate change and biodiversity, promoting open data sharing and facilitating technology transfer to foster international collaboration. Furthermore, developing comprehensive regulations for bio prospecting is necessary to address emerging interests, along with establishing a moratorium on mineral resource extraction to protect the environment from potential exploitation. Finally, assessing the impacts of latest technologies will ensure their responsible use in Antarctica.

The aforementioned analyses exhibit both similarities and differences when compared to previously conducted research on the subject of Antarctica. S.L. Chown *et al.* (2022) and E. Cabrera (2015) found that even though the Antarctic Treaty System (ATS) recognises ice melting in the region as a threat to the global community, there is no mechanism set up under the ATS to prevent such occurrences. The study also found that there is no recommended mechanism to prevent ice melting, even though the treaty considers it a threat. Additionally, the researchers' findings urge for immediate global collaboration among governments, civil society, NGOs, and all stakeholders to take part in saving Antarctica; the present study also supports this viewpoint.

Although previous research, such as that conducted by Y. Yermakova (2021) and S. Prior (2022), has touched upon the impact of emerging technologies, this article provides a more detailed examination of the specific challenges posed by advancements in areas such as remote sensing, artificial intelligence, and biotechnology. This difference in findings may be related to the fact that the previous studies were written before the emergence of these technologies and thus could not address them, which accounts for the difference in conclusions. Furthermore, the theory of global commons states that global commons have been conventionally defined as those parts of the planet that fall outside the scope of national jurisdictions and to which all nations have access. Four global commons are identified, namely, the High Seas, the Atmosphere, Antarctica, and Outer Space, which belong to all nations without being owned by any one nation or group (Bosio & Torres, 2019).

While many previous studies, such as those by G. Lowe & H. Lewis-Jones (2014) as well P. Uribe (2015), focused on the environmental and scientific aspects of Antarctica, the present study delved deeper into the geopolitical implications of the region. It discussed the potential for strategic competition and the role of emerging powers in Antarctic affairs, examining how this competition could affect the region and transform it into a zone of conflict and competition that affects wildlife and bioprospecting in the area. Previous studies did not analyse these issues from such a profound perspective. To address this, the researchers highlighted the role of science diplomacy in fostering international cooperation and addressing global challenges. They discussed how scientific collaboration can help bridge political divides and promote peaceful coexistence rather than competition in the region. Additionally, while previous studies by G. Lowe & H. Lewis-Jones (2014) did not observe the possible effects of tourism in a different light, the present study offered a more detailed analysis of the environmental impacts of tourism in Antarctica. It discussed the need for stricter regulations and sustainable tourism practices to minimise disturbances to wildlife and habitats.

In general, while this study is comparable to previous research in that it highlighted the lack of a mechanism within the Antarctic Treaty System to prevent ice melting, it also differs from previous studies in that it urges global collaboration. Furthermore, this study explored the changes posed by emerging technology, geopolitical implications, and the need for science diplomacy in greater detail than previous studies. Additionally, it emphasised the necessity of stricter regulations on tourism to mitigate the adverse environmental impact, offering a more compressive analysis than earlier studies.

Conclusions

This paper examined the efficiency of the Antarctic Treaty System (ATS) in addressing the contemporary challenges facing Antarctica. The primary objective was to assess the Treaty's capacity to protect the continent's unique environment and ensure its long-term sustainability. The study found that while the ATS has been instrumental in preserving Antarctica as a global common dedicated to peace and science, it faces significant challenges in addressing emerging issues such as marine protection, bioprospecting, and climate change. The study highlighted the need for a comprehensive

framework for Marine Protected Areas, stricter regulations on bioprospecting, and enhanced enforcement mechanisms. It also emphasised the significance of addressing climate change impacts, strengthening the inspection regime, and acknowledging Indigenous Peoples' rights.

Key findings include the need for mandatory Environmental Impact Assessments, expanded Marine Protected Areas, sustainable tourism management, and robust climate change mitigation strategies. Additionally, the study recommended strengthening the inspection regime, fostering international cooperation, acknowledging Indigenous Peoples' rights, and enhancing scientific research. The findings of this study have significant implications for international law, environmental governance, and scientific research. They provide valuable insights for policymakers, scientists, and stakeholders involved in Antarctic affairs, guiding efforts to protect this vital region for future generations. This study contributes to the ongoing discourse on Antarctic governance by offering a comprehensive analysis of the ATS's strengths, weaknesses, and potential for reform. The study highlighted the urgent need to adapt the Treaty to the evolving challenges of the 21st century. By addressing these challenges, the international community can ensure that Antarctica stays a pristine wilderness and a beacon of international cooperation.

Areas for further research include a more in-depth analysis of the economic impacts of tourism and scientific research on Antarctic communities, a comparative study of the ATS with other international environmental regimes, and an exploration of the role of emerging technologies in Antarctic governance. Additionally, further research is needed to assess the effectiveness of proposed reforms and to develop innovative solutions to address the complex challenges facing Antarctica.

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Conflict of Interest

The authors of this study declare no conflict of interest.

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Правовий режим управління Антарктикою: виклики й можливості

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Анотація

Система Договору про Антарктику як наріжний камінь міжнародного співробітництва постає перед новими викликами ХХІ століття. У цьому дослідженні було розглянуто ефективність системи Договору про Антарктику для розв'язання сучасних проблем, таких як захист морського середовища, біорозвідка та зміна клімату. Проаналізовано переваги й недоліки Договору, виявлено прогалини в його охопленні, оцінено його адаптивність до майбутніх викликів. У дослідженні використано міждисциплінарний підхід, що поєднував правовий, політичний, порівняльний та критичний аналіз, а також поглиблений аналіз положень договору, його обмежень і потенціалу для реформування. Результати засвідчили, що хоча Система Договору про Антарктику відіграє життєво важливу роль у збереженні Антарктики як глобального надбання, її здатність протистояти новим загрозам є обмеженою. Дослідження дозволило стверджувати про необхідність створення всеосяжної системи морських природоохоронних територій, суворіших правил щодо біорозвідки й механізмів правозастосування. Серед основних висновків – необхідність обов'язкового оцінювання впливу на довкілля, розширення морських природоохоронних територій, сталого управління туризмом й ефективних стратегій пом'якшення наслідків зміни клімату. У статті рекомендовано посилити режим інспекцій, сприяти міжнародному співробітництву, визнати права корінних народів й активізувати наукові дослідження. Вирішення цих питань і впровадження запропонованих реформ дасть змогу Системі Договору про Антарктику продовжувати захищати унікальне довкілля Антарктики, забезпечувати його довгострокову стійкість

Ключові слова:

Система Договору про Антарктику; збереження морського середовища; зміна клімату; біорозвідка; права корінних народів; міжнародне співробітництво