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Climate Change is not a Distant Multidimensional Risk

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The importance of this vast Atlantic space is widely recognized for the development of a sustainable economy in coastal states and island nations and is vital for carbon absorption, climate regulation, and stabilization, through ocean currents such as the Atlantic Meridional Overturning Circulation, as well as in coastal protection.

However, the Atlantic basin must also be understood as a complex and evolving security space marked by unpredictability that spans the entire region. It serves as the backdrop for a range of risks and threats that can challenge international law and impact human security. In this context, the coast, or shoreline, as a boundary, becomes superficial, as insecurity on land and at sea is deeply interconnected through transnational flows.

The Atlantic Centre, as a strategic platform for cooperation and dialogue among Atlantic nations, plays a growing role in addressing these complex common challenges, recognizing that climate issues are no longer solely environmental concerns but critical security matters that demand coordinated, informed, and cross-sectoral responses.

To that effect, the V Maritime Security Course, organized by the Atlantic Centre, took place in the Azores, from June 2 to 6, bringing together experts, policymakers, and civil society representatives from 36 nations. This year's theme, "Climate Change and Security Challenges in the Atlantic," underscored the growing recognition of climate change as a pressing, multidimensional risk that transcends not only environmental concerns but also poses risks to development, stability, and human security across the Atlantic region.

The impacts of climate-induced environmental shocks on society are not uniform around the world and differ according to the various natural conditions of each region, as well as the social, economic, political, and cultural environment¹. According to the Global Risks Report Perception Survey, Figure 1 illustrates that, over the past five years, respondents have consistently perceived climate change as the most severe global risk over the coming decade.

	1st	2nd	3rd	4th
2025	State based armed conflict	Extreme weather events	Geoeconomic confrontation	Misinformation and disinformation
2024	Extreme Weather events	Critical change to Earth systems	Biodiversity loss and ecosystem collapse	Natural resource shortages
2023	Failure to mitigate climate change	Failure of climate change adaptation	Natural disasters and extreme weather events	Biodiversity loss and ecosystem collapse
2022	Climate action failure	Extreme Weather events	Biodiversity loss	Livelihood crises
2021	Extreme Weather events	Climate action failure	Human environmental change	Infectious diseases

Figure 1 – The most severe risks on a global scale over the next 10 years
Source: Created by the author from World Economic Forum, Global Risks Report Perception Survey (2021 to 2025 editions)

Climate change is not a distant, multidimensional risk and will represent the “new normal”. Urgent action is required simultaneously to mitigate its causes and adapt to its effects through integrated solutions grounded in science, technology, governance, social justice, and cooperation, assuming there is no definitive knowledge and that a constant update is necessary with the use of pragmatic research that values the ability to transform the results obtained into useful and applicable actions.

¹ IFI-SDGs Unit Working Paper no. 4, Kazuyo Hanai, March 2021.

An example of this is the phenomenon of coastalisation, a trend which, combined with the already visible and projected sea level rise, poses a serious risk to the livelihoods of coastal and island communities and presents an important test to the resilience of maritime critical infrastructure.

Focusing on the Gulf of Guinea as a region that is already experiencing climate-induced changes in rainfall, ocean currents, and storm patterns, and given the region's dependence on rain-fed agriculture and fisheries, climate variability becomes an existential imperative for these communities whose food security and livelihoods become increasingly threatened.

On the other side of the Atlantic, in July 2024, the Caribbean region witnessed the formation of Hurricane Beryl², the earliest Category 5 hurricane on record and the first Category 4 hurricane to pass over the archipelago of St. Vincent and the Grenadines and the island of Grenada.

In April 2025, an unprecedented storm affected an important commercial port city in Argentina, Bahía Blanca³, which became a good example of how interagency cooperation is essential for crisis response.

Considering Central America, this year also saw an unprecedented event. The annual phenomenon of upwelling in the Gulf of Panama failed to occur in 2025 for the first time on record⁴. The finding underscores how changes in climate can directly affect essential ocean processes and the coastal populations that depend on them.

And up north, climate change is also taking its toll. This year, the Arctic space witnessed not only the second-lowest sea-ice volume on record but also the tenth warmest air temperatures. These environmental changes underline an important factor in transforming the world we live in, given the geopolitical, geoeconomic, and international law implications.

These examples highlight a simple yet daunting truth: the cross-border and multifaceted nature of

climate change impacts on the Atlantic and its coastal and island nations as a whole, emphasizing, once again, that geography and politics are no match for the transnational character of today's interconnected challenges.

Climate change is a present and growing reality that demands urgent, coordinated, and structured responses. Overcoming this challenge requires not only mitigating its causes but also adapting to its effects to safeguard environmental integrity, economic development, and security in the face of unprecedented atmospheric conditions.

Now, coming back to the V Maritime Security Course, the reflections developed during the course proposed a set of recommendations which underscore the importance of coordinated action that bridges scientific research, public policy, and civil-military (CMR) preparedness and readiness:

- Adopt Integrated Climate Strategies: Treat mitigation, adaptation, and prevention as complementary dimensions of a coordinated response;
- Develop a cohesive strategy and cross-departmental action plans: Align scientific research, governance, and technology to address systemic climate challenges effectively;
- Revise international legal frameworks, adapting legal frameworks to reflect new climate realities, including redefining maritime boundaries and creating legal protections for climate refugees;
- Invest in Sustainable Technologies: Focus on renewable energies and sustainable solutions tailored to the needs of vulnerable coastal, island, and maritime communities;
- Engage the private sector and academia, involving private sector and academia as partners in innovation, policy development, and knowledge dissemination.

It is in this increasingly complex and unpredictable environment that spaces like the Atlantic Centre gain new importance, and the “Whole-of-Atlantic approach” allows for a serious and realistic debate on the problems that affect the Atlantic.

² <https://gpm.nasa.gov/applications/weather/news/beryl-becomes-first-major-2024-atlantic-hurricane>

³ <https://www.reuters.com/business/environment/argentina-storm-leaves-six-dead-bahia-blanca-port-city-media-report-says-2025-03-07/>

⁴ <https://www.mpic.de/5770179/schwaechere-passatwinde-verhindern-tiefenwasserauftrieb-im-golf-von-panama>

The Atlantic region, as a shared space, entails a collective responsibility. Promoting sustainable development to build resilience, integrating climate-related risks into national security strategies, and strengthening early warning systems to enhance disaster preparedness are but a few of the challenges and opportunities we collectively face.

Closing on a note of unity and shared responsibility, the call is for a renewed Atlantic commitment, one that is grounded in science, driven by dialogue, and focused on resilience. The message can't be clearer: no country can face these challenges alone.

Only through collective action, embodying the true Atlantic spirit of cooperation, can we safeguard our shared future. There is no other viable course forward.

Climate Change and Maritime Security in Ghana and Nigeria

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Introduction

Climate change is increasingly recognised as a critical factor in shaping maritime security across the globe. The interactions between environmental change, economic stability, and human security are complex; however, direct policy and analytical frameworks remain underdeveloped. Scholars and policymakers alike emphasise the need for multidisciplinary approaches to understand how climate change drives maritime insecurity, such as illegal fishing, migration, and resource conflict. While these links are acknowledged, factors such as migration pressures and economic disruption dominate the discourse, while climate change is not widely considered as a precursor to maritime security (Brennan & Germond, 2024; Germond & Ha, 2018).

The Atlantic Context

The Atlantic Basin highlights diverse climate-induced maritime risks. In the Western Tropical Atlantic and Caribbean, escalating hazards such as

hurricanes, storm surges, and sargassum blooms disrupt maritime transport and threaten coastal livelihoods (Hillebrandt-Andrade et al., 2021; Moore et al., 2017). In the Northwest Atlantic, climate models project significant sea surface temperature increases and altered ocean currents, leading to habitat loss and the redistribution of marine species, with direct consequences for fisheries and food security (Alexander et al., 2020; Braun et al., 2023; Franco et al., 2020). The South Atlantic is experiencing similar shifts, with the intensification and southward movement of the Brazil Current reshaping both industrial and small-scale fisheries (Franco et al., 2020). These environmental transformations amplify non-traditional maritime security threats, including illegal fishing and human trafficking, by exacerbating resource scarcity and economic instability (Mazaris & Germond, 2018). Calls for integrated risk assessment tools and adaptive governance frameworks are growing, although their operationalisation remains a challenge (Germond & Ha, 2018).

Gulf of Guinea Vulnerabilities

Within this wider Atlantic picture, the Gulf of Guinea (GoG) emerges as a particularly vulnerable subregion. Long regarded as a maritime haven sustaining coastal communities and national economies, the region is now warming at rates exceeding the global average, with temperatures rising between one and three degrees Celsius since the 1970s and further shifts projected by the 2040s (Khomsi et al., 2023). Rising sea surface temperatures, erratic monsoons, and accelerated coastal erosion are reshaping littoral environments in ways that act as “threat multipliers”, intensifying pressures on populations, ports, fisheries, and offshore energy installations (Goodman et al., 2023).

In Ghana, erosion from the Ada estuary to the Volta Delta threatens fishing settlements, inundates roads, and undermines coastal activities (Brempong et al., 2023). Harmattan-induced upwelling shifts pelagic species farther offshore, beyond the reach of the limited patrol fleets (Amponsah, 2015; Cook et al., 2021). Nigeria, with a coastline six times longer, faces compounded flooding and pollution in the Niger Delta (Musa et al., 2014; Balogun, 2022), while plastic-laden runoffs disrupt navigation and contaminate marine ecosystems. The poleward migration of fish stocks, such as sardinella and mackerel, threatens

fisheries relationships among communities, with the potential to escalate into interstate disputes (Kapstein, 2023).

Climate Change as a Security Risk Compounder

Rising sea temperatures alter fish migration, erode shorelines, and reduce catch volumes, forcing artisanal fishers to migrate to new fishing grounds. Many are drawn into informal or illicit economies, including piracy, smuggling, and human trafficking (Otto & Jernberg, 2020). Piracy and armed robbery at sea typically adapt to altered seasonal windows when patrol vessels are grounded by extreme weather (Jiang & LaFree, 2023). Coastal communities, stripped of mangroves and income, are driven to adopt precarious survival strategies that further erode maritime order. Climate-induced displacement is already visible, with millions projected to be forced to leave coastal zones by mid-century (IOM, 2008). West Africa is witnessing this phenomenon, as migrants embark on perilous sea voyages to Europe, driven by poverty, conflict, and environmental degradation.

Policy Gaps and Institutional Challenges

Despite these converging realities, academic and policy discourses remain compartmentalized. Climate research often emphasises terrestrial concerns such as agriculture and inland flooding (Hemat et al., 2025), while maritime security studies focus narrowly on pirates and smugglers (Song, 2023). Even where climate-security links are discussed, analyses are often global in scale (Timidi et al., 2024), obscuring the political and ecological differences between Ghana's centralised governance and Nigeria's fragmented federal structure. This disconnection leaves decision-makers without clear insights into how specific climate stressors translate into unique maritime security patterns.

The Gulf of Guinea is a clear example of how climate change is evolving from an environmental stressor to a catalyst for maritime insecurity. In Ghana, the collapse of small-pelagic fisheries has already undermined livelihoods, pushing some fishers into smuggling and piracy. In Nigeria, environmental degradation in the Niger Delta has compounded long-standing grievances, fuelling oil theft, human trafficking, and organised maritime crime. Both countries face the challenge of aligning climate adaptation with maritime security; however, their

responses remain uncoordinated. Ghana has invested in sea defence projects and policy frameworks, yet capacity gaps persist. Nigeria has developed naval and institutional initiatives; however, corruption and overlapping mandates limit their effectiveness.

Conclusion

This study, therefore, poses a single, urgent question: how does climate change become security volatility in the maritime domains of Ghana and Nigeria, and what can these countries do individually and collectively to manage the situation? Without a thorough comparative analysis of how climate stress contributes to maritime crimes, both countries may fail to act promptly, thus creating more problems than anticipated.

By situating Ghana and Nigeria within the broader Atlantic framework, there is evidence that demonstrates the Gulf of Guinea is not an isolated case but a vital component of the wider Atlantic basin. Its environmental and security dynamics are deeply interlinked with global trade, energy flows, and migration patterns. Insights from Ghana and Nigeria, therefore, enrich a broader Atlantic dialogue on climate – security interdependence, advancing the case for comprehensive and adaptive governance across the Atlantic.

In summary, to make strides and deal with pertinent challenges, it is expedient to approach maritime governance using a climate adaptation lens. This means that both national and regional actors must champion strategies that build the resilience of coastal communities, safeguarding livelihoods as a pillar of security. This will ensure the maritime futures of the region are secured for subsequent

Mapping and Monitoring Potential Deep-Sea Mining Areas in the Atlantic: Strategies for Environmental Protection and Sustainable Management

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Deep-sea mining in the Atlantic Ocean represents both a technological opportunity and a critical governance challenge. The growing global demand for strategic metals such as cobalt, copper, zinc, gold, silver, and rare earth elements has intensified interest in mineral deposits located along mid-ocean ridges, abyssal plains, and hydrothermal vent fields (Hannington et al., 2011; Halfar & Fujita, 2007). These resources are considered essential for energy transition, advanced electronics, and defense technologies. However, extraction at great depth poses substantial environmental risks, particularly related to sediment plume dispersal, heavy metal contamination, and damage to fragile benthic ecosystems (Glasby, 2000; Hauton et al., 2017). Recognizing these risks, Portugal has taken a pioneering step by approving Law no. 36/2025, which establishes a moratorium on deep-sea mining in the Atlantic until 2050. This legal measure reflects a precautionary approach and creates a strategic window to generate robust scientific knowledge that will underpin future environmental, regulatory, and security strategies.

Despite the economic promise of seabed mineral resources (Hoagland et al., 2010), global experience with deep-sea mining remains limited, and most of its environmental impacts are still poorly understood. Empirical studies demonstrate that sediment plumes produced during extraction activities can travel long distances from the source area, transporting fine particles and dissolved metals that may affect benthic and pelagic organisms well beyond the mining zone (Washburn et al., 2019). In hydrothermal vent ecosystems, exposure to such plumes has been associated with tissue necrosis, genetic damage, and increased mortality in habitat-forming cold-water corals and other sensitive fauna (Carreiro-Silva et al., 2022). In addition, variations in metal concentrations, particularly iron, may alter microbial diversity

and interfere with organic matter processing, further amplifying ecosystem impacts (Hansen et al., 2022). These findings illustrate how mining-induced disturbances may extend beyond localized extraction sites, potentially triggering cascading effects on ecosystem functioning, nutrient cycling, and biogeochemical processes (Boschen et al., 2016; Van Dover et al., 2020).

Although the International Seabed Authority (ISA) has advanced environmental guidelines to regulate exploration and exploitation in international waters, regulatory frameworks remain fragmented and insufficient to address the complexity of deep-sea ecosystems (Ardron et al., 2018; Washburn et al., 2019). This is particularly relevant in the Atlantic, where mineral resources are less characterized than in the Pacific's Clarion-Clipperton Zone and where baseline ecological and geochemical data remain scarce (Van Dover et al., 2020). The current moratorium period, therefore, provides a unique opportunity to fill these gaps through systematic mapping, environmental monitoring, and impact modeling, ensuring that future decisions are informed by science and aligned with Portugal's strategic maritime interests.

To address these challenges, the project proposes an integrative methodological framework that combines geology, ecology, geochemistry, and security studies. The first component focuses on geological and ecological mapping using existing datasets and GIS tools to identify mineral-rich zones and overlap them with biodiversity and habitat data to highlight ecologically sensitive areas. The second component evaluates environmental vulnerability through biodiversity indices, endemism analysis, and comparative modeling with analogous ecosystems, such as the Clarion-Clipperton Zone, allowing the prediction of areas where ecological impacts would be more severe. The third component develops predictive models for sediment plume dispersion and contaminant transport, supporting the design of monitoring strategies capable of anticipating environmental scenarios and assessing potential risks to both benthic and pelagic communities. Finally, the fourth component integrates environmental science with policy and Atlantic security considerations, linking mining activities to broader issues of maritime sovereignty, regional cooperation, and ocean governance.

The impacts of this project are expected to be multidimensional. Environmentally, it will support risk reduction through the creation of ecological baselines and predictive tools that inform precautionary management decisions. Strategically, it will reinforce Portugal's role in Atlantic maritime governance by integrating environmental and geopolitical dimensions into decision-making processes. From an operational perspective, the development of standardized monitoring protocols aligned with international standards will facilitate early detection of ecological disturbances and provide a basis for regulatory oversight. Scientifically, the project will generate open-access data, peer-reviewed publications, and policy briefs aimed at regulators, security actors, and stakeholders, strengthening capacity for evidence-based environmental governance.

Ultimately, this initiative will produce an atlas of potential deep-sea mining areas in the Atlantic, integrating mineral deposits with ecological sensitivity indices and security considerations. By establishing standardized monitoring frameworks and informing regulatory and strategic action, the project aligns environmental protection with national and international security agendas. This approach reflects the precautionary principle and underscores the strategic importance of science-based governance for the sustainable and secure management of Atlantic mineral resources.

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Defesa Transatlântica Contra Ameaças Híbridadas a Sistemas Espaciais

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O espaço tem-se afirmado como um domínio estratégico para a defesa transatlântica. Contudo, apesar da sua relevância, as ameaças híbridadas continuam a expor vulnerabilidades nas infraestruturas críticas espaciais. Neste contexto, apresentámos um projeto ao Atlantic Security Awards, que é uma iniciativa em resultado da parceria entre a Fundação Luso-Americana para o Desenvolvimento (FLAD), o Centro do Atlântico e o Instituto da Defesa Nacional (IDN).

O projeto tem o objetivo de reforçar a capacidade dos Estados-membros da União Europeia (UE) e dos Estados Unidos na América (EUA) na defesa e dissuasão de ameaças híbridadas, criando uma base científica e política sólida que promova a resiliência e a cooperação entre aliados transatlânticos. A iniciativa assenta em quatro objetivos principais: (1) identificar vulnerabilidades nos sistemas de defesa espacial transatlânticos; (2) aprofundar o conhecimento científico sobre ameaças híbridadas; (3) formular recomendações políticas baseadas em evidências científicas; e (4) promover o desenvolvimento de capacidades através de formação conjunta dirigida a futuros oficiais das academias militares da UE e dos EUA. O domínio espacial tornou-se um elemento essencial à defesa euro-atlântica, dada a crescente dependência de sistemas de comunicações, navegação, comando e controlo (Denis et al., 2020). A sua importância é amplamente reconhecida em documentos estruturantes da UE, como o EU Strategic Compass, materializando-se do outro lado do Atlântico, com a criação da US Space Force. No entanto, persistem múltiplas lacunas críticas, tais como a ausência de conhecimento transversal transatlântico e a falta de mecanismos integrados de resposta a ameaças híbridadas que afetem as infraestruturas espaciais. Estas ameaças híbridadas incluem ataques cibernéticos, sabotagem de satélites, manipulação de dados, interferências eletromagnéticas e campanhas de desinformação associadas a ativos espaciais. Dado que grande parte dos serviços civis e militares da UE e dos EUA dependem de sistemas espaciais, qualquer

perturbação destas infraestruturas tem impacto direto na segurança, na economia e na estabilidade política. Assim, o projeto parte da constatação prática de que a defesa do espaço é inseparável da proteção das infraestruturas críticas e das relações transatlânticas. O estudo integra conhecimentos das engenharias aeroespacial e industrial, das ciências militares e da ciência política, refletindo o caráter multidimensional das ameaças híbridas. Até ao momento, a investigação teórica que desenvolvemos permitiu criar modelos conceptuais sobre tipologias de ameaças híbridas, mas a sua aplicação ao domínio transatlântico da defesa espacial permanece limitada (Reis, 2024a; 2024b). Apesar dos crescentes investimentos, com orçamentos espaciais globais a ultrapassar os 100 mil milhões de euros em 2022 e um aumento de 16% em defesa espacial, as iniciativas de segurança mantêm-se dispersas e de reduzida escala. Os esforços atuais concentram-se em quatro eixos: (1) avaliação de ameaças; (2) resiliência e proteção de infraestruturas; (3) parcerias estratégicas internacionais; e (4) estímulo à investigação e desenvolvimento. Contudo, faltam estruturas integradas que convertam o conhecimento científico em medidas concretas. É precisamente nesse vazio que este projeto se posiciona. O projeto desenvolve-se em quatro etapas principais: Etapa 1 – Diagnóstico e avaliação de vulnerabilidades. Será realizada uma revisão sistemática da literatura (base de dados Scopus) e elaborada uma matriz de risco que identifique vulnerabilidades críticas nos sistemas espaciais da UE e dos EUA. Etapa 2 – Consolidação científica e consulta especializada. Será aplicado o método Delphi na recolha de contributos de peritos internacionais para validar as ameaças identificadas e propor medidas de mitigação. Etapa 3 – Formulação de recomendações políticas. Com base nas evidências recolhidas, será elaborada uma análise política com propostas concretas para reforçar a resiliência e a interoperabilidade transatlântica. O documento será submetido ao Instituto da Defesa Nacional (IDN) ou a entidade europeia equivalente. Etapa 4 – Formação e capacitação. Será desenvolvido um programa de formação online de curta duração (microcredencial), dirigida a estudantes das academias militares dos 27 Estados-membros da UE e da Academia Militar de West Point (EUA). O curso incluirá 8 horas de formação direta, 40 horas de trabalho em grupo e 8 horas de apresentações, totalizando 56 horas (2 ECTS). Esta fase visa criar uma cultura

comum de segurança e defesa no domínio espacial, estabelecendo redes de cooperação entre futuros líderes militares transatlânticos. Em relação ao impacto do projeto, esperamos que este influencie três áreas distintas: científica, política e educacional. Do ponto de vista científico, a publicação de artigos em revistas científicas de elevado impacto, como a *Acta Astronautica*, espera consolidar a investigação europeia na área das ameaças híbridas e dos sistemas espaciais. A criação de uma matriz de risco e de um modelo conceptual atualizado servirá de referência para futuras investigações e políticas públicas. Em segundo lugar, esperamos que as recomendações dirigidas à UE e aos EUA tenham valor operacional e estratégico, permitindo uma resposta coordenada a ameaças híbridas. Nesse sentido, a análise política apoiará decisores civis e militares, promovendo resiliência e cooperação tecnológica. Por fim, a microcredencial constituirá a primeira formação estruturada sobre defesa e dissuasão espacial transatlântica. A partilha de conhecimentos entre cadetes europeus e norte-americanos fomentará uma comunidade epistémica emergente no domínio da segurança espacial, com efeitos duradouros nas futuras lideranças militares. A médio prazo, o projeto poderá ser alargado a universidades civis com cursos de engenharia aeroespacial, ampliando a literacia de segurança espacial no meio académico não militar. No que respeita ao contributo inovador, o projeto é pioneiro ao propor um modelo de defesa e dissuasão híbrida específico para o domínio espacial, num formato transatlântico. No nosso entendimento, a articulação entre ciência e desenvolvimento de capacidades cria um círculo virtuoso entre o conhecimento produzido, que alimenta políticas, e estas, por sua vez, formam novos quadros capazes de implementar soluções. O sucesso deste projeto será avaliado com base em indicadores de desempenho como a capacidade de publicação científica e de análises políticas, bem como a adesão das academias militares ao programa de formação. Serão ainda aplicados questionários de avaliação junto dos estudantes para aferir a qualidade pedagógica e a aquisição de competências. Concluindo, o projeto “Defesa Transatlântica Contra Ameaças Híbridas a Sistemas Espaciais” responde às prioridades estratégicas da UE e da NATO na defesa de infraestruturas críticas (Weber et al., 2023) e na preparação de futuras lideranças para ameaças emergentes. A nosso ver, a ligação entre ciência,

política e ensino cria a base para uma cultura comum de segurança e defesa espacial atlântica, essencial para a dissuasão e resiliência face às ameaças híbridas do século XXI.



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