MILITARY LEADERSHIP AND CLIMATE CHANGE: DOING MORE, WITH LESS AND BETTER

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ABSTRACT

As we know, the world stands at a critical juncture – on the brink of irreversible damage due to global warming. This tipping point demands urgent, decisive action, leaving no space for indifference, hesitation, or delay. In this context, considering climate change as a threat multiplier, institutions with centuries – if not millennia – of history, such as the military, cannot afford to overlook this pressing glocal challenge. Given its vast social influence, operational reach, and sheer scale as a major collective force, the military has a unique responsibility to act. The question we seek to address is both timely and provocative: should military priorities remain exclusively focused on mission effectiveness, or must environmental efficiency – aligned with global climate preservation and mitigation goals – become an integral pillar of military doctrine and leadership decision-making. This transformation would transcend existing frameworks advocated by organizations like the United Nations and the European Union. Furthermore, we will explore which leadership models are best suited to navigate this dual imperative, balancing operational excellence with environmental governance.

Keywords: Climate change, effectiveness, efficiency, military leadership, mitigation.

1. INTRODUCTION

The world stands at a defining moment in history. According to the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change [IPCC], 2021; 2023) and leading scientific research (Rockström et al., 2009), humanity is approaching critical and potentially irreversible planetary tipping points. Climate change no longer represents a distant or abstract threat – it constitutes a real and present danger to global security, ecological stability, and human well-being. Sea-level rise, extreme weather events, desertification, and resource scarcity are not merely environmental issues. They are geopolitical catalysts that exacerbate social unrest, undermine development, and strain global peace and security infrastructures (Department of Defense [DoD], 2021; NATO, 2021; UNEP, 2022).

In this context, the armed forces – arguably one of the most structured and logistically powerful institutions in the modern world – occupy a unique and paradoxical position. Militaries are simultaneously contributors to and victims of climate change. On the one hand, the global military sector accounts for approximately 5.5% of total carbon emissions (UNEP, 2022), making it a major emitter of greenhouse gases and a consumer of vast natural resources. On the other hand, climate-related disruptions increasingly compromise military operations, readiness, and global humanitarian missions.

This duality presents a compelling imperative: armed forces must now navigate the challenge of maintaining strategic and operational effectiveness while simultaneously reducing their environmental footprint. As mentioned, climate change is widely recognised as a threat multiplier (NATO, 2021), military institutions can no longer remain away from global sustainability efforts. Their strategic, logistic, and normative capacities place them in a privileged position to lead by example in both climate adaptation and mitigation.

In this context, the question guiding this paper is urgent and forward-looking: should military strategy remain focused almost exclusively on mission effectiveness, or must environmental efficiency become a central pillar of military doctrine and leadership?

So, we aim to explore how environmental considerations can be systematically integrated into military strategy, doctrine, and decision-making. It also seeks to identify and analyse leadership frameworks – particularly transformational and adaptive leadership models (Bass & Riggio, 2006; Verfuerth et al., 2023) – that are capable of balancing mission readiness with sustainability, innovation, and long-term planetary stewardship.

Moving beyond compliance with international environmental norms, such as those of the United Nations Framework Convention on Climate Change (UNFCCC) or the European Green Deal, this approach calls for a fundamental paradigm shift. Military leadership must internalise ecological intelligence not as an external mandate but as a core component of resilience, foresight, and ethical command. As Dalby (2020) and Timmermans et al. (2024) argue, 'green militaries' are not a contradiction in terms: they are essential actors in the Anthropocene.

In addressing this imperative – to do more, with less, and better – militaries have the potential to shape a new defence and security narrative: one in which the protection of the planet becomes inseparable from the protection of people.

2. LITERATURE REVIEW

2.1 OVERVIEW AND CRITIQUE OF EXISTING LITERATURE

Recent literature explores the intersection of military leadership and climate change, emphasizing the dual role of armed forces: contributing 5-6% of global CO_2 emissions (Heede, 2019) and being impacted by climate-driven disruptions that compromise operational readiness (DoD, 2021). Strategic efficiency—the integration of operational preparedness and ecological governance—emerges as a solution, supported by transformational (Bass & Riggio, 2006) and adaptive leadership models (Heifetz et al., 2009), which drive innovations such as hybrid-electric vehicles and circular logistics (RAND, 2023; IPCC, 2022).

Critiques highlight biases in existing scholarship: an overemphasis on institutional reforms and technological fixes, neglecting cultural dynamics within military hierarchies and non-Western contexts (Bennett & Peters, 2020). Standardized metrics for assessing military ecological footprints remain underdeveloped, and qualitative case studies (e.g., NATO's solar-powered bases) limit generalizability (UNEP, 2022).

Theoretical foundations need to include: i. ecological footprint methodology (Wiedmann & Minx, 2008) to quantify emissions and resource consumption; ii. transformational leadership theory, aligning sustainability with institutional identity; iii. systems-oriented approaches (Rockström et al., 2023), linking logistics to planetary ecological thresholds.

Methodologies may combine: i. case studies (e.g., Finland's 2030 carbon neutrality targets); ii. Policy analyses (e.g., NATO's Climate Change Action Plan): iii. cost-benefit models (Global Commission on Adaptation, 2021).

Gaps and recommendations: i. cultural resistance (limited exploration of hierarchical barriers in non-Western militaries, for instance, from Asia and Africa; ii. metrics (absence of global standards for tracking 3 emissions in defense supply chains: iii. Echnology (underexplored potential of AI/blockchain for environmental transparency: iv. ethics (neglect of intergenerational equity as a driver of ecological stewardship).

2.2 PROPOSED EFFECTIVE METHODS AND ORIGINALITY

This study proposes employing comparative cross-national analyses to identify regulatory best practices, participatory action research to integrate junior personnel into sustainability initiatives, and lifecycle assessments to evaluate emerging technologies such as hydrogen-powered drones.

This review identifies a critical lack of interdisciplinary frameworks integrating leadership theory, climate science, and geopolitical analysis. It proposes leveraging cultural narratives (e.g., honor/duty) to foster ecological accountability and advocates for AI-driven systems and transnational governance. By synthesizing adaptive leadership with planetary boundaries, it positions militaries as pioneers in Anthropocene security (Dalby, 2020), transcending conventional policy critiques.

2.3 CLIMATE CHANGE AS A THREAT MULTIPLIER AND MILITARY RESPONSIBILITY

The ecological footprint, a metric quantifying human demand on natural ecosystems (Rees & Wackernagel, 2018), extends beyond greenhouse gas emissions to include unsustainable resource extraction, waste generation, and irreversible ecological damage. Military supply chains exemplify this multidimensional impact, with their reliance on fossil fuel-intensive vehicles, single-use materials in equipment, and insufficient waste management protocols (Bennett & Peters, 2020; DoD, 2021). For instance, “the armored vehicles, aircraft, and naval vessels accounting for over 75% of operational energy consumption” (DoD, 2021). Single-use materials, such as non-recyclable packaging and disposable equipment, further exacerbate waste streams, while inadequate disposal protocols – particularly in forward-deployed environments – often lead to environmental contamination (DoD, 2019; Falvo et al., 2015; Morales et al., 2024; Qayyum et al., 2021). Such practices create a 'triple burden' of carbon emissions, resource depletion, and ecological degradation and starkly contradict international climate mitigation frameworks, including the Paris Agreement’s goal of limiting warming to 1.5°C (IPCC, 2023), underscoring the urgency for systemic reforms in defence sector sustainability.

Climate change functions as a geopolitical threat multiplier, amplifying security risks by intensifying resource competition, mass migration, and interstate tensions (EU, 2020; NATO, 2021). Projections indicate that rising temperatures could reduce global crop yields by up to 30% by 2050, exacerbating water scarcity and displacing over 140 million people in climate-vulnerable regions by mid-century (World Bank, 2022). Concurrently, extreme weather events – such as intensified cyclones and prolonged droughts – destabilize fragile states, creating fertile ground for conflict (IPCC, 2023). Paradoxically, military infrastructure is both a contributor to and a casualty of these dynamics. Coastal naval bases face escalating risks from sea-level rise and storm surges, while inland installations grapple with operational disruptions caused by heatwaves and water shortages (DoD, 2021; UNEP, 2022). Recognizing this dual vulnerability, NATO (2021) and the United Nations (UN Resolution A/RES/75/212, 2021) have mandated the integration of climate resilience into defence strategies, including infrastructure hardening and disaster-response preparedness.

Nevertheless, the military sector remains a disproportionate environmental stressor. Defence activities account for 5-6% of global CO_2 emissions – surpassing the aviation industry – due to energy-intensive armaments production, fossil fuel-dependent deployments, and large-scale exercises (Heede, 2019; UNEP, 2022). Single fighter jet missions, for instance, emit over 25 tons of CO_2 hourly (Fly a Jet Fighter, 2023; Smith, 2012), while permanent bases in ecologically sensitive regions drive habitat fragmentation and toxic waste accumulation (Singer & Cole, 2020). These impacts are magnified in jurisdictions with lax environmental oversight, highlighting the need for binding transnational regulations (Mach et al., 2020).

To move 'more mission-ready with fewer emissions', armed forces must adopt the concept of the ecological footprint – a holistic measure encompassing direct greenhouse gas releases, material consumption, waste generation and ecosystem impacts (Wiedmann & Minx, 2008). Recent analyses reveal that military supply chains – ranging from diesel powered transport to single use plastic packaging – remain a largely under regulated environmental hotspot (Timmermans et al. (2024).

Urgent reforms are therefore required:

a) energy transition in military platforms, leveraging biofuels, hydrogen, and electrification where feasible (DoD, 2022);
b) green procurement standards, prioritising low impact materials and circular economy principles in equipment and rationing (EU Green Deal, 2020);
c) ecosystem based adaptation, integrating conservation and restoration of natural buffers – mangroves, wetlands and forests – into base and perimeter planning (IPCC, 2022);
d) robust environmental governance, including transparent carbon accounting, third party verification and stringent host nation environmental protocols for overseas deployments (UNEP, 2022).

However, we also find some important barriers to reducing the military food footprint:

a) cultural resistance, as hierarchical structures often oppose changes to entrenched practices (Heifetz et al., 2009);
b) budgetary constraints, driven by short-term financial cycles hinder long-term investments in sustainable infrastructure (Bar-El et al., 2009; NATO, 2021).
c) measurement gaps and challenges arise from the absence of globally recognized standardized metrics, impeding accurate tracking and assessment of progress (UNEP, 2022);
d) system integration challenges emerge as legacy technological infrastructures

encounter significant barriers to assimilating emerging digital solutions, creating persistent interoperability obstacles within modern technological ecosystems (Linhard, 1996).

Despite these difficulties, by embedding environmental efficiency as a core pillar of doctrine and command – alongside mission effectiveness – the military not only reduces its own vulnerability but also demonstrates national leadership in global sustainability. In doing so, armed forces can help stabilise climate vulnerable regions, support humanitarian responses to climate disasters, and contribute to the wider endeavour of mitigating and adapting to climate change as outlined in the Paris Agreement and UN Sustainable Development Goals.

2.4 MISSION EFFECTIVENESS VERSUS EFFICIENCY: A STRATEGIC DILEMA

The perceived tension between mission effectiveness and environmental efficiency constitutes a false dichotomy rooted in 20th-century industrial military paradigms, where operational success was narrowly defined through immediate tactical outcomes rather than systemic resilience (Dalby, 2020; Frerks et al., 2024). Contemporary security landscapes, however, demand a reconceptualization of effectiveness to incorporate sustainability as a force multiplier. This shift aligns with emerging frameworks of strategic efficiency – a synthesis of mission readiness and ecological stewardship that enhances long-term operational viability while mitigating climate risks (Bousquet et al., 2020; European Union Defence Agency [UEDF], 2022).

2.4.1 THE FALLACY OF THE TRADE-OFF NARRATIVE

Historically, military planning prioritized short-term mission success, externalizing environmental costs through fossil fuel dependency, resource-intensive logistics, and ecologically disruptive deployments (Crawford, 2019). This approach, however, engenders strategic vulnerabilities: reliance on fragile hydrocarbon supply chains exposes forces to geopolitical instability, while climate-driven disasters disrupt deployment timelines and base functionality (DoD, 2021; NATO, 2021). The DoD Climate Adaptation Plan 2022 underscores that 60% of critical bases face climate-related threats, directly compromising readiness (DoD, 2022). Conversely, integrating renewable energy systems – such as solar microgrids in forward operating bases – reduces logistical footprints and enhances energy security, enabling sustained operations in contested environments (Dalby, 2020; Timmermans et al., 2024; UEDF, 2022).

2.4.2 ENVIRONMENTAL EFFICIENCY AS OPERATIONAL INNOVATION

Emerging research demonstrates that environmental efficiency initiatives can yield dual dividends. For instance:

a) deploying hybrid-electric military vehicles to reduce fuel consumption by 20–30%, lowering emissions and refueling frequency in hostile zones (RAND Corporation, 2023);
b) promoting circular logistics frameworks, such as The Netherlands Ministry of Defene’s ‘Green Base Initiative,’ which reduced material waste by 40% through 3D-printed spare parts and closed-loop water systems, cutting costs while enhancing self-sufficiency (Van der Zwaan et al., 2021);
c) restoring mangroves around naval installations in Southeast Asia, mitigating storm surge risks by 25% and sequestering carbon (IPCC, 2022);
d) advancing carbon neutrality through fleet electrification and AI-driven energy optimization, as demonstrated by Finland’s Defence Forces targeting 2030 goals (Finnish Ministry of Defence, 2022); and

e) expanding renewable energy adoption and ecosystem restoration, including solar-powered NATO bases and African peacekeeping-led reforestation programs, cataloged in the Military Environmental Responsibility portal (Climate Sustainability Directory, 2024).

These cases exemplify the resilience-efficiency nexus, where sustainability measures directly contribute to mission assurance by reducing dependencies and vulnerabilities (Busby et al., 2022).

2.5 MILITARY LEADERSHIP FOR INTEGRATING CLIMATE MITIGATION AND ENVIRONMENTAL GOVERNANCE

To reconcile uncompromised operational effectiveness with environmental impact reduction, leadership paradigms must shift to grant sustainability strategic parity with mission readiness. Four complementary models – transformational, adaptive, systems-oriented, and ethical leadership – provide frameworks for defence organizations to embed climate mitigation and resilience across strategic frameworks and operations.

Transformational leadership, as theorised by Bass and Riggio (2006), relies on crafting a compelling, values driven vision that links environmental stewardship directly to institutional identity and long term effectiveness. In Finland's Defence Forces, for example, carbon neutrality has been reframed as a "readiness multiplier," with electrification of facilities and AI driven energy management embedded into their 2030 operational goals (Finnish Ministry of Defence, 2022). By institutionalising green metrics – such as carbon budgets and lifecycle emissions – into commanders' performance indicators, militaries can mirror the UK Royal Navy's sustainable procurement reforms and foster intrinsic motivation for ecological innovation (Ministry of Defence, 2023).

Adaptive leadership, defined by Heifetz et al. (2009), enables organisations to tackle ‘wicked’ problems like climate change through interative learning and decentralised decision making. The Netherlands ‘Green Base Initiative’ illustrates this approach: pilot programmes such as on site 3D printing of spare parts and waste reduction trials cut refuse by 40 % without compromising operational continuity (Van der Zwaan et al., 2021). Similarly, the U.S. Army’s partnerships with renewable energy firms to develop Net Zero bases demonstrate how cross sector coalitions can generate scalable solutions while preserving mission (Linnenluecke et al., 2021).

Systems oriented leadership employs holistic thinking to optimise resource flows, recognising interdependencies among logistics, security risks and ecological thresholds. The U.S. Army’s Net Zero Initiative exemplifies how waste to energy systems increase base autonomy and cut supply chain vulnerabilities (NATO, 2021). NATO’s Climate Change and Security Action Plan embeds resilience metrics in planning tools, ensuring that force posture remains aligned with scientifically derived planetary boundaries (Rockström et al., 2023).

Ethical leadership reframes environmental governance as a moral and strategic imperative. By emphasising intergenerational equity and a duty of care, commanders can counter narratives that sustainability undermines combat readiness. African peacekeeping contingents have pioneered reforestation programmes that reduce resource scarcity drivers of conflict while rebuilding critical ecosystems (Climate Sustainability Directory, 2024). Cost benefit analyses further validate such investments: Global Commission on Adaptation (2021) calculates a 4 to 1 return on sustainable infrastructure through avoided disaster relief expenditures.

Overcoming institutional inertia requires both quantifiable incentives – for instance, hybrid electric vehicles that cut fuel use by 30 % and extend operational range in austere environments (RAND Corporation, 2023) – and tactical synergies, such as hydrogen powered stealth drones that combine low detectability with zero in flight emissions (DARPA, 2023; NATO; 2022). These examples demonstrate that green policies can directly enhance, rather than detract from, mission capability.

In sum, the old dichotomy between efficacy and efficiency belongs to a bygone era. Leading militaries are already proving that ecological realism – the strategic integration of sustainability into every layer of command – strengthens defence rather than diluting it. From mangrove restoration around forward bases (IPCC, 2022) to solar powered expeditionary camps (Climate Sustainability Directory, 2024), the transformation is underway. As future conflicts increasingly hinge on environmental resilience (Cóbar et al., 2022), armed forces must adopt pluralistic leadership frameworks that embed planetary stewardship at the heart of doctrine, training and procurement – thereby making environmental efficiency the modern foundation of security.

2.6 CULTIVATE CLIMATE LITERATE LEADERSHIP THROUGH ADAPTIVE TRAINING

Military academies must overhaul their curricula to embed comprehensive modules on climate science, systems thinking and sustainability ethics, thereby equipping future officers with the skills to address intertwined operational and environmental imperatives. By integrating adaptive leadership frameworks (Heifetz et al., 2009) with practical instruction in AI driven energy management – as exemplified by Finland’s Defense Forces – institutions can develop commanders capable of anticipating, assessing and mitigating complex socio ecological risks (Finnish Ministry of Defence, 2022). This interdisciplinary approach not only reinforces strategic foresight and resilience but also ensures that decision makers internalize environmental stewardship as a core dimension of mission readiness.

3. RESULTS AND DISCUSSION

Our research reveals that the global military sector contributes significantly to environmental degradation, accounting for 5-6% of total CO_2 emissions, with fossil fuel-dependent logistics, energy-intensive platforms, and unsustainable supply chains being primary drivers. As we have shown, some case studies demonstrate tangible progress in reconciling operational effectiveness with environmental efficiency.

We can also note that leadership models proved pivotal in overcoming institutional barriers. However, transformational leadership, as applied by the UK Royal Navy, institutionalized carbon budgets into performance metrics, fostering a culture of accountability, and adaptive leadership enabled decentralized innovation, exemplified by the U.S. Army's Net-Zero partnerships with renewable energy firms. However, systemic challenges persist, including cultural resistance to change, short-term budgetary cycles hindering green investments, and a lack of standardized metrics for tracking environmental impact.

These findings underscore the viability of integrating environmental efficiency into military doctrine without compromising mission readiness. The dual dividends observed in case studies, align with strategic efficiency frameworks (Bousquet et al., 2020; UEDF, 2022), which posit sustainability as a force multiplier. Transformational leadership's emphasis on values-driven vision (Bass & Riggio, 2006) and adaptive leadership's iterative problem-solving (Heifetz et al., 2009) mirror theoretical constructs, validating their applicability to climate governance in hierarchical institutions.

Contradictions persist between short-term operational priorities and long-term sustainability goals. For instance, while hybrid-electric vehicles reduce emissions and refueling needs, upfront costs and legacy infrastructure delays adoption – a tension noted in budgetary analyses (Bar-El et al., 2009). Yet, the resilience-efficiency nexus demonstrates that environmental measures, such as ecosystem-based adaptation, directly mitigate climate risks to military infrastructure, thereby safeguarding operational continuity (IPCC, 2022; NATO, 2021).

The absence of binding transnational regulations remains a critical gap, as lax oversight in some regions exacerbates ecological harm (Mach et al., 2020). However, initiatives like the 'EU's Climate Defence Roadmap' and NATO's emissions-tracking protocols signal growing institutional alignment with global climate frameworks. The military's capacity for large-scale coordination makes it vital in climate action. By integrating ecological priorities into training and procurement, it can redefine security, proving environmental stewardship as essential to modern resilience – not a compromise.

4. SOME RECOMMENDATIONS FOR ENHANCING SUSTAINABILITY IN THE MILITARY SECTOR: A SCIENCE-DRIVEN FRAMEWORK

4.1 POLICY INTEGRATION: INSTITUTIONALIZE COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENTS

To mitigate the ecological footprint of military activities, systematic Environmental Impact Assessments (EIAs) must be mandated for all operational planning phases, including exercises, deployments, and infrastructure development (Digital Commons, 2023). These assessments should quantify direct and indirect environmental externalities, such as greenhouse gas emissions, resource depletion, and ecosystem degradation, using standardized frameworks like the ecological footprint methodology (Wiedmann & Minx, 2008).

4.2 TRANSPARENCY AND REPORTING: ADOPT PARIS-ALIGNED ACCOUNTABILITY MECHANISMS

Military institutions should publish annual sustainability reports adhering to the transparency requirements of the Paris Agreement (UNEP, 2022). These reports must include granular data on Scope 1-3 emissions, renewable energy adoption rates, and progress toward circular-economy targets (for example, waste reduction, material reuse). The UK Royal Navy's integration of carbon budgets into commanders' performance evaluations provides a replicable model for aligning accountability with planetary boundaries (U. K. Ministry of Defence, 2023).

4.3 CROSS-SECTOR COLLABORATION: ACCELERATE GREEN INNOVATION THROUGH STRATEGIC ALLIANCES

Partnerships with academia, NGOs, and private-sector innovators are critical to advancing sustainable military technologies. Collaborative initiatives could focus on scalable solutions such as:

a) bio-based materials, involving transitioning to biodegradable packaging and lab-grown protein to reduce supply-chain emissions, as highlighted in the Climate Sustainability Directory (2024);
b) renewable energy systems, including deploying hydrogen fuel cells for naval fleets or AI-optimized microgrids for remote bases, with examples such as NATO's solar-powered installations, a s set out by Linnenluecke et al. (2021).

4.4 EMBED SUSTAINABILITY INTO MILITARY DOCTRINE VIA REGULATORY ALIGNMENT

Military frameworks must integrate climate resilience and mitigation into core strategic documents, aligning with transnational standards such as the EU's Climate Defence Roadmap (2020) and NATO's emissions-tracking protocols (NATO, 2021). This includes revising procurement policies to prioritize low-carbon technologies (e.g., hybrid-electric vehicles) and circular-economy principles, as seen in Finland's carbon-neutrality targets for 2030 (Finnish Ministry of Defence, 2022).

5. CONCLUSION

The escalating climate crisis necessitates a paradigm shift in military strategy, transcending traditional trade-offs between operational effectiveness and environmental stewardship. As evidenced, climate change functions as a geopolitical threat multiplier, exacerbating security risks through resource scarcity, mass migration, and infrastructure vulnerabilities. Concurrently, the military sector remains a significant contributor to global, underscoring an urgent need for systemic reform. This duality demands that armed forces adopt strategic efficiency – a synthesis of mission readiness and ecological governance – to enhance long-term resilience while mitigating planetary degradation.

Key findings demonstrate that integrating environmental metrics into military doctrine, such as mandatory Environmental Impact Assessments (EIAs) and Paris-aligned sustainability reporting, reduces operational vulnerabilities. Case studies like Finland's carbon-neutrality targets (2030) and the Netherland's 'Green Base Initiative' (40% waste reduction) validate the dual dividends of sustainability innovations, including hybrid-electric vehicles and circular logistics. Furthermore, transformational and adaptive leadership models prove critical in overcoming institutional inertia, fostering climate-literate commanders capable of navigating socio-ecological complexities.

Cross-sector collaboration with academia and industry accelerates scalable solutions and ethical leadership frameworks further reframe sustainability as a moral imperative, exemplified by peacekeeping-led reforestation programs that address conflict drivers.

In short, the military's unique capacity for large-scale coordination positions it as a pivotal actor in the climate transition. By institutionalizing ecological realism – embedding sustainability into every layer of command – armed forces can redefine security paradigms, ensuring the protection of both people and the planet. This transformation not only safeguards operational viability but also aligns defence institutions with global climate imperatives, proving that environmental efficiency – the foundational capacity to do more, with less and better – is the cornerstone of 21st-century security.

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