



EUROPE



A Changing Climate

Exploring the Implications
of Climate Change for UK
Defence and Security

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Preface

This document is the Final Report of a study commissioned by the UK Ministry of Defence (MOD) in November 2019 to inform the ongoing development of the MOD's climate change strategy. It presents the main findings of the study, including:

- The strategic defence and security implications of climate change on UK MOD activities.
- A conceptual framework to help decision makers (i) map a range of impacts of climate change in relation to the MOD's strategic objectives, and (ii) inform policy development in this area.
- Recommendations to support the MOD in mitigating risks and adapting to the challenges and opportunities presented by climate change.

The work builds on existing MOD research on climate change, particularly in relation to the Development, Concepts and Doctrine Centre's (DCDC) *Global Strategic Trends – The Future Starts Today* (GST6). This study further expands on the potential implications of climate change identified in existing policy and analysis, offering new strategic insights on how the MOD should adapt to and mitigate the impacts of climate change.

This report will be relevant for the MOD, other government departments and for overseas partners with an interest in understanding the strategic effects of climate change and strengthening resilience in anticipation of climate-related challenges.

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Executive summary

This study explores the effects of climate change on UK defence and security

Temperatures have been rising across the globe since the 1950s.¹ This trend is expected to continue and temperatures are predicted to increase by 2.3–3.5°C by 2100, despite the 2016 Paris Agreement commitment to limit the global temperature rise to 1.5°C.² Floods, heavy rainfall, droughts, heatwaves, storms, hurricanes and other extreme weather events are also likely to become more frequent in the future.³ In the UK, flooding is expected to be one of the most pressing climate change risks to people, communities and buildings over the next five years,⁴ and rising temperatures could also induce heat-related deaths and the overheating of military installations, homes, hospitals, care homes, offices, schools and prisons.⁵

In this context, there is growing recognition that climate change may aggravate existing threats to international peace and security. The UN Security Council, for example, acknowledges climate change as one of the most urgent challenges to the maintenance of international security. Since 2019 the US, French and New Zealand defence departments have each published reports on the impacts of, and links between, defence and climate change. DCDC's 2018 *Global Strategic Trends – The Future Starts Today* (GST6) similarly highlights a wide range of implications of climate change on defence and security. Building on this work, the present study offers fresh insights into the defence implications of climate change in the UK context, as well as corresponding recommendations for the UK Ministry of Defence (MOD).

This Global Strategic Partnership (GSP) study was commissioned by the UK MOD to inform the ongoing development of the MOD's climate change strategy. Its overarching objectives are to identify the strategic implications of climate change for MOD activities out to 2035, and to support the development of an approach for assessing and responding to these implications.

In support of these objectives, this report has two research purposes:

1. **Developing a conceptual framework** to assist decision makers in mapping and understanding a broad range of potential implications of climate change for the MOD's activities.
2. **Providing strategies for risk mitigation and adaptation** in response to strategic implications of climate change identified through a literature review and research interviews.

To deliver the study objectives, the study team undertook a review of publicly available literature, conducted 12 research interviews, and delivered four analysis workshops.

¹ IPCC (2014).

² IPCC (2018).

³ DCDC (2018).

⁴ Kovats & Osborn (2017).

⁵ Kovats & Osborn (2017).

Climate change has a number of strategic implications for MOD activities

Climate change affects international defence and security in various ways, with rising sea levels in coastal regions, severe droughts in the sub-Saharan region and natural resource shortages likely to trigger population displacement and potential conflict. In regions where food shortages are combined with poor governance, climate change could also contribute to civilian protests, rioting and an increased likelihood of violent conflict.⁶ While recognising these wider security implications, our study focuses specifically on the strategic implications of climate change for UK MOD activities in relation to the Defence Lines of Development (DLODs): concepts and doctrine, training, personnel, infrastructure, equipment, information, organisation, logistics and interoperability. The following boxes summarise the strategic implications of climate change for each of the DLODs:

CONCEPTS AND DOCTRINE

- There is a growing need for concepts, doctrine and planning to reflect environmental considerations and there are opportunities for the MOD to demonstrate thought leadership in doing so. Given ongoing climate-related developments, there is likely to be a requirement for the MOD to conduct periodic reviews of assumptions in strategy setting, operating concepts and doctrine.
- An increase in Military Aid to the Civil Authorities (MACA) and Humanitarian Assistance and Disaster Relief (HADR) operations can be expected in response to climate change, which would have implications for force planning and the balance of national and international Armed Forces commitments.
- Climate change considerations will likely reinforce Fusion Doctrine and the Whole Force Concept.



TRAINING

- Coordination of military training activities could become more challenging, as extreme climate events could reduce the availability and accessibility of existing training sites.
- Certain skills – particularly related to engineering, search and rescue, evacuation, construction, air traffic control and diplomacy – may increase in demand in the Armed Forces, with a corresponding need for tailored training in these areas.
- Health and safety issues related to flooding, extremely high temperatures and physically demanding training programmes may increase.
- Climate-related developments may alter the design requirements for wargames and strategic training exercises, including a need to adapt these exercises for multiple simultaneous large-scale disasters.



PERSONNEL

- Personnel may have to operate in climate-degraded conditions more frequently, affecting physical and psychological well-being.
- Climate change can affect infectious disease transmission, and the spread of diseases could increase the need for medical assistance, vaccinations and personal protective equipment.



⁶ DCDC (2018).

INFRASTRUCTURE

- Military infrastructure in the UK and overseas (e.g. Permanent Joint Operating Bases, Diego Garcia) may become increasingly vulnerable to climate-related events.
- Overheating of military installations will render some processes, such as the movement of personnel and critical equipment, far more challenging.
- High temperatures could damage equipment in storage and increase demand for air-conditioning, resulting in higher energy costs and impact on the environment.
- Degradation of civilian infrastructure (e.g. energy grids, railroads, water systems and airfields) may also indirectly disrupt the MOD's activities.



EQUIPMENT

- Higher temperatures could impede the performance of existing equipment, and changes to the operating environment could increase the demand for climate-resilient equipment.
- Access to critical supply chain inputs (e.g. rare minerals) could be impeded by extreme weather events which could, in turn, increase violent conflict.
- Equipment storage temperature requirements and associated costs could increase.
- Civilian infrastructure that offers support to the armed forces, such as energy grids, railroads, water systems, airfields, may also be impacted by climate change and indirectly disrupt the MOD's activities.



INFORMATION

- Building a narrative to showcase the MOD's role in tackling climate change could become increasingly important, both at the national and international levels.
- This type of narrative could help secure buy-in from key decision makers for the MOD's climate change adaptation measures, as well as attracting resources for implementation.
- In addition, UK preparedness to deploy in response to climate-related events could become part of strategic messaging to UK and NATO allies and adversaries.
- If adversaries are seen to be more active in addressing climate change issues, this may have strategic implications for the UK's ability to project global diplomatic influence.



ORGANISATION

- Climate change could adjust the balance of existing military tasks and generate discussion on new activities and roles for the Armed Forces.
- Given the breadth of actors involved in responding to climate change, there is a need for a discussion of the responsive role and remit of the Armed Forces vis-à-vis the police, a specialised civilian force or volunteer local civilian services.
- Additional personnel with skills in engineering, diplomacy and humanitarian aid provision may be required to work in climate change-affected operating environments.



INTEROPERABILITY

- Climate change could increase the need for cooperation between a wide range of actors including the emergency services, other government departments (e.g. DfID, FCO, DfT, Defra, Met Office, Home Office), NGOs and NATO.
- In cases where NATO Member Nations are affected by climate change, this may compromise their ability to support Alliance activities, with detrimental effects on interoperability. The elevation of climate change on NATO's agenda may create opportunities for countries such as the UK to demonstrate thought leadership.



LOGISTICS

- Delivery of logistics support could be more difficult due to a lack of infrastructure or equipment capacity to access disaster-struck areas.
- As temperatures rise, there could be growing demand for critical supplies (e.g. water, fuels, medicine), as well as increased energy requirements to keep personnel cooler.
- Climate events may increase the need for surface vessels to access flooded areas, helicopters for rapid access to degraded areas, and mobile communication kits.
- An increase in HADR operations could result in rising logistics costs and a growing requirement for airlift, water supply, medical care and port and traffic control.
- The opening of the Arctic and High North and the diversity of actors involved could have implications for global shipping patterns, including for defence equipment transportation routes.

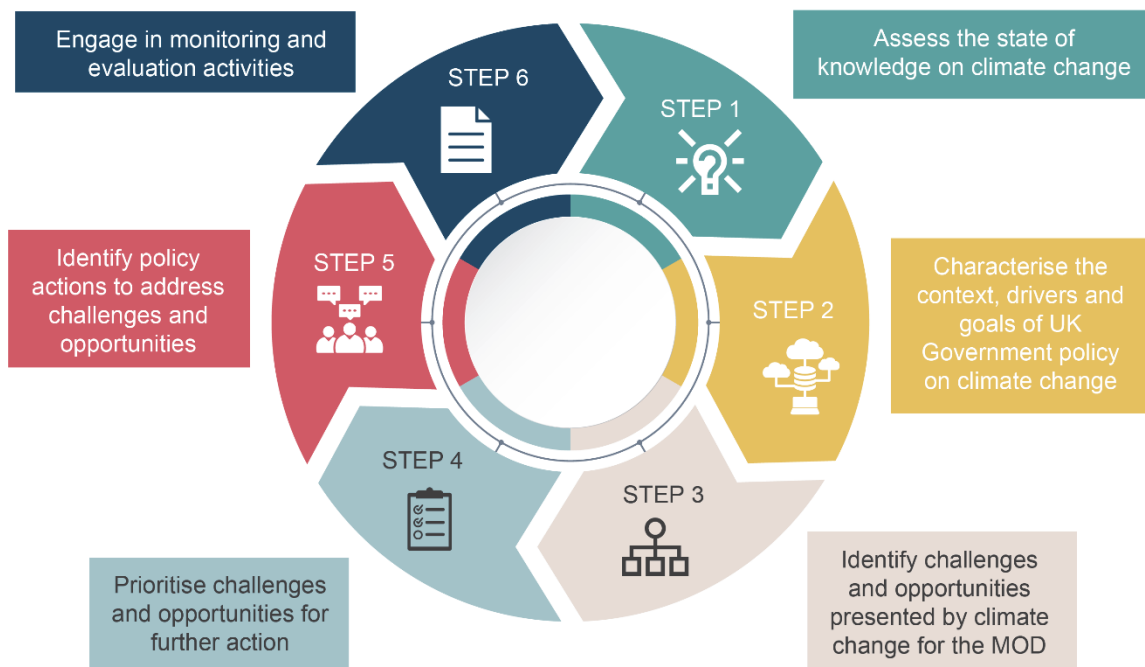


A core output of this study is a conceptual framework designed to support decision makers in understanding and responding to climate change

Based on the strategic implications identified, a central output of this study is an overarching conceptual framework (Figure ES-1) that is designed to assist decision makers in:

- Mapping a broad range of impacts of climate change in relation to the MOD's policy objectives.
- Identifying strategic opportunities associated with climate change to inform policy development.

Figure ES-1. Overview of conceptual framework



As illustrated above, the conceptual framework consists of six steps. The foundational steps are designed to improve the MOD's situational awareness, with Step 1 aiming to establish the existing state of MOD and cross-Government knowledge on climate change and Step 2 building understanding of UK government policy in this area. By first understanding the current state of knowledge (Step 1), the MOD will be well placed to identify appropriate analytical tools to understand associated risks and opportunities (e.g. risk assessment, scenario analysis, horizon scanning, sensitivity testing, cost-benefit/decision analysis). This step is particularly important, as traditional risk assessment methodologies are not well-suited to the inherent uncertainty of climate change. Mapping existing government policies on climate change (Step 2) will also help ensure that the policy actions identified under Step 5 are aligned with government priorities on climate change and support strategic objectives. Steps 1 and 2 are *defence-agnostic*, to help reduce the risk of missing key developments affecting other policy areas that, while not traditionally viewed as a threat to national security, may be relevant in the context of climate change.




Step 3 then examines the *defence-specific* implications of climate change to form the basis for a shortlisting exercise where priority challenges and opportunities are identified for further action (Steps 4 and 5). This shortlisting exercise could take the form of a workshop at which UK defence stakeholders undertake a high-level scoring exercise to prioritise challenges and opportunities for further action, based on qualitative and quantitative scoring of, for example, the urgency of the challenge faced, the time-sensitivity of the response required, and the financial and strategic costs of inaction. After developing a set of recommendations for policy action, Step 6 then focuses on ensuring that data is gathered on the effectiveness of policy actions against their planned outcomes, as well as informing future programming and priority-setting.




As Figure ES-1 shows, the conceptual framework is cyclical: as policy, threats and opportunities relating to climate change continue to evolve, it will remain important to periodically reassess the state of knowledge on climate change (Step 1), revisit the current policy context (Step 2), identify climate change challenges and opportunities for the MOD (Step 3), prioritise areas for further action (Steps 4 and 5) and engage in continuous monitoring and evaluation (Step 6).

This report presents six high-level recommendations for the MOD

This study draws on the findings presented above to generate a set of overarching recommendations for the MOD. These recommendations are listed in Table ES-1, along with the identified implication of climate change that each recommendation seeks to address and activities that could be undertaken to support their implementation.

Table ES-1. Recommendations for the MOD

Recommendation (R)	Corresponding implications for the MOD	Description and supporting activities for the MOD
<p>Recommendation 1: Develop a tool that enables the MOD to develop robust policy in response to climate change.</p>	 <p>There appears to be limited defence-specific information-gathering on the impacts of climate change on the MOD's activities.</p>	<p>Developing a tool to provide a structured means of understanding and responding to the effects of climate change on the MOD's activities</p> <p>Drawing on cross-Government consultation to implement this tool – which could take the form of the conceptual framework presented above</p> <p>Depending on the level of ambition, scaling up this activity to involve overseas and industry partners to learn from other countries and sectors</p>
<p>Recommendation 2: Leverage resources across government, civil society, emergency services and industry to coordinate on climate change-related issues.</p>	 <p>Climate change could increase the need for collaborative decision making, resource-sharing and communication across key stakeholders.</p>	<p>Engaging with other UK government departments and overseas partners to support a shared understanding of the threats and challenges of climate change</p> <p>Creating a centralised government database to capture information on climate change roles, activities and lessons identified for future planning</p> <p>Engaging with the Foreign & Commonwealth Office (FCO), Department for International Development (DFID) and other departments to strengthen regional cooperation in areas with likely HADR deployments</p> <p>Developing a set of HADR training case studies under a range of climate-related scenarios for the Armed Forces and for relevant agencies</p> <p>Creating wargaming exercises that support interoperability across the Armed Forces, emergency services, police, fire services and coastguard</p>
<p>Recommendation 3 Provide leadership on climate change issues at the strategic, operational and tactical levels.</p>	 <p>Concepts and doctrine do not consistently acknowledge climate change as a security driver or incorporate climate change as part of national security threat assessments.</p>	<p>Building on existing efforts to develop a clear strategy on <i>Climate Change for Defence</i>, including a roadmap of UK Defence responses</p> <p>Updating key documentation (e.g. <i>Strategic Defence and Security Review</i>, <i>Innovation Priorities</i>) to strengthen the focus on climate threats and opportunities for Defence</p> <p>Embedding climate resilience as a core part of strategic, operational and tactical planning, monitoring how climate change affects allies/adversaries</p> <p>Identifying funding options to support future MACA and HADR activities</p> <p>Considering a minimum level of climate impact Suitably Qualified and Experienced Personnel (SQEP) across the MOD</p>

Recommendation (R)	Corresponding implications for the MOD	Description and supporting activities for the MOD
		Developing a narrative to showcase the MOD’s role in tackling climate change and sharing this strategically
<p>Recommendation 4: Assess the resilience of Defence Estate infrastructure relative to the future operating environment.</p>	 <p>Military infrastructure in the UK and overseas may become increasingly vulnerable to climate events, and degradation of civilian infrastructure (e.g. energy grids, water systems) may also indirectly disrupt MOD activities.</p>	<p>Initiating a review of the ability of the MOD’s assets, infrastructure, estate and land holdings to withstand extreme climate and weather conditions</p> <p>Confirming a stakeholder engagement approach early to enable timely access to the best available information to inform the review</p> <p>Repeating the review periodically (e.g. every 5–10 years), and conducting a parallel review of UK civilian infrastructure that enables military operations</p>
<p>Recommendation 5: Increase the capacity and resilience of equipment relative to the future operating environment.</p>	 <p>Rising temperatures and other climate-related developments could impede the performance of equipment.</p>	<p>Critically assessing the resilience of equipment in a range of scenarios that exemplify possible impacts of climate change on the operating environment</p> <p>Considering mandating the inclusion of climate-resilient design features (e.g. ability to withstand extreme heat) in business cases for defence acquisition</p> <p>Considering investing in research into alternative fuel sources and energy-efficient innovations to reduce the vulnerability of fuel supply for Defence</p> <p>Incentivising the adoption of ‘greener’, all-weather defence equipment by initiating prize competitions to drive innovation in this area</p>
<p>Recommendation 6: Leverage research and innovation to mitigate risk.</p>	 <p>There appears to be limited defence-specific information-gathering on the impacts of climate change for the MOD’s activities.</p>	<p>Organising current MOD and government knowledge and understanding on climate change through stakeholder consultation (see Recommendation 1)</p> <p>Undertaking or commissioning research on key trends – e.g. in relation to the MACA/HADR trends, risks and opportunities created by climate change</p> <p>Exploring how best to harness emerging tools and capabilities (e.g. AI) to better understand contested concepts and priority areas on climate change</p> <p>Investigating the increased use of simulations to help deliver training when in situ training is not possible in climate-degraded environments</p> <p>Coordinating with partners across other government departments, NATO, overseas governments, academia and other sectors when setting climate-related priorities for research and innovation.</p>

Looking to 2035, the MOD could play a key role in developing robust policy and programming on climate change

As a defining issue of our time, climate change continues to evolve and disrupt UK defence and security. Resilience to climate change is likely to become a key focus area for the MOD and, as the findings of this study show, climate change will continue to affect a range of UK defence activities to 2035 and beyond. Personnel may have to operate in climate-degraded conditions more often – affecting physical and mental well-being – and climate events could reduce access to training sites, increase the vulnerability of military infrastructure, impede the performance of equipment, and compromise the delivery of logistics support.

In the face of these challenges, there is an ever-growing need for coherent policy and planning on climate change, with a key role for the MOD. The type of framework presented in this report could help support the MOD in developing robust policy in this area, involving collaboration with other climate change stakeholders to pool knowledge, share tools and resources, and learn from experience in other departments, sectors and nations. Looking to 2035, the MOD could further demonstrate thought leadership in mitigating and adapting to the challenges of climate change through evidence-based planning and delivery.

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Abbreviations

CCS	Civil Contingencies Secretariat
Defra	Department for Environment, Food and Rural Affairs
DfID	Department for International Development
DfT	Department for Transport
DIME	Diplomatic, Information, Military, Economic
DLODs	Defence Lines of Development
DoD	US Department of Defense
Dstl	Defence Science & Technology Laboratory
EDA	European Defence Agency
FCO	Foreign & Commonwealth Office
GSP	Global Strategic Partnership
GST	Global Strategic Trends
KPI	Key Performance Indicators
KSE	Knowledge, Skills and Experience
HADR	Humanitarian Assistance and Disaster Relief
IPCC	Intergovernmental Panel on Climate Change
M&E	Monitoring and Evaluation
MACA	Military Aid to the Civil Authorities
MOD	Ministry of Defence
NATO	North Atlantic Treaty Organization
NDPP	NATO Defence Planning Process
NGO	Non-Governmental Organisation
NSC	National Security Council
NSS	National Security Strategy
NSSIG	National Security Strategy and Implementation Group
NDPP	NATO Defence Planning Process

PESTLE	Political, Economic, Social, Technological, Legal, Environmental
PPE	Personal Protective Equipment
R&I	Research and Innovation
RAAF	Royal Australian Air Force
SAS	Special Air Service
SDSR	Strategic Defence and Security Review
SRO	Senior Responsible Owner
SQEP	Suitably Qualified and Experienced Personnel
WBGT	WetBulb Globe Temperature

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1. Introduction

This report presents the findings of Global Strategic Partnership (GSP) research into the implications of climate change for UK defence and security out to 2035.⁷ The study was commissioned by the UK Ministry of Defence (MOD) in November 2019 to inform the ongoing development of the MOD's climate change strategy.⁸

1.1. Context

In recent years, international organisations and ministries of defence have begun to acknowledge climate change as a prominent driver of security threats. The United Nations Security Council, for example, recognises climate change as a threat multiplier for peace and security issues,⁹ with climate-related events exacerbating resource scarcity and human security issues across the globe.¹⁰ Similarly, NATO's 2017 *Strategic Foresight Analysis* report finds that climate change creates challenges for governments' ability to provide for their populations,¹¹ while the MOD's 2018 *Global Strategic Trends* (GST6) report recognises the increasing disruption and cost of climate change.¹² Beyond these challenges, GST6 also acknowledges the growing need to understand the strategic implications of climate change to inform the MOD's defence and security planning assumptions.

The UK MOD and other national ministries of defence have published a range of strategic documents on the implications of climate change for defence. In the UK context, examples include a 2015 Met Office report assessing implications for selected UK Overseas Territories (e.g. St. Helena, Tristan de Cunha, the British Indian Ocean Territory),¹³ and a 2018 House of Commons Defence Committee report on UK

⁷ The GSP is an independent, interdisciplinary consortium responsible for the provision of research and analysis support to the DCDC Strategic Analysis Team. Led by RAND Europe, the GSP also includes the International Institute for Strategic Studies (IISS) and the University of Exeter as partners, along with an advisory panel of other organisations and individuals including QinetiQ, Newman Spurr Consulting, Aleph Insights, Simplexity Analysis and Sir Hew Stachan.

⁸ In this report, references to 'MOD' refer to the UK MOD unless otherwise specified.

⁹ UN News (2019).

¹⁰ INT 01; INT 11.

¹¹ NATO (2017).

¹² UK MOD (2018).

¹³ Wade et al. (2015).

Defence in the Arctic.¹⁴ The New Zealand Ministry of Defence also published a 2018 report on climate change and responsibilities for defence;¹⁵ while the French Ministry of Defence has released a report on its green defence¹⁶ commitments and research cooperation programmes on climate change and defence.¹⁷ The US Department of Defense's (DoD) 2019 report on the implications of climate change for DoD activities offers one of the most advanced publicly available documents in this area, covering the impacts of climate change on:

- Operations
- Mission execution vulnerabilities
- Humanitarian assistance and disaster relief (HADR)
- Defence support to civil authorities
- Testing
- Training
- Military installation resiliency
- Operational viability
- Research requirements on the intersection between defence and climate change.¹⁸

Building on this work, the present study offers fresh insights into the defence and security effects of climate change in the UK context, as well as corresponding recommendations for the MOD.

1.2. Study objectives

The overarching objectives of this study are to identify the strategic implications of climate change for UK MOD activities out to 2035,¹⁹ and to support the development of an approach for assessing and responding to these implications. In this report, MOD activities are categorised under the Defence Lines of Development (DLODs)²⁰ framework.²¹ This approach does not preclude the significant linkages and dependencies between the different DLODs, and interoperability should be considered as an overarching theme between the DLODs.

¹⁴ House of Commons, Defence Committee (2018).

¹⁵ NZ MOD (2018).

¹⁶ 'Green defence' refers to design features in defence equipment and infrastructure to limit environmental impacts, while ensuring the best possible match between operational performance and environmental efficiency.

¹⁷ French MOD (2018).

¹⁸ US DoD (2019).

¹⁹ The timeframe 'out to 2035' was selected to strike a balance between: (i) keeping the timeframe sufficiently large for study findings to have utility for MOD policy and planning; and (ii) keeping the timeframe sufficiently contained so as to reduce the uncertainty and speculation associated with the study findings.

²⁰ DLODs include training, equipment, personnel, information, doctrine and concepts, organisation, infrastructure and logistics; they offer a categorised framework for decision making on defence acquisition. In this report, the study team uses the DLODs as a way of clustering the UK MOD's activities.

²¹ UK MOD (2015).

In support of these overarching objectives, the study has two research purposes:

1. **Development of a conceptual framework** to assist decision makers in mapping and understanding a broad range of potential implications of climate change for the MOD's activities.
2. **Provision of strategies for risk mitigation and adaptation** in response to strategic implications of climate change identified through a literature review and research interviews.

This study builds upon existing MOD and wider defence work to support the development of an approach for assessing and responding to the implications of climate change for MOD activities.

To maximise the utility of this study for the MOD, the GSP study team sought to avoid:

- Repeating or duplicating existing work on climate change by the MOD.
- Focusing on academic research that contests climate change or climate conflict.
- Considering climate change as a driver of instability in isolation from other drivers, or as a priority over other threats, national security interests or threat assessments.
- Identifying specific solutions for capabilities, investments or infrastructure that the MOD should make across defence and/or DLODs.

It should be noted that there is inherent uncertainty in identifying the **implications** of climate change out to 2035, given that analysis of future trends and developments necessarily involves a degree of speculation. To strengthen the robustness of the implications identified in this report, they were triangulated by the study team by combining a literature review with expert interviews and a series of workshops.

1.3. Research approach

To deliver the study objectives, the study team:

✓ **Completed a targeted review of publicly available literature** on the implications of climate change for MOD activities and on potential options for a conceptual framework. The search was conducted using Google and Google Scholar, and involved a review of both academic and grey literature (policy reports and industry publications). 'Snowballing' was also undertaken to identify additional articles from the reference lists of selected articles, before the data was extracted and a narrative synthesis produced.

✓ **Conducted 12 semi-structured interviews**, combining a core question set with the ability to ask follow-up questions. The interviews elicited insights from experts representing the UK and US governments, NATO, the European Defence Agency (EDA) and academia identified through study team contacts and online searches. The focus of the interviews was on: (i) validating the literature review findings and gathering additional data on the implications of climate change; (ii) identifying climate change and security frameworks to inform the development of the conceptual framework; and (iii) eliciting potential recommendations for the MOD.

✓ **Delivered three internal workshops (W)** involving the core study team, at which literature review findings were synthesised (W1), the conceptual framework was developed and subsequently refined (W2), and recommendations for the MOD were identified (W3).

✓ **Facilitated one external workshop** to further refine the conceptual framework through consultation with the MOD and experts from industry, academia and other UK Government departments identified by the study team in consultation with DCDC.

For a more detailed description of the research approach, please refer to Annex A.

1.4. Report structure

In addition to this introduction, this report contains three further chapters:

- **Chapter 2** outlines the identified implications of climate change for the MOD's activities.
- **Chapter 3** illustrates the conceptual framework developed to help decision makers assess and respond to the UK defence implications of climate change.
- **Chapter 4** presents recommendations identified for the MOD to mitigate or adapt to the strategic implications of climate change.

Annex A details the methodology applied for this report.

2. Implications of climate change for the MOD

This chapter examines the strategic implications of climate change for the UK MOD's activities. Section 2.1 outlines the predicted effects of climate-related events on the environment, geopolitics and society; Section 2.2 outlines the strategic implications of climate change for MOD activities, framed in relation to the Defence Lines of Development (DLODs).

2.1. Environmental, geopolitical and societal effects of climate change

According to the Intergovernmental Panel on Climate Change (2014), temperatures have been rising across the globe since the 1950s – a trend driven by human activities and, in particular, carbon dioxide emissions.²² A 2018 IPCC report estimates that, despite the commitments of the 2016 Paris Agreement to limit the temperature rise to 1.5 degrees Celsius, temperatures will have risen by a predicted 2.3 to 3.5 degrees Celsius by 2100.²³ Extreme weather events, such as droughts, heatwaves, floods, heavy rainfall, storms or hurricanes, are also likely to become more frequent in the future.²⁴ Simultaneously, rising temperatures are changing the natural environment of the Arctic and High North, making it more accessible and transforming it into a new geostrategic area of focus.²⁵ By one estimate, the Arctic Ocean is likely to be ice-free before 2050.²⁶

Rising sea levels in coastal regions and severe droughts in the Sub-Saharan region are likely to trigger population displacement.²⁷ Other drivers of displacement could include natural resource shortages and competition as drinking water becomes scarcer and crop yields lower, or as crops are destroyed by extreme weather as in China where several studies indicate that crop yields for rice, wheat and maize will decrease.²⁸ The demand for food and energy is estimated to rise by 50 per cent by 2030, while water demand has been projected to increase by 30 per cent.²⁹ In regions where food shortages are combined with poor governance, climate change could contribute to civilian protests, rioting and an increased likelihood of violent conflict.³⁰

²² IPCC (2014).

²³ IPCC (2018).

²⁴ DCDC (2018).

²⁵ House of Commons, Defence Committee (2018).

²⁶ Overland & Wang (2013).

²⁷ INT 02; Resetar & Berg (2016); US DoD (2019); Spanish MOD (2018); NATO (2017).

²⁸ UK MOD (2018); UK MOD (2015); Met Office (2011).

²⁹ HM Government (2015).

³⁰ DCDC (2018).

In the UK, flooding, rising sea levels, modified rainfall patterns and extremely hot temperatures have been forecast in the 2017 *UK Climate Change Risk Assessment Report*.³¹ Flooding is expected to be one of the most prominent climate change risks to people, communities, buildings and historic landmarks in the UK in the next five years.³² As landfills are flooded, there is a further risk that flooding could lead to the wider spread of pollution.³³ Rising sea levels are likely to be further exacerbated by storms,³⁴ with the potential for a sea level increase of 0.5–1.0m eroding England’s coastal flood defences.³⁵ To illustrate the disruptive effects of extreme weather events for the UK, the World Economic Forum estimates that a 4.5km area of coastal railway would experience 84 days of disruption each year in the UK with a 0.55m sea level rise,³⁶ which would have detrimental impacts on overall UK prosperity.

Beyond flooding and rising sea levels, increasing temperatures and heatwaves in the UK could also induce heat-related deaths and cause the overheating of buildings including military installations, homes, hospitals, care homes, offices, schools and prisons.³⁷ At present, around 20 per cent of homes in the UK (4.5 million homes) currently overheat in the summer,³⁸ and rates of overheating would further increase with rising temperatures. When military installations and civilian buildings overheat, they not only become unsafe to use for the people working inside but also render processes such as the movement of personnel and critical equipment far more challenging. The overheating of infrastructure could also create challenges for engineering facilities, storage of sensitive equipment, and staging points for large numbers of personnel. Additionally, high temperatures could damage equipment in storage and increase demand for air-conditioning, resulting in higher energy costs and further impact on the environment.³⁹ Extreme weather could also disrupt transportation networks, create challenges for healthcare delivery or cause damage to critical national infrastructure. Climate change could in addition create more favourable conditions for UK mosquito species and increase rates of transmission for certain arboviruses.⁴⁰ Invasive species that migrate to the UK due to rising temperatures could also transmit West Nile virus, dengue fever, chikungunya and Zika, for example.⁴¹

³¹ HM Government (2015); Kovats & Osborn (2017).

³² Kovats & Osborn (2017).

³³ DCDC (2018).

³⁴ Met Office (2018).

³⁵ Kovats & Osborn (2017).

³⁶ World Economic Forum (2019).

³⁷ Kovats & Osborn (2017).

³⁸ Committee on Climate Change (2019).

³⁹ UK MOD (2016).

⁴⁰ Kovats & Osborn (2017). Note: an arbovirus is a virus transmitted to humans by arthropods (e.g. mosquitoes and ticks).

⁴¹ Baylis (2017).

2.2. Strategic implications of climate change for the MOD's activities

In the context of these wider environmental, geopolitical and societal impacts of climate change, specific implications for UK defence and security can be identified. These are presented below and structured in relation to the DLODs: concepts and doctrine, training, personnel, infrastructure, equipment, information, organisation, logistics and interoperability. While presented in relation to the separate DLODs, as noted in the following sections there are various links between implications across the DLODs. These strategic implications have been identified through a targeted review of grey and academic literature, interviews, internal workshops and an external workshop (see Section 1.3 and Annex A for further details).

2.2.1. Concepts and doctrine



In light of ongoing climate-related developments, there is likely to be a requirement for the MOD to conduct periodic reviews of assumptions in strategy setting, operating concepts, doctrine and joint operational planning.⁴² Many of the challenges and opportunities presented by climate change extend beyond the MOD's remit,⁴³ requiring an increased need for MOD collaboration with other government departments, international partners and non-defence stakeholders outside of UK government (see also Section 2.2.9).⁴⁴ Climate change considerations will reinforce Fusion Doctrine, which refers to the adoption of a 'whole-of-government' approach to addressing national security issues,⁴⁵ and the Whole Force Concept, which is an approach to human capability planning that draws on the security sector's 'total force', including regulars, reservists and contractor personnel.⁴⁶ Box 2.1 describes Fusion Doctrine and the Whole Force Concept in more detail.

Box 2.1. Fusion Doctrine and the Whole Force Concept

Fusion Doctrine is aimed at optimising the ability of the National Security Council (NSC) to develop national security strategy and implement decisions across government.⁴⁷ After the 2018 National Security Capability Review, cross-government structures and processes were established to support this overarching objective.⁴⁸ As part of these activities, a National Security Strategy and Implementation Group (NSSIG) was created for each of the NSC's national priority areas. Each NSSIG is led by a Senior Responsible Owner (SRO) at Director-General level, with SROs coordinating across government to enable collective decision making.⁴⁹

The **Whole Force Concept** envisages defence as an integrated force that is supported by the most sustainable, effective, integrated and affordable balance of regular military personnel, reservists, MOD

⁴² INT 11.

⁴³ INT 03; Resetar & Berg (2016); NATO (2017); US DoD (2019, 2014); GSP external workshop, 8 January 2020, DCDC Shrivenham.

⁴⁴ GSP external workshop, 8 January 2020, DCDC Shrivenham.

⁴⁵ UK Parliament (2019).

⁴⁶ UK MOD (2017).

⁴⁷ UK Parliament (2019).

⁴⁸ UK Parliament (2019).

⁴⁹ UK Parliament (2019).

civilians and contractors.⁵⁰ The concept stems from recognition of the recruitment and retention challenges experienced in the Army's element of Joint Force 2025,⁵¹ and is supported by the 2015 National Security Strategy and Strategic Defence and Security Review (SDSR).

Climate change is likely to reinforce both Fusion Doctrine and the Whole Force Concept, given that the implications for training, personnel, infrastructure, equipment, information, organisation, logistics and interoperability will **increase the need for MOD engagement with other departments, nations and sectors, as well as industry** in responding to these challenges. As outlined below and in Section 2.2.3, a growing need for Humanitarian Assistance and Disaster Relief (HADR) operations and Military Aid to the Civil Authorities (MACA) will also require the involvement of personnel with certain skills (e.g. engineering skills for reconstruction), which may be offered by regulars, reservists and/or contractors.

In the future, climate change developments could increase demand for the Armed Forces to respond to unforeseen or extreme climate-related events, both at home and abroad.⁵² Military Aid to the Civil Authorities (MACA) is likely to grow in importance as more climate-related disaster events affect the UK.⁵³ Similarly, the Armed Forces may be requested to provide more Humanitarian Assistance and Disaster Relief (HADR) to local agencies overseas⁵⁴ as part of UK commitments to international disaster relief.⁵⁵ Operations abroad in the aftermath of climate-related disasters may become more commonplace, for example in relation to hurricanes in the Caribbean, flooding in East Asia and severe drought in Sub-Saharan Africa.⁵⁶ Approximately 50 per cent of the global population lives in coastal regions and most of the world's largest cities are on or near the coast,⁵⁷ which means that these urban centres are particularly vulnerable to flooding. If a major city is flooded abroad, military assistance is likely to be needed as part of HADR operations.⁵⁸

An increased frequency of HADR operations would have implications for force planning and the balance of national and international Armed Forces commitments.⁵⁹ Multiple commitments would also put more pressure on the availability and readiness of troops and other resources requested for these operations (see Section 2.2.3).⁶⁰ As multiple commitments stretch human capability resources, there would be further pressure on the Armed Forces due to the need to deploy rapidly⁶¹ in response to extreme climate-related events. Multiple commitments could also reduce recovery periods for service personnel.

⁵⁰ UK Parliament (2015).

⁵¹ UK Parliament (2015).

⁵² INT 01.

⁵³ UK MOD (2017).

⁵⁴ UK MOD (2018); Lippert (2016); DfID (2011); NATO (2017); NZ MOD (2018); French MOD (2018).

⁵⁵ HADR, in contrast to MACA, does not focus on delivering military assistance in the UK.

⁵⁶ Lippert (2016).

⁵⁷ UK MOD (2018).

⁵⁸ UK MOD (2018).

⁵⁹ Gemenne et al. (2019); French MOD (2018).

⁶⁰ NATO (2017); Resetar & Berg (2016).

⁶¹ INT 01.

2.2.2. Training



Climate-related events have the potential to disrupt military training at home and overseas. In particular, existing training programmes may be disrupted due to the more limited availability and accessibility of training sites. For example, training sites may only be available during certain times of the year because of the risks of flooding from heavy rainfall or drought-induced wildfires in surrounding areas.⁶²

There is some evidence of the disruptive environmental impacts of climate change in other countries, which offers insights for the UK given shared environmental challenges and has implications for UK participation in joint training overseas and interoperability with allies. In the US, beach erosion due to rising sea levels in coastal states is predicted to reduce the frequency of beach training exercises, and comparable conditions could be applicable in the UK. In California, beach areas available for military training are expected to decrease by 50 to 77 per cent.⁶³ Rising temperatures are also predicted to reduce training periods because of their effects on the physical condition of personnel (see Section 2.2.3).⁶⁴ In the UK the Wet Bulb Globe Temperature (WBGT) – measuring the effects of the environment on the human body – cannot exceed 20–25 degrees Celsius for service personnel wearing a single layer uniform without helmets, while carrying 25kg of weight at 6.4kph for 2 hours.⁶⁵ In the US, training must be adjourned if the WBGT exceeds 32 degrees Celsius, which would similarly limit available training time.

In reducing training times to cooler periods, military training coordinators may choose to reduce the risks of heat-related stress or – in extreme cases – heat-related deaths of service personnel during physically demanding training programmes. In 2017, for example, two Special Air Service (SAS) soldiers were charged with negligence following the deaths of three recruits during an SAS training exercise in the Brecon Beacons on a particularly hot day,⁶⁶ with similar incidents of SAS deaths reported in 2015 and 2016.⁶⁷ Reduced training duration could result in decreasing force readiness as military personnel may no longer benefit from the full training provision that is currently on offer. US Marines have already experienced this challenge in 2018 when the certification of the 22nd Marine Expeditionary Unit for deployment was delayed in the aftermath of Hurricane Florence.⁶⁸

Climate change could affect the knowledge, skills and experience (KSE) needed to prepare the Armed Forces for deployment.⁶⁹ The 2019–2020 bushfires in Australia have, for example, shown that some Royal Australian Royal Air Force (RAAF) personnel were not trained to use aerial water bombers.⁷⁰ Engineering, search-and-rescue, evacuation and reconstruction skills could be in higher demand following further climate

⁶² Stein et al. (2019).

⁶³ Stein et al. (2019); US DoD (2014).

⁶⁴ King (2014).

⁶⁵ UK MOD (2019), p.1-E-3.

⁶⁶ Baynes (2017).

⁶⁷ Morris (2019).

⁶⁸ Stein et al. (2019).

⁶⁹ NATO (2017).

⁷⁰ INT 01.

change developments.⁷¹ Some HADR operations may also benefit from personnel with local cultural knowledge and/or with a humanitarian background⁷² to be able to establish dialogue with local populations and have a better understanding of local customs, culture and communities.⁷³

Furthermore, climate-related developments could alter the design requirements for wargames and strategic training exercises. Required changes could include a need to adapt wargames and strategic training exercises for multiple simultaneous and large-scale disasters, as well as a need to incorporate the emergency services, other government departments, civil society organisations and international partners in order to develop crisis management plans and familiarise military decision makers and their civilian counterparts with climate change-related disaster preparation.⁷⁴ While NATO has started to develop courses on disaster preparation for this reason,⁷⁵ there do not appear to be existing strategic-level exercises that cover the breadth of actors involved in responding to climate-related events.

2.2.3. Personnel



Climate change may necessitate lengthy HADR operations and environmental disaster relief interventions (Section 2.2.1),⁷⁶ while also requiring the ability to provide agile, short-term support in response to climate-related crises. Furthermore, resource shortages could lead to increased conflict and instability, requiring additional military operations. Climate change is likely to affect various parts of the world simultaneously, and service personnel may have to operate in climate-degraded conditions with increasing frequency, with limited breaks between deployments, and with reduced recovery periods.⁷⁷ Challenging operational conditions wrought by climate change could affect the physical and psychological health of service personnel.⁷⁸ Extreme weather events constitute significant risks to life and physical security, and human performance could suffer during prolonged periods of demanding operations, fatigue and potential injuries.⁷⁹

Higher temperatures could also affect the rate of transmission and geographical reach of various infectious diseases.⁸⁰ For example, the growing spread and geographic reach of diseases transmitted by arthropod vectors (e.g. malaria, Zika and dengue fever) could increase pressure on personnel, creating challenges for force survivability and increasing the need for individual medical assistance and vaccinations.⁸¹ Medical preparations for deployments to areas with a risk of exposure to mosquito-borne diseases could become

⁷¹ INT 05; INT 08.

⁷² French MOD (2018).

⁷³ INT 05.

⁷⁴ INT 11; INT 06.

⁷⁵ INT 06.

⁷⁶ INT 01.

⁷⁷ INT 08.

⁷⁸ Gemenne et al. (2019).

⁷⁹ Spanish MOD (2018); INT 10.

⁸⁰ World Health Organization (n.d.).

⁸¹ INT 01; INT 04.

more costly.⁸² Higher rainfall could also increase the dissemination of infectious agents in water sources – exposing personnel to waterborne diseases – and high temperatures could affect the growth and survival of infectious agents.⁸³ As climate change increases rainfall and temperatures, these health risks to service personnel could be exacerbated.

2.2.4. Infrastructure



The entire Defence Estate⁸⁴ is likely to become more vulnerable to climate-related events such as flooding, wildfires, storms and cyclones, both domestically and overseas.⁸⁵ Although climate-related disasters appear less likely in the UK than in other parts of the world, UK commitments to overseas territories and regions of strategic interest such as the Caribbean could require UK involvement in line with UK humanitarian policy.⁸⁶ Physical, digital and communications infrastructure may become more vulnerable to extreme climate events,⁸⁷ with coastal bases and infrastructure likely to be affected by rising sea levels, for example.⁸⁸

Given the potential for climate-related damage, there may be a need to relocate coastal infrastructure,⁸⁹ and infrastructure risk mitigation or repair costs are likely to rise as the vulnerability of such infrastructure increases.⁹⁰ Natural systems such as dunes and wetlands nonetheless play an important role in protecting infrastructure from climate-related damage: for example, estimates show that in 2012 natural systems prevented up to \$625 million in damage during Hurricane Sandy in the US.⁹¹ In the UK, a study of natural flood defences in Debenham, Suffolk, found that installing a range of natural flood management features could store 30,000m³ of water and prevent damage to properties and farmland.⁹²

Climate-related events could affect communities in a broader sense as infrastructure such as bases play an important social and economic role in the areas where they are established.⁹³ Civilian infrastructure that offers support to military operations and the Armed Forces – such as energy grids, railroads, water systems and airfields – may also be impacted by climate change and indirectly disrupt the MOD's activities.⁹⁴

⁸² INT 01; INT 04.

⁸³ World Health Organization (n.d.).

⁸⁴ The Defence Estate refers to the range of military infrastructure, installations and facilities in the UK, as well as in overseas territories, e.g. Permanent Joint Operating Bases, the Falklands, Diego Garcia, the UK presence in Antarctica.

⁸⁵ Wade et al. (2015); Tucker & Herrera (2019); Resetar & Berge (2016); Spanish MOD (2018); INT 05.

⁸⁶ INT 04.

⁸⁷ INT 11; INT 01; INT 07.

⁸⁸ INT 05.

⁸⁹ King (2014).

⁹⁰ US GAO (2019).

⁹¹ Stein et al. (2019).

⁹² Environment Agency (2017).

⁹³ INT 08.

⁹⁴ INT 11.

Defence industry infrastructure is also likely to be exposed to climate-related events that could disrupt parts of or whole supply chains, affecting the supply of essential equipment and battle-winning capabilities. Manufacturing may be delayed if suppliers suffer climate-related damage or are forced to evacuate or relocate due to climate events.⁹⁵ Additionally, access to supply chain inputs such as minerals used for manufacturing defence equipment, platforms and components⁹⁶ could be disrupted if extreme climate events cause damage to transport and communications infrastructure, or if violent conflict takes place in mineral-mining regions as a result of resource shortages. Disruption of supply chain inputs could have detrimental impacts on force readiness.

2.2.5. Equipment



Climate-related changes in different operating environments are likely to increase the need for equipment to have resilience, or to be designed to enable efficient adaptation to environmental extremes.⁹⁷ For example, in response to the strategic opportunities in the Arctic (see Section 2.1), there may be greater demand for ships that are resistant to cold water temperatures.⁹⁸ The high temperatures of hotter theatres can damage engines, and increased dust in these theatres can also impede the performance of equipment. For example, the performance of helicopters in Afghanistan was compromised by the heat: high temperatures reduced the helicopters' capacity for airlift, limited load-bearing capacity, and affected the helicopters' ability to transport essential equipment and supplies (see Section 2.2.8).⁹⁹ As extremely high temperatures become more prevalent in other parts of the world, theatres that were once considered to have more benign climates could induce similar equipment failures in the future.

Equipment may come under strain due to a higher number of operations, which could affect maintenance periods, shorten equipment life, and increase demand for new equipment that complies with potentially new operational requirements induced by climate change.¹⁰⁰ An increasing number of storms and rougher seas could extend transit times, destroy or damage equipment, or hamper flight operations.¹⁰¹ Repair time periods and costs could also increase due to the number of simultaneous engagements expected in the future operating environment.¹⁰²

If equipment stored in military facilities is not suited to extremely high or low temperatures, this could result in climate change-induced damage or destruction of equipment.¹⁰³ Solutions for mitigating this risk include the use of temperature-controlled storage, but this comes at the cost of increased energy

⁹⁵ INT 03.

⁹⁶ Parliamentary Office of Science & Technology (2011).

⁹⁷ UK MOD (2018).

⁹⁸ House of Commons, Defence Committee (2018).

⁹⁹ INT 03; INT 05.

¹⁰⁰ INT 01.

¹⁰¹ CNA Corporation (2007).

¹⁰² US DoD (2014); CNA Corporation (2007).

¹⁰³ US DoD (2014).

requirements. Another climate-related risk concerns the handling of metal equipment: in high temperatures, human operators may not be able to handle platforms, equipment and other infrastructure constructed out of metal. As weather becomes more volatile, dust and sand storms and flooding could also contribute to damage or destruction of equipment. Although technological and scientific advances may well support the use of more resilient materials able to withstand greater extremes of temperature, this would require deliberate investment as well as re-training and health and safety mitigations in the nearer term. Overall, climate-related developments could reduce equipment availability, which could in turn affect levels of force readiness. These changes could nonetheless also create opportunities for Defence to take the lead on developing new and emerging technologies.

2.2.6. Information



There is likely to be an increasing need for accurate forecasts of the effects of climate change on a range of operating environments in order to inform UK defence skills requirements (Section 2.2.3) and to understand the conditions that particular equipment will need to function in (Section 2.2.5).¹⁰⁴ To better understand climate change developments affecting military capabilities and personnel, decision makers will need reliable information on the real-time and projected future effects of climate change.¹⁰⁵ Although there are a number of existing security threat and conflict risk analysis tools available at both the national and international levels (e.g. NATO's Intelligence Warning System), these tools often do not focus on climate-related risks.¹⁰⁶

Information dissemination on climate change may also become more important for the MOD in addressing climate change-related issues that threaten national security. Building a narrative to showcase the military's role in combatting climate change could become increasingly important, both at the national and international levels.¹⁰⁷ This type of narrative could help secure buy-in from other decision makers for the MOD's climate change adaptation measures, as well as helping to attract the resources necessary for the MOD to implement climate change policy.¹⁰⁸

In addition, UK preparedness to deploy in response to climate-related events could become part of strategic messaging to UK and NATO adversaries. Specifically, the UK Armed Forces' preparedness to operate and carry out expeditionary missions in the High North and Overseas Territories as part of climate-related crisis response operations could become more important in the future. Moreover, if adversaries are seen to be more active in addressing climate change issues or in implementing expeditionary missions in relation to climate change, this may have strategic implications for the UK's ability to project diplomatic influence in the global strategic security arena.¹⁰⁹

¹⁰⁴ INT 08; INT 09; GSP workshop, 8 January 2020, DCDC Shrivenham.

¹⁰⁵ INT 01; INT 05.

¹⁰⁶ Lippert (2016); GSP workshop, 8 January 2020, DCDC Shrivenham.

¹⁰⁷ GSP workshop, 8 January 2020, DCDC Shrivenham.

¹⁰⁸ INT 11.

¹⁰⁹ INT 02.

2.2.7. Organisation



Climate change could potentially adjust the balance of existing Defence Tasks, and may generate discussion on new roles and activities for the Armed Forces.¹¹⁰ The structure of the military may accordingly need to be adapted to enable rapid response to climate-induced crises while continuing to deliver existing commitments.¹¹¹ Alternatively, if new structures are not required, climate change could potentially lead to the creation of new roles within existing structures. Wider discussion may be required to establish whether the Armed Forces are best positioned to respond to (a sub-set of) climate events, or if a specialised civilian force, the police force or volunteer local civilian services¹¹² may be better placed to conduct such operations.¹¹³

Climate change may also have an impact on the total UK force required (see Section 2.2.3). As climate change could potentially increase the number and type of deployments of military personnel, either at home or abroad (or both), the military may need to grow in capacity and recruit more personnel to meet this demand.¹¹⁴ Furthermore, additional personnel with skills in engineering, diplomacy and humanitarian aid provision may be required to work in climate change-affected operating environments.¹¹⁵ However, the study findings on total force size were mixed, with some experts consulted instead suggesting that the required size of the total force is unlikely to grow significantly in the near future, based on the assumption that climate-related events could instead be addressed by a civilian national force or an international climate change emergency force, for example through NATO.¹¹⁶

2.2.8. Logistics



As a result of climate-related events, the Armed Forces may experience increasing logistical delays – that is, delays in the delivery of assets, supply chain issues, and challenges regarding the storage of supplies (see Section 2.2.5).¹¹⁷ According to the MOD, climate change is likely to have adverse effects on most forms of transport, affecting flight duration, creating a need for alternative routings (noting the associated diplomatic engagement required to enable this), and having a significant impact on fuel consumption and the requirement to store greater quantities of fuel in theatre.¹¹⁸ An increase in HADR operations (see Section 2.2.1) could also result in rising logistics costs¹¹⁹ and a growing requirement for airlift, water supply, engineering equipment for debris removal, medical care,

¹¹⁰ It should be noted that defence and security implications relating to ‘organisation’ (Section 2.2.7) and ‘logistics’ (Section 2.2.8) were not discussed by workshop participants to the same extent as the other implications under analysis.

¹¹¹ Gemenne et al. (2019).

¹¹² INT 01.

¹¹³ INT 04.

¹¹⁴ INT 05.

¹¹⁵ INT 05.

¹¹⁶ INT 07; INT 03.

¹¹⁷ UK MOD (2018); Lippert (2016); DfID (2011); NATO (2017); NZ MOD (2018); French MOD (2018).

¹¹⁸ UK MOD (2014).

¹¹⁹ UK MOD (2018); Lippert (2016); DfID (2011); NATO (2017); NZ MOD (2018); French MOD (2018).

communications and port and traffic control. Ensuring that Armed Forces personnel continue to have sufficient access to water and medicine in theatre will be particularly important for the survivability of personnel.¹²⁰

Changing weather patterns and salt water intrusion into coastal operating areas could reduce fresh water supplies in theatre¹²¹ and, as temperatures around areas of deployment increase, service personnel may have higher hydration requirements.¹²² The latter would increase the amount of water required which could, in turn, lead to a greater logistical burden for service personnel.¹²³ Beyond the provision of water and other essential supplies, hotter temperatures could also affect energy requirements and associated costs for keeping service personnel in sufficiently cool conditions that do not hinder operational performance.¹²⁴

Further to this, climate-related developments may increase the need for surface vessels to access flooded areas, helicopters for rapid access to degraded areas, mobile communication kits, and observation drones to gather intelligence on inaccessible areas.¹²⁵ With a focus on the Arctic and High North in particular, the opening of new geo-strategically important regions could also have significant implications for global shipping patterns – including for defence equipment transportation routes – particularly if military presence in the region is enhanced.¹²⁶

2.2.9. Interoperability



Interoperability refers in this report to the ability of all relevant national and international policymakers to act coherently, effectively and efficiently to achieve tactical, operational and strategic objectives. Activity in this area would have implications across all DLODs. Although bilateral cooperation on HADR is reportedly already quite developed in certain regions (e.g. the US, China, France, Australia and New Zealand),¹²⁷ there is a broad range of additional actors who could also be involved in the delivery of coordinated responses to climate events.¹²⁸ For the UK, there does not yet appear to be routinised cooperation between stakeholders who could be involved in responding to climate change-related threats in advance of an emergency, including the MOD, local authorities, other government departments (FCO, DfID, Defra, DfT, Met Office, Home Office, Cabinet Office), civil society stakeholders, NATO and the UN (see Section 2.2.1).¹²⁹

¹²⁰ Resetar & Berg (2016); INT 01.

¹²¹ Resetar & Berg (2016).

¹²² Resetar & Berg (2016).

¹²³ Resetar & Berg (2016).

¹²⁴ Resetar & Berg (2016).

¹²⁵ INT 05.

¹²⁶ INT 07.

¹²⁷ French MOD (2018).

¹²⁸ INT 03; Resetar & Berg (2016); NATO (2017); US DoD (2019, 2014); NZ MOD (2018); GSP external workshop, 8 January 2020, DCDC Shrivenham.

¹²⁹ GSP workshop, 8 January 2020, DCDC Shrivenham.

Furthermore, climate change is likely to affect NATO Allies in different ways. If a NATO member is impacted particularly severely, this may impede their ability to contribute to existing or emerging Alliance activities, with detrimental effects on interoperability.¹³⁰ The elevation of climate change on NATO's agenda may generate opportunities for countries such as the UK to demonstrate thought leadership on climate change.

2.2.10. Summary

Resilience to climate change is likely to become a key issue for MOD activities across all DLODs, and the main strategic implications for MOD activities discussed in this chapter are summarised in Table 2.1.

¹³⁰ NATO (2017).

Table 2.1. Summary of the strategic implications of climate change for MOD activities

DLODs	Strategic implications of climate change for MOD activities
<p>Concepts and doctrine</p> 	<ul style="list-style-type: none"> • There is a growing need for concepts, doctrine and planning to reflect environmental considerations (and opportunities to demonstrate thought leadership in doing so). • Increase in MACA and HADR operations can be expected in response to climate change. • Climate change considerations are likely to reinforce Fusion Doctrine and the Whole Force Concept.
<p>Training</p> 	<ul style="list-style-type: none"> • Coordination of military training activities could become more challenging, as extreme climate events could reduce the area and timeframe available for military training delivery. • Health and safety issues related to flooding, extremely high temperatures and physically demanding training programmes may increase. • Demand for certain skills, particularly related to engineering, search and rescue, evacuation, construction, air traffic control and diplomacy may increase in the Armed Forces. • Climate-related developments may require wargames and strategic training exercises to account for simultaneous large-scale disasters and involve a wide range of actors.
<p>Personnel</p> 	<ul style="list-style-type: none"> • Personnel may have to operate in climate-degraded conditions more frequently, affecting physical and psychological well-being. • Climate change can affect infectious disease transmission, and the spread of certain diseases could increase the need for medical assistance and vaccinations and personal protective equipment (PPE). • Defence may encounter difficulties in recruiting if it is perceived as inactive on climate change.
<p>Infrastructure</p> 	<ul style="list-style-type: none"> • Military infrastructure in the UK and overseas (e.g. Permanent Joint Operating Bases, Diego Garcia) may become increasingly vulnerable to climate-related events, particularly coastal infrastructure. • Infrastructure risk mitigation, adaptation or repair costs may rise, and remote working may increase. • Degradation of civilian infrastructure (e.g. energy grids, railroads, water systems and airfields) may also indirectly disrupt the MOD's activities.
<p>Equipment</p> 	<ul style="list-style-type: none"> • Operating environment changes could increase demand for climate-resilient equipment. • Higher temperatures, increased dust and other changes could impede performance of equipment. • Access to critical supply chain inputs (e.g. rare minerals) could be impeded by extreme weather events which could, in turn, increase violent conflict. • Equipment storage temperature requirements and associated costs could increase.
<p>Information</p> 	<ul style="list-style-type: none"> • Accurate and defence-specific meteorological forecasting information is needed to better understand climate developments affecting military capabilities and personnel. • Building a narrative to showcase the MOD's role in tackling climate change could become increasingly important for securing buy-in from key decision makers.
<p>Organisation</p> 	<ul style="list-style-type: none"> • Climate change could adjust the balance of existing military tasks and generate discussion of new activities and roles for the Armed Forces. • Given the breadth of actors involved in responding to climate change, there is a need for discussion of the responsive role and remit of the Armed Forces vis-à-vis the police, a specialised civilian force or volunteer local civilian services.
<p>Logistics</p> 	<ul style="list-style-type: none"> • Delivery of logistics support could be more difficult due to a lack of infrastructure or equipment capacity to access disaster-struck areas. • As temperatures rise, there could be growing demand for critical supplies (water, fuels, medicine), as well as increased energy requirements to keep personnel cooler. • Climate events may increase the need for surface vessels to access flooded areas, helicopters for rapid access to degraded areas, and mobile communication kits. • The opening of the Arctic and High North and the diversity of actors involved could have implications for global shipping patterns, including for defence equipment transportation routes.
<p>Interoperability</p> 	<ul style="list-style-type: none"> • Climate change could increase the need for cooperation between a wide range of actors including the emergency services, other government departments (e.g. DfID, FCO, DfT, Defra, Met Office, Home Office), NGOs and NATO. • In cases where NATO member nations are affected by climate change, this may compromise their ability to support Alliance activities, impeding interoperability.

3. Conceptual framework

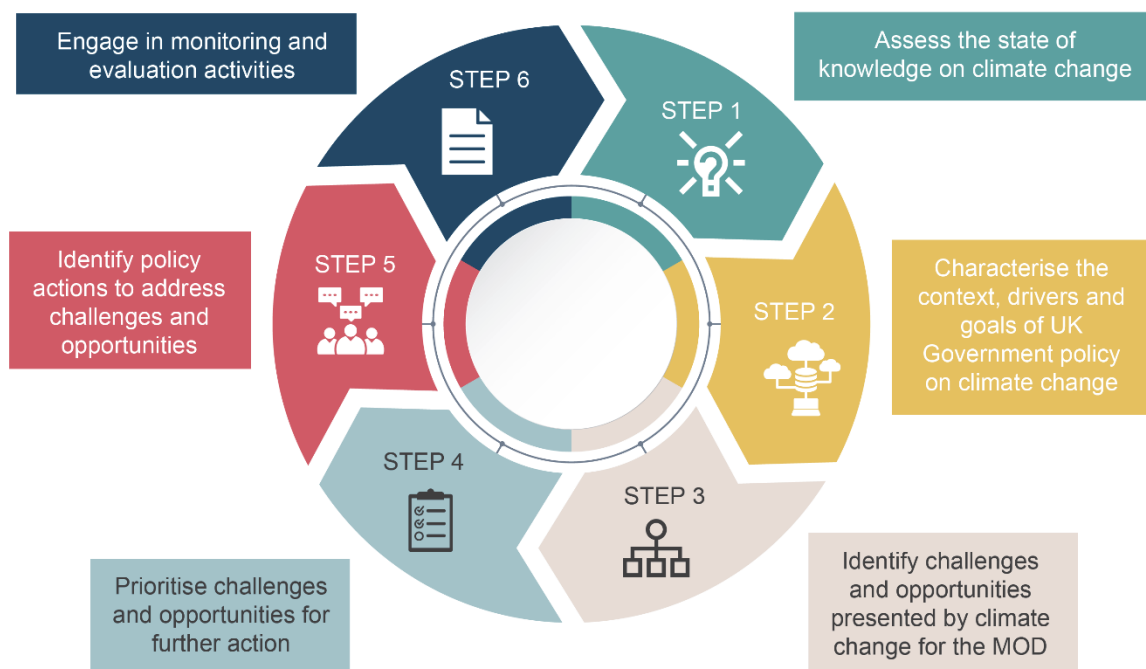
Based on the strategic implications identified in Chapter 2, this chapter presents an overarching conceptual framework that is designed to assist decision makers in:

- Mapping a broad range of impacts of climate change in relation to the MOD’s policy objectives.
- Identifying strategic opportunities associated with climate change to inform policy development.

The conceptual framework is based on the findings of a review of literature on existing frameworks, key informant interviews, and workshop discussions (see Annex A).

Figure 3.1 presents a high-level outline of this framework, and the following sections describe each of the six steps in more detail. For each step, a description of the underlying rationale is provided, before the step’s aims, methods, outcomes and indicative implementation timings are outlined.

Figure 3.1. Overview of conceptual framework



Steps 1 and 2 are closely linked in that they are both designed to improve the MOD's situational awareness, with Step 1 focusing on the state of knowledge on climate change and Step 2 building understanding of existing UK government policy in this area. While Steps 1 and 2 are defence-agnostic, Step 3 then examines the *defence-specific* implications of climate change to form the basis for a shortlisting exercise where priority challenges and opportunities are then identified for further action (Steps 4 and 5). Step 6 then focuses on ensuring that data is gathered on the effectiveness of policy actions against their planned outcomes, as well as informing future programming and priority-setting. As Figure 3.1 illustrates, the conceptual framework is cyclical and policy, threats and opportunities relating to climate change will continue to evolve, requiring periodic reassessment of the state of knowledge, re-prioritisation of policy actions, and continuous monitoring and evaluation.

Step 1: Assess the state of knowledge on climate change

Rationale: The challenges and opportunities that climate change presents for the MOD and other areas of UK government are characterised by uncertainty and complexity. As the impacts of climate change are not static, their implications will need to be reviewed periodically. Risk assessments are appropriate when potential implications of a trend are already known, but are less useful when there is little or fragmented knowledge about potential implications – as is the case with climate change. Conventional threat and risk assessments are reliant on clarity of knowledge about outcomes and likelihoods, which does not apply to climate change.

In this context, the MOD may wish first to consider organising its thinking around what is known about climate change. In doing so, the experiences of government stakeholders interviewed during this study indicate that the MOD could further tap into the skills and knowledge of other departments (e.g. Defra, Met Office, FCO, DfID, DIT, HM Treasury).¹³¹ Additionally, workshop participants suggested that there is a need within the MOD to further develop internal futures and foresight techniques to better understand non-traditional security threats, and/or to draw on this capability externally.

This step will enable the MOD to:

- Assess the state of current departmental and cross-government knowledge on the vulnerabilities and risks presented by climate change out to 2035 (see examples in Table 2.1).
- Identify the appropriate analytical tools to understand the level of risk posed by climate change.

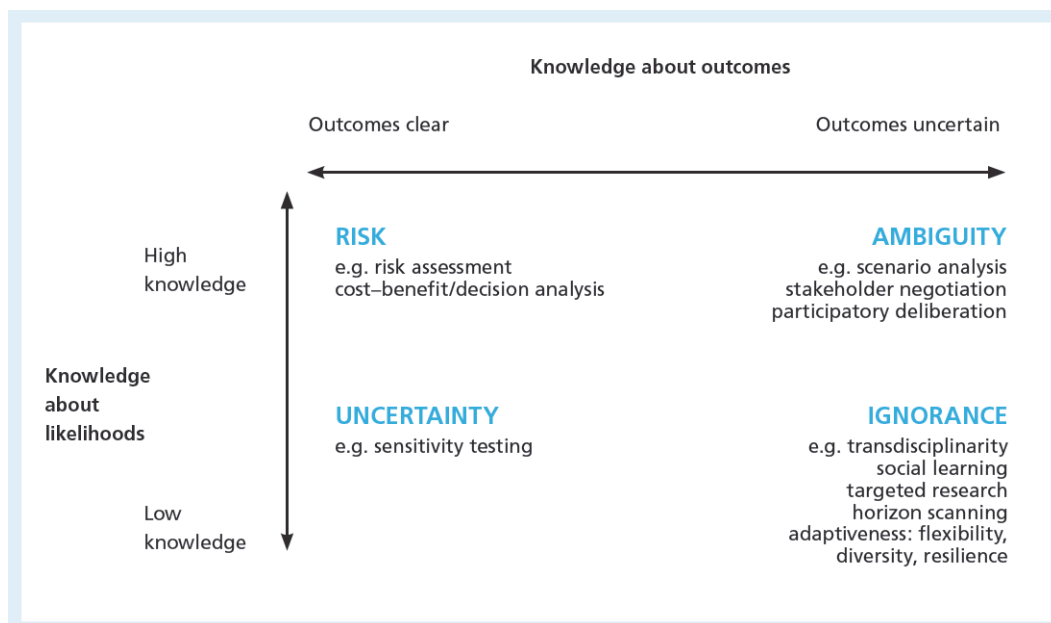
This step will explore knowledge of *general* developments in relation to climate change – i.e. agnostic of defence – to ensure that the full spectrum of potential factors that could affect MOD activities is taken into consideration. Initially approaching the information-gathering exercise from a more general perspective could help reduce the risk of missing key developments affecting other policy areas that, while not traditionally viewed or monitored as a risk to national security, may be relevant in the context of climate change. As outlined later in this chapter, Step 3 will build on the general overview developed through Steps 1 and 2 to consider the specific implications of climate change for defence and security.

¹³¹ INT 03; Resetar & Berg (2016); NATO (2017); US DoD (2019, 2014); GSP external workshop, 8 January 2020, DCDC Shrivenham.

Aim: The aim of this step is to establish the existing level of MOD and cross-government knowledge in relation to climate change in order to determine how the MOD should subsequently analyse its implications for defence and security.

Method: The MOD and/or an external contractor could undertake an initial assessment of the state of knowledge on climate change out to 2035 through a series of consultations with representatives from the MOD and other government departments, and through characterisation against Stirling’s matrix (see Figure 3.2). This matrix represents different levels of knowledge about likelihoods and outcomes and recommends a range of analytical approaches tailored to varying levels of knowledge. The consultation approach could involve a series of workshops – given the high number of government departments involved in responding to climate change – to enable cross-departmental engagement, an understanding of areas of shared knowledge, and the identification of knowledge gaps in relation to climate change.

Figure 3.2. Example of approaches for decision making in different dimensions of uncertainty



Source: Stirling (2008).

For example, there is a high level of knowledge regarding the potential implications of climate change on the Arctic (e.g. the opening of global shipping routes), with relatively high availability of published and unpublished scientific analysis on the subject. However, given that the outcomes are arguably uncertain (e.g. how international actors will respond to opportunities in the Arctic), scenario analysis, stakeholder consultation and participatory deliberation may be useful methods to think through potential implications.

Outcomes: The envisaged outcomes of this step include an improved understanding of the state of knowledge on climate change within the MOD and across other government departments, as well as a more informed understanding of which conceptual and analytical tools would be most appropriate for analysing the implications of climate change.

Indicative timescale:¹³² The proposed timescale for delivering this work is approximately 3–4 months, encompassing four workshops (one MOD-only workshop and three cross-departmental workshops), workshop analysis and reporting.

Step 2: Characterise the context, drivers and goals of UK Government policy on climate change

Rationale: Once the state of knowledge on climate change is understood, a second contextual step would involve mapping existing UK government policies on climate change to inform the subsequent identification of MOD policy actions for addressing climate-related challenges. This step would frame subsequent implementation to ensure that MOD policy actions are aligned with government priorities on climate change, support strategic objectives, and reflect the context and drivers of policy in this area.

This step will enable the MOD to:

- Take stock of existing national commitments and international obligations relating to climate change.
- Collate good practices and lessons identified from current and past climate change policies under the MOD and other government departments.
- Identify a broad range of potential cross-government, national and international partners who could collaborate to achieve the MOD's strategic aims in relation to climate change.
- Identify other policy goals with which MOD climate change priorities may overlap or need to compete for resources and buy-in, given the political context of the next programming period (e.g. the upcoming Integrated Security, Defence and Foreign Policy Review and the NATO Defence Planning Process (NDPP)).

This step will situate the MOD's options for addressing the defence implications of climate change within a deeper understanding of policy context, drivers and goals across government departments.

Aim: The aim of this step is to identify the range of UK government policies related to climate change, situating the MOD's options for addressing the defence implications of climate change.

Method: To deliver Step 2, the MOD and/or an external contractor could identify and map the range of UK government strategy and policy documents related to climate change through an initial document review. A series of cross-government workshops could then be undertaken to discuss the findings of the document review; to discuss areas for potential cross-government cooperation on climate change; to identify the key drivers and goals of the climate change policies identified; and to elicit information on non-public policy, programming and associated guidance on climate change not captured through the document review. The findings of the workshops could then be synthesised and integrated into a report for the MOD.

¹³² Timelines proposed throughout this chapter are indicative based on the study team's assessment of timescales for delivery. Timelines can be expanded for a more in-depth approach or contracted (within reason), and apply to work undertaken by the MOD or an external contractor. The timelines are estimated for the first implementation of the framework. It may be possible to reduce these timelines for future iterations of the framework, based on lessons identified and efficiencies gained following the first application – but this should be revisited and decided upon following the first cycle.

Outcomes: The intended outcome of this step is a more informed understanding of the context, drivers and goals framing climate change policy within UK government.¹³³

Indicative timescale: The envisaged timescale for this work is approximately 2–3 months, assuming the delivery of four workshops, workshop analysis and reporting.

Step 3: Identify climate change challenges and opportunities for the MOD

Rationale: As outlined above, Steps 1 and 2 are intended to improve the MOD's situational awareness of the state of knowledge on climate change and to enhance the MOD's understanding of the UK government policy context in this area. From this broader, defence-agnostic picture, Step 3 will allow the MOD to examine the *defence-specific* implications of climate change, with a focus on challenges and opportunities for UK defence, adversaries and allies. This will form the basis for a shortlisting exercise where priority challenges and opportunities will be identified (Step 4).

Aim: The purpose of this step is to analyse how the environmental impacts of climate change are likely to affect MOD activities, commitments and priorities in the timeframes under consideration (i.e. to 2035).

Method: The MOD and/or an external contractor could carry out a systems-mapping exercise to illustrate the different areas of potential climate change impacts for UK Defence. Potential impacts could be mapped in various ways, for example according to a structured analysis of DIME or PESTLE¹³⁴ impacts that climate change may have on the Defence Lines of Development (DLODs), Defence Tasks,¹³⁵ and/or on other MOD activities and commitments not encompassed by DLODs or Defence Tasks. In undertaking this analysis, consideration could be given to which defence activities are likely to be *affected directly* (i.e. directly impacted by changes to the environment), which will likely be *affected indirectly* (i.e. shaped by the direct impacts), and which are *unlikely to be affected*.

This work could draw on a structured literature review and interviews with climate change and defence experts across UK government and academia. The climate change challenges and opportunities identified through these research activities could then be clustered according to the MOD's preferred framework (e.g. DLODs, DIME, PESTLE, Defence Tasks). After structured data extraction, a workshop could then consolidate key messages from the analysis, which would be integrated into a report. The findings of the work undertaken in Steps 1–3 could then be validated and refined through another workshop, which would be attended by the MOD (e.g. Defence Infrastructure Organisation, Defence Equipment and Support, Defence Science & Technology Laboratory, Warfare Centres and/or single service HQ representatives),

¹³³ The scope, ambition and resource required for this step could be expanded to include mapping of international activities undertaken by other national governments, multilateral organisations and other sectors.

¹³⁴ DIME: Diplomatic, Information, Military, Economic; PESTLE: Political and regulatory, Economic, Social and cultural, Technological and scientific, Legal, Environmental.

¹³⁵ Defence Tasks include: (1) defending the UK and its overseas territories; (2) providing strategic intelligence; (3) providing nuclear deterrence; (4) supporting civil emergency organisations in times of crisis; (5) defending our interests by projecting power strategically and through expeditionary interventions; (6) providing a defence contribution to UK influence; and (7) providing security for stabilisation. Source: SDSR (UK MOD 2010).

NATO and defence industry stakeholders, ensuring a balance across domains and institutions. The report would be updated and refined based on the feedback from the validation workshop.

Outcomes: The envisaged outcome for this step is an improved understanding of the defence and security implications of climate change, presented as a systems map. The systems map could be conceptualised as a geographic map of the world, highlighting the implications of climate change for strategic regions of interest to UK defence.

Indicative timescale: The indicative timescale for this work is 3–4 months, based on the assumption that the step would consist of structured data extraction, one data analysis workshop, data synthesis and reporting, and one validation workshop with the MOD.

Step 4: Prioritise challenges and opportunities for further action

Rationale: This step is designed to support the MOD in down-selecting priority issues to tackle within a given timeframe (in this case, to 2035). This step will enable the MOD to prioritise key climate change opportunities and challenges from those identified as part of Step 3, before identifying corresponding policy actions (Step 5). As outlined below, to deliver this step there is a need for clearly articulated definitions and scoring criteria that can equip the MOD to down-select areas for action in a way that is systematic, easily implementable and replicable.

Aim: The aim of this step is to focus the MOD's efforts under Step 5 on the policy issues that will derive the most positive impact depending on the urgency of the challenge or opportunity, the time-sensitivity of the adaptation action, and the financial and strategic costs of inaction (or according to other metrics adopted as part of Step 4).

Method: A workshop could be conducted at which UK defence stakeholders implement a high-level scoring exercise to prioritise challenges and opportunities for further action. Scoring criteria could include:

- a) Time-sensitivity of the challenge/opportunity (*i.e. is the potential impact likely to materialise in the short-term future?*)
 - (-2) very low urgency of challenge/opportunity
 - (-1) low urgency of challenge/opportunity
 - (0) temporal considerations do not affect urgency of challenge/opportunity
 - (+1) some urgency of challenge/opportunity
 - (+2) very high urgency of challenge/opportunity
- b) Time-sensitivity of adaptation action (*i.e. would mitigation measures need to be applied urgently to be effective?*)
 - (-2) very low urgency of adaptation action
 - (-1) low urgency of adaptation action
 - (0) temporal considerations do not affect urgency of adaptation action
 - (+1) some urgency of adaptation action
 - (+2) very high urgency of adaptation action

- c) Financial and strategic costs of inaction
 - (-2) very low financial and strategic cost of inaction
 - (-1) low financial and strategic cost of inaction
 - (0) no financial and strategic costs associated with inaction
 - (+1) some financial and strategic costs associated with inaction
 - (+2) very high financial and strategic costs associated with inaction

The findings of the workshop could then be synthesised into a report, including recommendations for the MOD in relation to prioritised challenges and opportunities for further action.

Outcomes: The envisaged outcome of this step is an improved awareness of the risks and opportunities presented by climate change for MOD activities, and a clear indication of which should be prioritised for further action.

Indicative timescale: The indicative timescale for this work is approximately 2 months, encompassing workshop preparation, workshop delivery, synthesis and reporting.

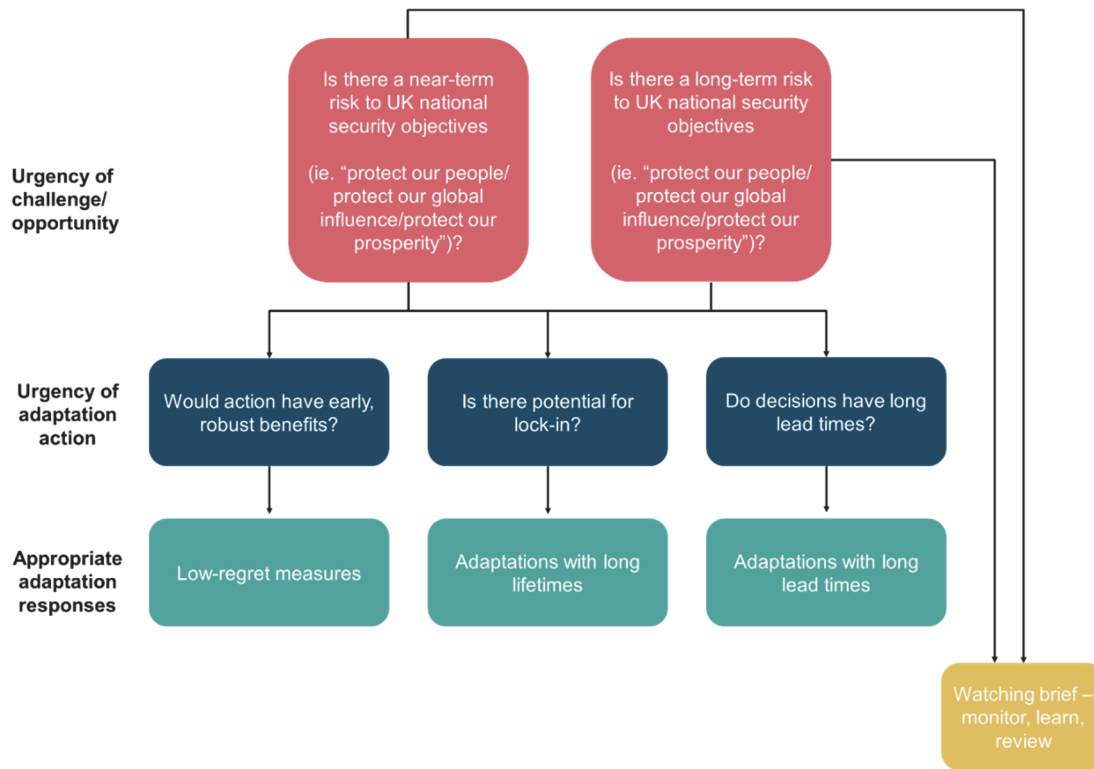
Step 5: Identify policy actions to address challenges and opportunities

Rationale: This step is designed to assist the MOD in developing policy actions in response to the priority challenges and opportunities identified in Step 4. This would involve identifying a set of recommended policy actions, with associated guidance on roles and responsibilities, coordination between different actors, and resource requirements (financial, human, infrastructure, other). This step would also calibrate how climate change challenges, opportunities and corresponding policy actions are communicated by the MOD to obtain political and public buy-in for these actions.

Aim: The aim of this step is to develop a range of implementable policy actions designed to address the prioritised challenges and opportunities identified under Step 4.

Method: The MOD and/or an external contractor could facilitate workshops or interviews to generate a set of recommendations for policy action. Each policy action would relate directly to the prioritised list of challenges and opportunities identified under Step 4, and stakeholder engagement could be guided by a decision-tree approach as outlined in Figure 3.3. The MOD and/or an external contractor could then consolidate the generated policy recommendations, sequencing them as appropriate and identifying aims, methods/activities, roles and responsibilities, resource requirements, outputs and envisaged outcomes for each recommended policy action. Finally, a workshop within the MOD could challenge, validate and refine the recommendations, with the finalised policy actions presented in a report.

Figure 3.3. Illustrative decision-tree for prioritising adaptation



Note: 'Lock-in': A decision that has long implementation periods; 'Low regret': Decisions with no identifiable or tolerable risks. Source: Adapted from Fankhouser et al. (2017).

Outcomes: The intended outcome of this step is a clear set of priority policy actions, encapsulated within a document that details each action’s envisaged aims, approach, outputs and intended outcomes.

Indicative timescale: The envisaged timescale for this work is 2–3 months, including two workshops, analysis, synthesis and reporting.

Step 6: Engage in policy monitoring and evaluation activities

Rationale: This step is intended to ensure that data is gathered on the effectiveness of policy actions against their envisaged outcomes, as articulated under Step 5, as well as to capture further areas for consideration in prioritising objectives for the next programming period. This step would also assist the MOD in developing a business case for the continuation or scaling up of programmes.

Aim: The purpose of this step is to ensure that envisaged policy actions are implemented as planned and continue to support the MOD’s strategic objectives.

Method: The MOD and/or an external contractor could develop a set of appropriate key performance indicators (KPIs) to support monitoring and evaluation (M&E) of policy action implementation and effectiveness. For example, long lead times in capability development require KPIs that are sensitive to the length of time that it takes to demonstrate evidence of good performance or impact.

Further to the development of KPIs, the MOD could identify a Senior Responsible Owner (SRO) within the Defence Management Board to assume ownership of climate change policy M&E. This individual could also develop or sign off on a reporting document template for M&E in this area. The template could be developed by the SRO, the MOD or an external contractor.

To ensure independent review, an external contractor could undertake regular evaluation activities using the template developed for this purpose.

Outcomes: This step would support a clear understanding of how the policy actions identified in Step 5 could be monitored and evaluated and would identify a Senior Responsible Owner who would be accountable for ongoing M&E of the policy actions identified.

Indicative timescale: The envisaged timescale for identifying KPIs, preparing an M&E reporting template, and identifying a Senior Responsible Owner is 3–4 months. The timescale for subsequent M&E activities would be determined by factors including the number of policy actions under review, the detail required by the template, and the extent of stakeholder consultation involved.

It should be noted that the conceptual framework presented in this document is cyclical: as policy, threats and opportunities relating to climate change continue to evolve, it will remain important to periodically reassess the state of knowledge on climate change (Step 1), revisit the current policy context (Step 2), identify corresponding climate change challenges and opportunities for the MOD (Step 3), prioritise areas for further action (Steps 4 and 5) and to engage in continuous monitoring and evaluation (Step 6). Two high-level recommendations for implementing the framework are outlined in the following chapter, as part of a wider set of recommendations for MOD consideration.

4. Recommendations

This chapter presents a synthesis of high-level recommendations for the MOD based on the findings of this study. The recommendations were generated by the GSP team analysis and reflect the insights of study interviewees and participants at the GSP workshop held on 8 January 2020 at DCDC Shrivenham.

The chapter is in two parts:

- An overarching summary of immediate climate change challenges framing the recommendations for adaptation and mitigation.
- A synthesis of high-level recommendations and supporting activities for the MOD.

4.1. Summary of immediate challenges relating to climate change

As outlined in Chapter 2, climate change presents a range of potential challenges for UK defence. Based on the views of a majority of experts consulted during interviews and at the workshop, the strategic areas that would benefit from immediate action relate to concepts and doctrine, information, interoperability, equipment, infrastructure and logistics. Challenges in these areas include:

- Concepts and doctrine do not consistently acknowledge climate change as a security driver or incorporate climate change as part of national security threat assessments.
- There appear to be limited defence-specific information-gathering efforts in relation to the implications of climate change for the MOD's activities.
- Climate change is likely to increase the need for collaborative decision making, resource-sharing and communication across climate change stakeholders including UK government departments, emergency services, civil society organisations and NATO partners.
- Rising temperatures and other climate-related developments could impede the performance of equipment, with increased costs for equipment maintenance and storage due to temperature requirements.
- Military infrastructure in the UK and overseas may become increasingly vulnerable to climate events – particularly in the case of coastal infrastructure – and degradation of civilian infrastructure (e.g. energy grids, water systems) may also indirectly disrupt MOD activities.
- Delivery of logistics support could become more difficult due to a lack of infrastructure or equipment capacity to access disaster-struck areas.

Most of the experts consulted noted that challenges related to training, personnel and organisation, although relevant, appear to be less pressing than the issues outlined above. Secondary challenges in these areas include:

- Coordination of military training activities could become more challenging, with increasing health and safety issues related to extremely high temperatures and physically demanding training.
- Personnel may have to operate in climate-degraded conditions more frequently, affecting physical and psychological well-being, and climate change could increase the spread of infectious diseases.
- Climate change may create challenges for the balance of existing military tasks, generating discussion of whether any change to the current organisational structure is required.

As noted in Sections 1.2 and 2.2, it is important to recognise that there are various links and dependencies between DLODs, and inaction or failure in one area could create challenges for others.¹³⁶ This is reflected in the recommendations below.¹³⁷

4.2. Recommendations for mitigation and adaptation

In the context of the challenges described above, strengthening resilience to climate change is likely to become a growing focus area for the MOD. To support the MOD in addressing the challenges of climate change, we present six recommendations for consideration. Summarised in Table 4.1, they are based on the implications of climate change identified in Chapter 2 and aim to support the MOD in responding to the immediate challenges summarised in Section 4.1.

¹³⁶ For example, effective logistical support is required to provide food and medical supplies for deployed personnel. Should climate change developments impede the delivery of logistics support and obstruct access to deployed personnel, the health and wellbeing of personnel will suffer.


¹³⁷ While each of the recommendations presented in this chapter is linked to a DLOD-specific challenge, the description of the recommendation itself highlights implications for a range of areas across defence.

Table 4.1. Overview of recommendations for mitigation and adaptation

Identified implications for the MOD	Recommendations
<ul style="list-style-type: none"> There appears to be limited defence-specific information-gathering on the impacts of climate change on the MOD's activities (<i>information</i>). 	<p>Recommendation 1: Develop a tool that enables the MOD to develop robust policy in response to climate change (<i>see Chapter 3</i>).</p>
<ul style="list-style-type: none"> Climate change could increase the need for collaborative decision making, resource-sharing and communication across key stakeholders (<i>interoperability</i>). 	<p>Recommendation 2: Leverage resources across government, civil society, emergency services and industry to coordinate on climate change-related issues (<i>see Chapter 3</i>).</p>
<ul style="list-style-type: none"> Concepts and doctrine do not consistently acknowledge climate change as a security driver or incorporate climate change as part of national security threat assessments (<i>concepts and doctrine</i>). 	<p>Recommendation 3: Provide leadership on climate change issues at the strategic, operational and tactical levels.</p>
<ul style="list-style-type: none"> Military infrastructure in the UK and overseas may become increasingly vulnerable to climate events, and degradation of civilian infrastructure (e.g. energy grids, water systems) may also indirectly disrupt MOD activities (<i>infrastructure, logistics</i>). 	<p>Recommendation 4: Assess the resilience of Defence Estate infrastructure relative to the future operating environment.</p>
<ul style="list-style-type: none"> Rising temperatures and other climate-related developments could impede the performance of equipment (<i>equipment</i>). 	<p>Recommendation 5: Increase the capacity and resilience of equipment relative to the future operating environment.</p>
<ul style="list-style-type: none"> There appears to be limited defence-specific information-gathering on the impacts of climate change for the MOD's activities (<i>information</i>). 	<p>Recommendation 6: Leverage research and innovation to mitigate risk.</p>

The recommendations and supporting activities discussed in this chapter are not intended to be progressive (i.e. they can be implemented in any order) or mutually exclusive. The order and extent of the MOD's implementation of these recommendations is dependent on the level of ambition and available resources.

Recommendation 1: Develop a tool that enables the MOD to develop robust policy in response to climate change

Summary of challenge	
There appears to be limited defence-specific information-gathering on the impacts of climate change on the MOD's activities.	
Description of recommendation	
The MOD should develop and implement a tool that provides a structured means of understanding and responding to the effects of climate change on MOD activities. This could take the form of the Conceptual Framework presented in this report, which is a cyclical tool designed to support the MOD in: assessing the state of knowledge on climate change; characterising UK Government policy in this area; analysing priority challenges and opportunities for further action; identifying policy actions; and engaging in ongoing M&E. The implementation of this framework would draw on periodic cross-Government consultation (see Recommendation 2) to identify lessons and good practices from other departments and – depending on the scale of ambition – could also be scaled up to involve overseas partners or industry representatives to facilitate learning from the experience of other countries and sectors. For further information about the envisaged aims, methods, outcomes and timescales for each step of the framework, please refer to Chapter 3.	
Rationale	
Climate-related disruption is likely to affect many of the MOD's activities, ¹³⁸ and may lead to a growing focus on monitoring non-traditional security threats. ¹³⁹ A structured mechanism for analysing evolving threats and informing policy design could accordingly be beneficial for the MOD. Such a conceptual tool would allow the MOD to identify priority issues and policy actions, de-conflict with climate change partners, and gather data on the effectiveness of policy actions against their envisaged outcomes. ¹⁴⁰ In addition, collaboration with overseas partners and industry representatives could generate opportunities for the MOD to demonstrate thought leadership. While there are a number of existing security threat and conflict risk analysis tools, often these do not focus on climate-related risks, and there is a need for more systematic data capture in this area to inform UK Defence planning.	

¹³⁸ INT 06; INT 08; Lippert (2016); Resetar & Berg (2016); United States Army War College (2019); US DoD (2019).

¹³⁹ GSP external workshop, 8 January 2020, DCDC Shrivenham.

¹⁴⁰ INT 11.

Recommendation 2: Leverage resources across government, civil society, emergency services and industry to coordinate on climate change-related issues

Summary of challenge

Climate change could increase the need for collaborative decision making, resource-sharing and communication across key stakeholders.



Description of recommendation

Given the broad range of actors involved in responding to the implications of climate change, the MOD should continue to coordinate on climate change-related issues in a targeted way. Discussions with other UK Government departments and overseas partners should aim to support a shared understanding of the threats and opportunities presented by climate change, as well as the roles, responsibilities and activities of different actors in this area. By coordinating on existing climate change policy and programming, the MOD could ensure that its climate change activities complement – and do not duplicate – activities being delivered in other parts of UK Government or by overseas partners. This could be done in several ways, for example through periodic (e.g. quarterly) cross-departmental or bilateral meetings, or through the creation of a centralised Government database to capture information on climate change responsibilities, activities, policy, programming and lessons identified for future planning. This work may be undertaken by an NSSIG on climate change-related issues.

Noting that climate change could increase requests for UK HADR support to local agencies overseas,¹⁴¹ the MOD should also seek to engage with the FCO, DfID and other departments to strengthen regional cooperation in areas where HADR deployments are likely to take place.¹⁴² To prepare partners for HADR, the MOD could also develop a set of HADR training case studies under a range of climate change-related scenarios for the Armed Forces and for relevant agencies.¹⁴³ More broadly, the MOD could develop wargaming exercises at all levels, that support interoperability across the Armed Forces, emergency services, police, fire services and coastguard, similarly drawing on a range of climate change scenarios that require collaborative responses.¹⁴⁴

Rationale

Valuable resources such as information, skilled personnel, finance and infrastructure already exist within NATO, UK Government (e.g. Defra), civil society and industry.¹⁴⁵ Coordinating on climate-related issues more closely could help align these resources when addressing climate-related challenges,¹⁴⁶ and allow the MOD and other climate change stakeholders to learn from good practices elsewhere. Sharing lessons on climate change mitigation at the policy level could help inform and secure buy-in for MOD policy actions in this area.¹⁴⁷

¹⁴¹ UK MOD (2018); Lippert (2016); DfID (2011); NATO (2017); NZ MOD (2018); French MOD (2018).

¹⁴² INT 05.

¹⁴³ INT 11.

¹⁴⁴ INT 11; INT 08.

¹⁴⁵ GSP external workshop, 8 January 2020, DCDC Shrivenham.

¹⁴⁶ Lippert (2016); INT 10.

¹⁴⁷ GSP external workshop, 8 January 2020, DCDC Shrivenham.

Recommendation 3: Provide leadership on climate change issues at the strategic, operational and tactical levels

<p>Summary of challenge</p> <p>Concepts and doctrine do not consistently acknowledge climate change as a security driver or incorporate climate change as part of national security threat assessments.</p>	
<p>Description of recommendation</p> <p>The MOD is well-positioned to assert leadership on climate change and could do this in a number of ways. Building on existing efforts, the MOD should develop a clear strategy on <i>Climate Change for Defence</i>. This strategy could include – or be accompanied by – a roadmap outlining UK Defence responses to climate-related challenges and be supported by tools to systematise MOD approaches in this area (see Recommendation 1). The MOD should also consider updating key documentation (e.g. the <i>Strategic Defence and Security Review</i>, <i>Innovation Priorities</i>, the <i>Acquisition Handbook</i>) to strengthen the focus on climate threats and opportunities for defence; broaden conceptualisations of force resilience; emphasise a Whole Force Concept approach to addressing challenges; and identify implications for new operating conditions and mission requirements.¹⁴⁸</p> <p>The MOD could also adopt a leading role in this area by embedding climate change considerations as part of planning processes, funding decisions and strategic communication. For example, climate change resilience planning could become a core part of strategic, operational and tactical planning,¹⁴⁹ with additional monitoring of how climate change developments are affecting the actions of allies and adversaries.¹⁵⁰ To support a tactical and strategic understanding of climate impacts across the MOD, the MOD could also consider embedding a minimum level of climate impact Suitably Qualified and Experienced Personnel (SQEP) across the organisation. In relation to funding, the MOD may wish to identify potential funding options to support future MACA and HADR activities, given the likely increase in these types of operations due to climate-related developments. Finally, developing a narrative to showcase the MOD’s role in tackling climate change and sharing this strategically could become increasingly important for demonstrating leadership in this area.</p>	
<p>Rationale</p> <p>There is increasing recognition of climate change as a driver of instability and as a threat to national security. Additionally, climate-related developments appear to be driving a growing future requirement for MACA in the UK¹⁵¹ and HADR operations abroad.¹⁵² The changing strategic context in the Arctic and High North could also generate economic opportunities for the UK relating to Prosperity as a national security objective, which could in turn increase the need to defend the UK’s strategic interests in the region.¹⁵³ Accordingly, there is a growing need for climate change considerations to inform MOD policy and planning, and an opportunity for the MOD to demonstrate leadership in this area in collaboration with a range of partners across departments, countries and sectors (see Recommendation 2).¹⁵⁴ If the MOD were to successfully demonstrate thought leadership on climate change issues successfully, this could contribute to the UK Government’s ability to exercise soft power.</p>	

¹⁴⁸ INT 11.

¹⁴⁹ INT 03.

¹⁵⁰ GSP Climate Change workshop, 8 January 2019, DCDC Shrivenham.

¹⁵¹ UK MOD (2018); Gemenne et al. (2019); NATO (2017).

¹⁵² UK MOD (2018); Lippert (2016); French MOD (2018); NZ MOD (2018); NATO (2017).

¹⁵³ HM Government (2015); Resetar & Berg (2016); UK MOD (2011).

¹⁵⁴ GSP external workshop, 8 January 2020, DCDC Shrivenham.

Recommendation 4: Assess the resilience of Defence Estate infrastructure relative to the future operating environment

Summary of challenge

Military infrastructure in the UK and overseas may become increasingly vulnerable to climate events, and degradation of civilian infrastructure (e.g. energy grids, water systems) may also indirectly disrupt MOD activities.



Description of recommendation

The MOD should initiate a review of the ability of its assets, infrastructure, estate and land holdings to withstand extreme climate and weather conditions. As climate change threats and opportunities continue to evolve, such an assessment should be undertaken periodically (e.g. every 5–10 years) to ensure that adaptation approaches that require long lead times are addressed in a timely way.¹⁵⁵ As set out under Recommendation 2, there would be merit in leveraging resources across UK Government and other sectors where possible to undertake this assessment, for example through engagement with the Civil Contingencies Secretariat (CCS) in the Cabinet Office, to enable a holistic understanding of the resilience of Defence Estate infrastructure. This assessment should seek to determine the fitness for purpose of existing assets, their ability to withstand future conditions and whether any changes are necessary (e.g. in relation to basing arrangements). A data access and stakeholder engagement approach should be coordinated early to enable timely access to the best available information to inform the review. Further to this, the MOD could undertake a review of UK civilian infrastructure in collaboration with other Government departments to assess the suitability and resilience of coastal, energy, water and transport infrastructure – all key enablers of military operations.¹⁵⁶

Rationale

The entire Defence Estate (military infrastructure and facilities in the UK and its overseas territories) is likely to become increasingly vulnerable to climate-related events such as flooding, wildfires, storms and cyclones.¹⁵⁷ Physical, digital and communications infrastructure may become more exposed to extreme climate events,¹⁵⁸ with coastal bases and infrastructure likely to be affected by rising sea levels.¹⁵⁹ There is accordingly an immediate need to ensure that infrastructure is sufficiently resilient to withstand a range of climate-related challenges, to explore remote-working options and to integrate climate risk mitigation plans into the construction of new installations. This extends beyond military infrastructure, given that UK defence activities are also enabled by civilian infrastructure, for example in relation to energy and water systems.¹⁶⁰

¹⁵⁵ INT 11.

¹⁵⁶ INT 11; INT 08.

¹⁵⁷ Wade et al. (2015); Tucker & Herrera (2019); Reseter & Berg (2016); Spanish MOD (2018); INT 05.

¹⁵⁸ INT 11; INT 01; INT 07.

¹⁵⁹ INT 05.

¹⁶⁰ Tucker & Herrera (2019); US GAO (2019).

Recommendation 5: Increase the capacity and resilience of equipment relative to the future operating environment

Summary of challenge

Rising temperatures and other climate-related developments could impede the performance of equipment.



Description of recommendation

To better understand the suitability of existing equipment, the MOD should critically assess the resilience of equipment in a range of scenarios that exemplify the possible impacts of climate change on the future operating environment.¹⁶¹ The MOD could also consider mandating the inclusion of climate-resilient design features in business cases for defence acquisition.¹⁶² These design features could include, for example, the ability to withstand extreme heat and cold for long periods or to remain unaffected by moisture.¹⁶³ Another related measure is to incentivise the adoption of 'greener', 'all-weather' defence equipment¹⁶⁴ by initiating prize competitions intended to drive innovation and develop solutions more quickly than possible through more traditional funding mechanisms. Further to this, the MOD may wish to invest in research into alternative fuel sources and energy-efficient innovations to reduce the vulnerability of fuel supply for defence.¹⁶⁵

Rationale

Climate change is likely to increase demand for climate-resilient equipment that can operate in extreme weather conditions. For example, in light of strategic opportunities in the Arctic, there may be greater demand for ships with resistance to cold water temperatures,¹⁶⁶ while higher temperatures in other theatres will continue to present challenges for existing equipment. Further considerations include ensuring that the equipment stored in military facilities is resilient against flooding and is suitable for extremely high or low temperatures,¹⁶⁷ and that equipment can withstand more volatile weather conditions without disruption to logistical support. In the future there is likely to be strain on equipment due to the high predicted frequency of climate-induced emergencies,¹⁶⁸ with implications for maintenance requirements, repair time and associated costs.¹⁶⁹

¹⁶¹ INT 03; INT 05.

¹⁶² INT 01.

¹⁶³ INT 07.

¹⁶⁴ INT 11; INT 09; INT 06.

¹⁶⁵ INT 11; INT 06; INT 05; INT 03.

¹⁶⁶ House of Commons, Defence Committee (2018).

¹⁶⁷ US DoD (2014).

¹⁶⁸ Gemenne et al. (2019).

¹⁶⁹ US DoD (2014); CNA Corporation (2007).

Recommendation 6: Leverage research and innovation to mitigate risk

Summary of challenge

There appears to be limited defence-specific information-gathering on the impacts of climate change on the MOD's activities.



Description of recommendation

The MOD should leverage research and technology to better anticipate climate-related threats and to mitigate risk. As discussed under Recommendation 1, there is a need to organise current departmental and UK government knowledge and understanding on climate change through stakeholder consultation. Further to this, there would be benefit for the MOD in undertaking or commissioning research on key trends – for example in relation to MACA and HADR and risks and opportunities created by climate change.¹⁷⁰ Noting the challenges of delivering training in climate-degraded environments, the MOD could investigate increased use of simulations to help deliver training when in-situ participation is not possible.¹⁷¹ Furthermore, the MOD should explore how best to harness emerging tools and capabilities – for example in relation to AI – to better understand contested concepts and priority areas relating to climate change. So that R&I activities remain coherent with those of other UK Government departments, NATO, overseas partners, academia and other sectors, the MOD should coordinate with these stakeholders when setting climate change-related priorities for R&I.

Rationale

Despite the growing relevance of climate change for defence, research on climate change in the UK Defence context remains limited. There is a need for further work in this area, as well as consolidation of existing knowledge across UK Government, other governments and other sectors engaged in climate-related research and innovation (R&I). To address some of the climate change challenges explored in this report – for example in relation to reduced access to training sites – there may also be a greater role for simulation and technology.¹⁷²

¹⁷⁰ INT 11.

¹⁷¹ INT 01.

¹⁷² Stein et al. (2019); King (2014); US DoD (2019).

4.3. Concluding observations

As a defining issue of our time, climate change continues to evolve and to disrupt UK defence and security. Resilience to climate change is likely to become a key focus area for the MOD and, as the findings of this study show, climate change will continue to affect a range of UK defence activities to 2035 and beyond. Personnel may have to operate in climate-degraded conditions more often – affecting physical and mental well-being – and climate events could reduce access to training sites, increase the vulnerability of military infrastructure, impede the performance of equipment, and compromise the delivery of logistics support.

In the face of these challenges, there is an ever-growing need for coherent policy and planning on climate change, with a key role for the MOD. The type of framework presented in Chapter 3 could help support the MOD in developing robust policy in this area, involving collaboration with other climate change stakeholders to pool knowledge, share tools and resources, and learn from experience in other departments, sectors and nations. Looking to 2035, the MOD could further demonstrate thought leadership in mitigating and adapting to the challenges of climate change through evidence-based planning and delivery.

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Annex A. Research methods

Three methods were used to examine the strategic implications of climate change for MOD activities: (i) a review of academic and ‘grey’ literature; (ii) expert interviews; and (iii) internal and external workshops. These methods are described below.

A.1. Literature review

The study team conducted a literature search on Google and Google Scholar to ensure coverage of both academic and grey literature (policy reports and industry publications). The search also used ‘snowballing’ to identify additional articles from reference lists of selected articles, and additional targeted searches in relation to relevant organisations. This search focused on the implications of climate change for the MOD’s activities.

In total 27 sources were reviewed, including reports from international organisations (e.g. the World Economic Forum, the United Nations, NATO, the European Parliament), national ministries of defence (e.g. US, French, New Zealand, Spanish), academia (e.g. University College London, US Army War College), UK Government (e.g. DfID, the Met Office, UK Committee on Climate Change) and independent research institutions. Overall, the review mainly identified grey literature (25 of the 27 sources), with peer-reviewed literature comprising the remaining 2 papers reviewed.

The data extraction and narrative synthesis were then structured according to the themes of the DLOD framework: concepts and doctrine, training, personnel, infrastructure, equipment, information, organisation, logistics and interoperability.

In addition, the study team conducted a search on Google and Google Scholar on the topic of climate assessment, response and adaptation frameworks and of defence frameworks in order to inform the development of the conceptual framework presented in Chapter 3. Examples of climate assessment, response and adaptation frameworks include the Coastal Climate Adaptation Decision Support framework, the Intergovernmental Panel on Climate Change integrated framework for the risk of climate-related impacts,¹⁷³ the MOVE framework,¹⁷⁴ and the UK Climate Impacts Programme risk framework.¹⁷⁵ Examples of defence frameworks explored include DLODs, Defence Tasks, and UK national security objectives.

¹⁷³ Oppenheimer et al. (2014).

¹⁷⁴ Birkmann et al. (2014).

¹⁷⁵ UKCIP (n.d.).

A.2. Interviews

The study team conducted semi-structured interviews with stakeholders from UK and US government departments, NATO, the European Defence Agency (EDA), and academia with backgrounds in:

- Climate resilience and defence
- Capability development
- Diplomacy
- Humanitarian missions
- National security.

Table B.1. Overview of interviewees

Interviewee number	Country	Organisation
INT 01	UK	Cranfield University
INT 02	UK	Foreign & Commonwealth Office
INT 03	UK	Cranfield University
INT 04	US	Henry Jackson Foundation
INT 05	UK	Global Military Advisory Council on Climate Change
INT 06	-	NATO
INT 07	US	US Naval War College
INT 08	US	Ohio University
INT 09	FR	Sciences Po, Paris
INT 10	-	EDA, MOD
INT 11	AUS	Australian government

The purpose of the interviews was to:

1. Gather inputs on the potential strategic implications of climate change across the DLODs.
2. Generate a repository of climate change and security frameworks to inform the development of the conceptual framework.
3. Elicit potential recommendations for risk mitigation and adaptation to the strategic implications identified through the literature review.

The interviewees were identified primarily through the GSP study team’s contact networks and through targeted online searches. Interviewees were also identified through the snowballing technique, which refers here to the recruitment of further interviewees through the recommendations and networks of interviewees contacted initially.

The interviews were designed to be semi-structured, in order to combine the exploration of specific questions with the flexibility to ask unplanned follow-up questions. An interview protocol was used to conduct the interviews, which were held via telephone and lasted for approximately one hour.

A.3. The first internal workshop

To consolidate the findings of the targeted review and the interviews, these were presented and synthesised through an internal core RAND Europe study team workshop on 19 November 2019, which was aimed at discussing potential options for visualising the essential components of the conceptual framework. The following areas were discussed: (i) findings on the strategic implications of climate change on the MOD's activities; and (ii) essential components and visualisation options for the conceptual framework.

A.4. The second internal workshop

To consolidate the findings of the targeted review and the interviews, the draft conceptual framework was further refined through an internal GSP workshop on 4 December 2019. The following areas were discussed: (i) potential design amendments to the conceptual framework; and (ii) language clarifications to the content of the conceptual framework.

A.5. External workshop

The external workshop involved the MOD and selected stakeholders from industry, academia and governmental departments (e.g. DfID, Stabilisation Unit, Met Office, General Headquarters, Dstl, FCO). The workshop discussed further points for refinement on the conceptual framework.

A.6. Final synthesis workshop

To synthesise potential recommendations and their supporting activities, the GSP project team implemented a final internal analysis workshop to discuss proposals gathered through the interviews and external workshop. The following areas were discussed: (i) potential ideas on recommendations based on the implications of climate change identified; and (ii) refinement of insights provided during interviews and the external workshop.