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Crisis Response in a Changing Climate

Implications of Climate Change for UK Defence Logistics in Humanitarian Assistance and Disaster Relief (HADR) and Military Aid to the Civil Authorities (MACA) Operations

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Preface

This document represents the final report of a study commissioned by the Development, Concepts and Doctrine Centre (DCDC) within the UK Ministry of Defence (MOD) to inform development of the MOD's Climate Change and Sustainability (CC&S) strategy. This study builds on a phase one piece of work delivered by the Global Strategic Partnership (GSP) in early 2020, which designed a conceptual framework to systematically examine implications of climate change for defence. In this second phase, the GSP team has applied the conceptual framework to a specific area of interest, namely the impact on defence logistics in the context of Humanitarian Assistance and Disaster Relief (HADR) and Military Aid to the Civil Authorities (MACA) operations.

This report presents the main findings of the study as a whole, including:

- Analysis of the knowledge base on climate change and its impact for defence logistics.
- An overview of UK government policy and priorities to tackle climate change.
- Identification of challenges that are likely to emerge for defence logistics in future, particularly in the context of supporting HADR and MACA operations.
- Identification of opportunities and policy actions that could be taken by the MOD to mitigate the impact of climate change on defence logistics.

This work builds on existing research on climate change and its relevance for defence and highlights relevant UK policy and strategy to mitigate the impacts of climate change.

This report will be relevant for the MOD, other government departments, and for overseas allies and partners with an interest in understanding the impact of climate change on defence logistics in the context of crisis response and the ways in which the resilience of defence logistics can be strengthened in anticipation of climate-related challenges.

The GSP is a research consortium led by RAND Europe with support from the University of Exeter, International Institute for Strategic Studies (IISS), QinetiQ, Simplexity, Newman Spurr Consulting (NSC) and Aleph Insights. The GSP was assembled to provide research and analysis support to DCDC and its customers across the MOD and UK government. Part of the RAND Corporation, RAND Europe is a not-for-profit research organisation whose mission is to help improve policy and decision making in the public interest through evidence-based research and analysis. This study was led by RAND Europe and delivered in collaboration with the University of Exeter.

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Executive summary

There is considerable evidence that climate change is already occurring.[1] The temperature of the Earth's surface has risen up by 1.5°C while the global mean surface (land and ocean) temperature has increased by 0.9°C over the principal industrial period (1850–1900 to 2006–2015).[2] The observed global warming over the past century has been affecting the natural world, triggering changes in species distribution, rivers and lakes and ice and glacier retreat.[3] Over the past 30 years, there have been substantial changes in the ocean and cryosphere beyond known thresholds of change (e.g. ocean warming, acidification and deoxygenation; ice sheet and glacier mass loss; and permafrost degradation) that are abrupt, long-term, unavoidable and irreversible, as reported by the Intergovernmental Panel on Climate Change (IPCC).[4] Climate change has been shown to have significantly altered patterns of weather extremes in all regions of the world, and there is a well-established climate change fingerprint in current extreme climate events.[5]

Climate change is expected to have a significant impact on defence and security, acting as a threat multiplier and straining resources

Climate change has been broadly acknowledged across international organisations and ministries of defence as a prominent factor that is either driving or contributing to security threats. The United Nations Security Council and the NATO (North Atlantic Treaty Organisation) Secretary General have both recognised climate change as a threat multiplier for peace and security issues,[6] and NATO's 2017 Strategic Foresight Analysis report acknowledged the potential of climate change to challenge governments' ability to provide for their populations in future.[7] The MOD's 2018 Global Strategic Trends (GST6) analysis also recognised the increasing disruption and cost of climate change.[8] Crucially, GST6 noted that the mitigation measures required to tackle its effects will become increasingly complex and expensive over time, highlighting the

[1] Herring (2020); MOD (2018); PWC (2021); MOD (2015); NATO (2017); Vautard et al. (2020).

[2] IPCC (2019).

[3] Rosenzweig et al. (2008).

[4] IPCC (2019).

[5] Herring (2020); Trenberth (2018); Vautard et al. (2020); Rosenzweig et al. (2008).

[6] UN News (2019); NATO (2020a).

[7] NATO (2017).

[8] MOD (2018).

need for defence and security planning assumptions to be reviewed now to minimise the risk of an impending strategic shock.[9]

The UK government generally and UK defence specifically have embarked on a proactive approach to better adapt to climate change impact

A range of initiatives, strategies and programmes are currently underway in the UK government and internationally to mitigate the causes of climate change and to adapt to current and future consequences. This includes the adoption of a net zero by 2050 pledge into UK law, the government's commitment to green energy and 'building back greener' in the wake of the Covid-19 pandemic, as well as its role hosting the upcoming UN Conference of the Parties 26 (COP26) summit on climate change in 2021. In defence specifically, in 2020 the MOD tasked Lieutenant General Richard Nugee with preparation of the ministry's Climate Change and Sustainability (CC&S) strategy, published in early 2021. The strategy's focus is both on enhancing operational capability in changing climatic conditions and on identifying and embedding sustainable solutions to enable UK defence to meet its net zero carbon emissions targets by 2050. Crucially, this remit emphasises the importance of addressing climate change not only from an environmentalist standpoint, but also to benefit the UK's strategic and military advantage as well as the resilience of UK defence in a changing physical and threat environment.

This study identifies implications of climate change for crisis response to inform the CC&S strategy, with a focus on defence logistics

This study, alongside other preparatory work commissioned by the MOD, forms part of the background evidence used to inform development of the CC&S strategy. The core components of this study involve:

- Analysis of the knowledge base on climate change and its impact for defence logistics.
- An overview of UK government policy and priorities to tackle climate change.
- Identification of challenges that are likely to emerge for defence logistics in future, particularly in the context of supporting Humanitarian Assistance and Disaster Relief (HADR) and Military Aid to the Civil Authorities (MACA) operations.
- Identification of opportunities and policy actions that could be taken by the MOD to mitigate the impact of climate change on defence logistics.

While the focus of this study has been on HADR and MACA operations, it has been noted by several interviewees that many if not most of the challenges pertinent to these operations are equally relevant for combat operations, stabilisation operations and other deployments that may need to take place in increasingly inhospitable environments in future.

[9] MOD (2018).

This study was conducted using a combination of literature review and extensive consultation with experts and stakeholders. This includes both thirteen key respondents and four online workshops with seventeen external experts from across the armed forces, the MOD, other government departments, industry and academia.

Table 0.1 presents an overview of the principal challenges identified through these research activities.

Table 0.1. Overview of challenges

Strategic-level challenges	
	Coordination between government departments, allies and partners, local authorities, industry and others (i.e. integration across the Whole Force and Fusion Doctrine)
	Concurrency of operations
	Resource constraints (e.g. personnel, skills, equipment, infrastructure)
	Deteriorated command and control in affected areas at all levels
Operational-level challenges	
	Greater quantities of supplies required and greater cost of logistics
	Accessibility of points of embarkation and disembarkation
	Erosion of defence infrastructure and disruption of supply chains
	Equipment not fit for purpose
	Incapacitated local response
Tactical-level challenges	
	Critical equipment and supplies may be destroyed
	Challenges with water supply
	Food supply disruptions

Source: RAND Europe analysis

There are policy choices and practical actions that UK defence can take to proactively adapt to climate change and build resilience for the future

In response to the challenges identified in this study and to absorb and adapt to the wider impacts of climate change on defence logistics, this study identified two concrete windows of opportunity for the MOD to capitalise on:

- **There is a unique momentum behind the climate change and sustainability agenda** within the UK government generally and UK defence specifically, under firm leadership and structured around a uniting effort behind the CC&S strategy. The Integrated Operating Concept (IOpC) published in 2020, for example – with its focus on integrating efforts across defence domains, the whole of government, allies and partners as well as drawing on wider UK talent to deliver a more competitive set of capabilities and actions – provides a useful framework for defence response to a wide range of threats including climate change.
- Past deployments in HADR and MACA contexts as well as ongoing emergencies, particularly the Covid-19 pandemic, **offer opportunities to draw out generalisable lessons and good practices** in the context of likely increased demand for future operations. Also, they have built valuable skills and expertise in the personnel involved and have strengthened coordination networks and liaison structures already in place as well as established new ones (e.g. with local authorities, NGOs).

In addition to the broader opportunities, this study also identified concrete policy actions, see Table 0.2.

Table 0.2. Overview of policy actions

Improving coordination, information and resource sharing	
	**Improve collaboration with multilateral and regional partners** (e.g. via UN OCHA, Lancaster House), OGDs (e.g. via PJHQ; SJC) and NGOs, drawing on liaison officers; firm ownership and leadership
	**Improve information sharing** of climate and environmental data to enable risk assessment and prioritisation; developing an integrated risk index
	**Build capacity** through joint training and regular exercises with OGDs, NGOs and multinational partners and sharing experience to mitigate loss of knowledge due to regular posting cycles
	**Share assets/resources** required for disaster response between different government departments (e.g. a multirole ship procured by an OGD, operated by the military)
	**Develop a coherent communication strategy** for HADR/MACA events, underpinned by aligned goals between local and national leaders and effective communication between liaison officers, coherent political narrative and effective media training
	**Review PJHQ's and SJC's contingency plans** to assess risks to the infrastructure that forces would be expected to use, to see the risks to their availability as a result of climate impact; stress-testing through wargaming, modelling, simulation
Building resilience and self-sustainment	
	**Enhance self-sustainment and resilience of UK deployed personnel and equipment** to minimise reliance on resources in disaster locations
	**Increase resilience** of logistics infrastructure and hubs using other organisations' logistics infrastructure and capabilities where appropriate (e.g. warehouses, DHL, Amazon)
	**Relocate defence logistics infrastructure and hubs** from vulnerable areas (e.g. prone to flooding) to more resilient areas to minimise potential disruption to delivery of logistics
Investing in capabilities, enablers and training	
	**Identify and invest in the right capabilities** for use in HADR/MACA, focusing on effective delivery of effect as well as minimising logistics footprint
	**Expand capacity to respond to MACA events** via greater recruitment of reservists, volunteers, use of external contractors (including establishing enabling contracts); greater use of societal resilience models (e.g. Finland, Sweden)
	**Introduce education and training courses on climate change risks** for military and civilian personnel to inform requirements specification, acquisition, logistics planning and delivery

Source: RAND Europe analysis

Based on the analysis, the study team proposes five concrete recommendations for future action

The policy actions presented in the earlier section present a longlist of activities and measures that have been identified during stakeholder workshops and further discussions within the study team. These represent a mix of measures; some of which directly build on ongoing efforts; some could be described as 'quick wins', while others would likely take longer to implement or face significant obstacles. In addition to this long menu of options, the study team has also identified five concrete recommendations aligned with the policy actions. To ensure greater effectiveness of crisis response, the MOD should:

- Create a generalisable plan or template for delivery of HADR operations and combine relevant doctrine publications into a single HADR doctrine.
- Strengthen the role and network of liaison officers in key organisations involved in HADR response across the UK government as well as exchange officers placed in other national governments.
- Explore and understand the costs and benefits of setting up enabling contracts for HADR/MACA operations.
- Design a roadmap for enhancing the resilience of defence infrastructure for the future.
- Set up education and training courses with specific climate change content for junior and senior defence staff and/or incorporate this content into existing curricula.

The future strategic approach to crisis response in a changing climate should be cognisant of several key trends

Aside from the specific policy actions and opportunities outlined above, the study identified several strategic observations and trends that the research team believe to be helpful to consider when designing future strategic approaches to crisis response.

With the projected rise in the demand for crisis response, the UK could benefit from shifting from an 'emergency' to 'resilience' paradigm

As climate-related hazards and disasters increase in frequency and intensity and become visible around the globe, a reactive posture is unlikely to suffice. Crisis response will likely need to change from a focus on one-off emergencies to planning more proactively for regular, periodic events that demand a different approach: one focused on long-term resilience. Part of such proactive management is capacity and resilience building across the entire crisis response delivery enterprise: from the organisations involved to the people, equipment and materiel, to the wider societies affected by disasters. Aside from a conscious shift in mindset and approach, practical tools will be required to enable the shift from 'emergency' to 'resilience', for example early warning systems and risk indices to enable early identification of where crisis response may be required in different time horizons, fusing meteorological and climate data as well as statistical models incorporating probability and risk calculations to produce an early 'demand signal' for UK defence.

Technologies focused on environmental efficiency and self-sufficiency are a powerful enabler of more environmentally sustainable logistics, though not a panacea

Emerging technologies present significant opportunities for setting up a more environmentally sustainable delivery of logistics. While there is varied progress and technological maturity of solutions across different environmental performance variables (e.g. fuel, energy, water, waste), significant resources are being dedicated to research and development of these technologies. Technology represents one of the fundamental enablers of an environmentally sustainable defence enterprise in general and defence logistics in particular. Understanding the types of solutions available on the market, the type of research projects undertaken and the roadmaps of relevant technologies is already a necessary prerequisite for defence logistics planners. Equally important is understanding any barriers to implementation and integration of these technologies and the wider enablers that would make their application in defence logistics both feasible and value for money. Last but not least, a change in culture, behaviours and human creativity will be just as important. Creating the right environment within the MOD to foster sustainable behaviours on the individual as well organisational levels and to enable greater innovation and its rapid adoption will require strong leadership, an agile set of processes and a fruitful dialogue with industry, academia and other relevant actors, including OGDs and government agencies.[10]

Climate change will increasingly disrupt global economies and ecological integrity and requires a global response, in which the UK should have a powerful voice

The impact of climate change is likely to be felt all around the globe. Short of a change in UK policy and strategic ambitions to play a less outward and active role in the world, the growing demand for crisis response type interventions is likely to continue to land on the shoulders of the UK just as well as other nations – allies and partners as well as other countries. Similarly, sustainability goals will need to be actively pursued not just by the UK but the global community as a whole if the negative impacts of climate change are to be mitigated or even reversed. The UK government's vision of a 'Global Britain' encompasses an outward-focused Britain that is active in its response to global challenges and ready to take up a confident role in pursuit of opportunities. Arguably, one of the greatest opportunities of our time is the ability to lead global adaptation to climate change and lead the global community in building greater resilience vis-à-vis climate hazards and other disasters. Supported by its allies and partners, the UK has an opportunity to champion a more constructive approach to adapt to and mitigate the impacts of climate change, drawing on its well-established climate and environmental science research base and favourable policy framework.

[10] See Freeman et al. (2015).

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Abbreviations

AM	Additive manufacturing
APOD	Airport of disembarkation
APOE	Airport of embarkation
ASEAN	Association of Southeast Asian Nations
ATARES	Air Transport & Air-to-Air Refuelling and other Exchange of Services
C2	Command and control
CAF	Canadian Forces
CAPAC	Capability and Acquisition courses
CC&S	Climate Change and Sustainability
CD&E	Concept Development and Experimentation
CJEF	Combined Joint Expeditionary Force
COP26	Conference of the Parties 26
DART	Disaster Assistance Response Team
DCDC	Development, Concepts and Doctrine Centre
Defra	Department for Food, Environment and Rural Affairs
DFID	(Former) Department for International Development
DLODs	Defence Lines of Development
DST	Defence Science and Technology
Dstl	Defence Science and Technology Laboratory
EATC	European Air Transport Command
EUMC	European Union Military Committee
EUMPC	European Union Movement Planning Cell
FCDO	Foreign, Commonwealth and Development Office
FCO	(Former) Foreign and Commonwealth Office

FPDA	Five Power Defence Arrangements
FRSA	Force rear support area
FTE	Full-time equivalent
GREENS	Ground Renewable Expeditionary Energy Network System
GSP	Global Strategic Partnership
GST6	Global Strategic Trends
HADR	Humanitarian Assistance and Disaster Relief
IGO	International government organisation
IOpC	Integrated Operating Concept
IPCC	Intergovernmental Panel on Climate Change
ISTAR	Intelligence, surveillance, target acquisition and reconnaissance
JEF	Joint Expeditionary Force
JIAG	Joint Information Activities Group
MACA	Military Aid to the Civil Authorities
MCCE	Movement Coordination Centre Europe
MOD	Ministry of Defence
MMR	Micro modular reactor
NATO	North Atlantic Treaty Organisation
NDC	Nationally determined contribution
NGO	Non-governmental organisation
NSSIG	National Security Secretariat Implementation Group
ODA	Overseas development assistance
OGD	Other government departments
PJHQ	Permanent Joint Headquarters
PJOB	Permanent Joint Operating Base
PLAN	People's Liberation Army Navy
POD	Point of disembarkation
POE	Point of embarkation
RAF	Royal Air Force
RAFRLO	RAF regional liaison officer
RFA	Royal Fleet Auxiliary

RN	Royal Navy
RNLA	Royal Netherlands Army
SID	Service d'infrastructure de la Défense
SJC	Standing Joint Command
SMR	Small modular reactor
SPOD	Seaport of disembarkation
SPOE	Seaport of embarkation
UAV	Unmanned aerial vehicle
UN	United Nations
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
US	United States
USINDOPACOM	US Indo-Pacific Command
WP	Workpackage

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1. Introduction

1.1. Climate change is likely to exacerbate threats to security and prosperity, with implications for defence, government and society

There is growing recognition that climate change is likely to exacerbate existing threats to defence and security in the UK and beyond.[11] The effects of climate change, particularly in relation to rising temperatures, rising sea levels and increasing frequency and intensity of extreme weather events, are likely to affect the global population, with particularly harmful impact on already vulnerable communities and areas.[12] Both observations and future predictive science shows that increases in average temperatures increase the incidence and severity of all major climate-related hazards such as heat waves, wildfire, floods and drought. Longer term impacts of rising sea levels, changes in the jet stream, and changes in monsoon and other weather patterns amplify weather extremes. These trends will, with high levels of certainty, increase demand for crisis response globally, including through international assistance. More often than in the past, the UK armed forces will be called to deploy in inhospitable environments and respond to natural disasters and other emergencies globally as well as at home.[13] Similarly, other government departments (OGDs) are likely to see an increased need to build resilience and mitigate against climate change-induced threats to people, infrastructure, equipment and nature. With the projected increase in climate-related emergencies such as floods, storms and droughts, the frequency of OGD involvement in crisis response is set to increase as well.

The impact of climate-related disasters will be experienced by UK society as risks of extreme weather events and related damages continue to rise.[14] Depending on the intensity of extreme weather events and other climate change-related effects and where they occur, their costs could rise sharply in terms of economic disruption, damage to critical national infrastructure and potential risk to life. UK defence and wider government have already embarked on a climate adaptation programme[15] and are beginning to prepare strategic approaches for the short, medium and long term to respond to these developments.

[11] MOD (2018).

[12] See Chapter 2 for more detail.

[13] Unanimous from interviews.

[14] See National Risk assessment (2019).

[15] See Chapter 3 for more detail.

1.2. This study informs the ongoing preparation of the defence Climate Change and Sustainability strategy

A range of initiatives, strategies and programmes are currently underway across UK government and internationally to mitigate the impacts of and adapt in response to climate change (see Chapter 3). Within UK defence, in 2020 the Ministry of Defence (MOD) tasked Lieutenant General Richard Nugee with the preparation of its Climate Change and Sustainability (CC&S) strategy, published in early 2021. The strategy's intended focus is both on enhancing operational capability in changing climatic conditions and on identifying and embedding sustainable solutions to enable defence to meet its net zero carbon emissions targets by 2050. This study, alongside other preparatory work commissioned by the MOD from other sources, forms part of the background evidence material to inform the content of the strategy. The strategy seeks to identify actions and approaches out to 2050, broken down into three epochs: epoch 1 (0–5 years), epoch 2 (5–15 years) and epoch 3 (15–30 years).

1.3. This research focused on building the evidence base on the implications of climate change for logistics in crisis response

The research objectives set out for this work included the following:

- **Objective 1:** Map out the current UK policy context on climate change.
- **Objective 2:** Identify implications of climate change for a specific MOD activity area: logistics in the context of Humanitarian Assistance and Disaster Relief (HADR) and Military Aid to the Civil Authorities (MACA) operations.
- **Objective 3:** Formulate recommendations for targeted policy action in the selected MOD activity area: logistics in the context of HADR and MACA operations.

To meet the research objectives, this study addressed the following research questions:

1. How might climate change affect demand for and delivery of logistics support and how should the MOD prepare for this? What evidence is there for increased demand for HADR/MACA operations which could stretch logistics support? – These questions are addressed in Chapters 4 and 5, with further contextual evidence on climate change-induced threats that are likely to require a military crisis response presented in Chapter 2.
2. Which logistics requirements for past HADR or MACA operations are likely to be relevant for future HADR or MACA operations in climate-degraded environments? – This question is addressed in Chapter 4, with additional examples of learning opportunities from past operations presented in Section 5.2.
3. How might increased investment in green technologies enable a reduced logistics burden for future operations and a commensurate reduction in force protection requirements? – This question is addressed in Section 5.3.

Throughout the research it quickly became evident that the first research question, the broadest in scope of all three, in fact contains several distinct sub-questions:

- How do climate-related hazards impact on the need for crisis response? – This sub-question is addressed in Section 4.2 of the report.
- How do the effects of climate change complicate the delivery of defence logistics? – This sub-question is addressed in Sections 4.3. and 4.4 of the report.
- How can defence logistics in crisis response be delivered in a more environmentally sustainable way? – This sub-question is addressed in Section 5.3.

In addition, the study also provides a summary overview of evidence on the climate change-induced threats (Chapter 2) and an updated overview of most recent climate change policy initiatives adopted by the UK government (Chapter 3) to contextualise the answers to research questions summarised above.

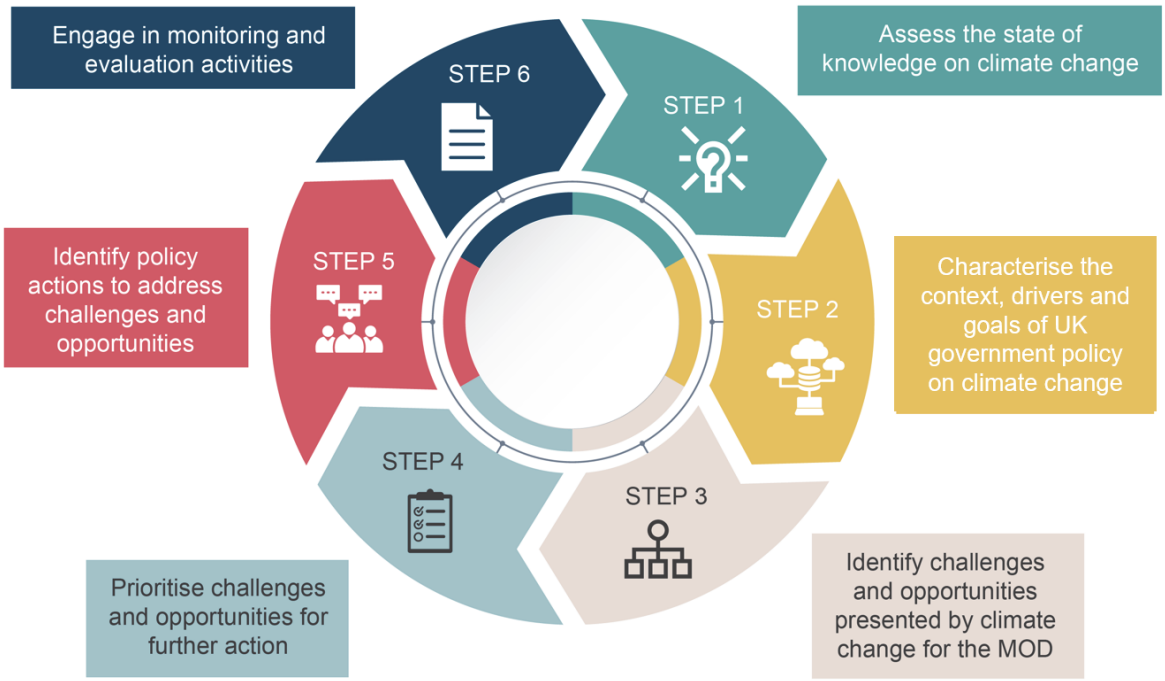
To answer the research questions, the study drew on a multi-method approach, relying on a combination of desk-based research and extensive consultation with experts and stakeholders via interviews and four workshops. Details on the methodology are included in Annex B.

1.4. Applying an analytical framework from earlier research, this study examines the implications of climate change for crisis response

This study builds on previous work conducted by RAND Europe and GSP that explored the implications of climate change across the Defence Lines of Development (DLODs)[16] and designed a conceptual framework that can be used for assessing impacts in any specific area of interest (see Figure 1.1).

[16] Training, equipment, personnel, information, concepts and doctrine, organisation, infrastructure, logistics and interoperability.

Figure 1.1. Conceptual framework for analysing implications of climate change on defence



Source: Cox et al. (2020)

1.5. The study applied definitions of defence logistics, HADR and MACA derived from UK and NATO doctrine

In the UK, Permanent Joint Head Quarters (PJHQ) Northwood commands joint and multinational military operations on behalf of the MOD, including HADR operations around the world. Headquarters Standing Joint Command (HQ SJC), based in Aldershot, coordinates defence's contribution to UK resilience operations in support of OGDs, comprising: (i) military aid to a government department; (ii) military aid to the civil power (e.g. police); or (iii) military aid to the civil community. For the purpose of this study, all three types of military contribution in support of OGDs or authorities fall under the term 'MACA'. Defence logistics is defined based on the NATO (North Atlantic Treaty Organisation) Logistics Handbook (2012), as shown in Box 1.

Box 1. Definition of defence logistics

Defence logistics is the science of planning and carrying out the movement and maintenance of forces.

Defence logistics deals with the following aspects of military operations:

- Design and development, acquisition, storage, movement, distribution, maintenance, evacuation and disposal of materiel.
- Transport of personnel.
- Acquisition or construction, maintenance, operation and disposition of facilities.
- Acquisition or furnishing of services.
- Medical and health service support.

Source: NATO (2012, 20)

1.6. This report is structured around steps to implement the analytical framework, summarised in six chapters

This introductory chapter has set out the context, aims and objectives of this study and outlined the approach taken to address its overarching research questions. The report features five additional chapters:

- **Chapter 2 Climate change and defence logistics** summarises briefly the evidence base on climate change and discusses its impact on defence logistics.
- **Chapter 3 Recent relevant UK policy developments on climate change** discusses high-level policy developments undertaken recently by the UK government on climate change.
- **Chapter 4 Challenges for defence logistics** discusses the list of strategic, operational and tactical challenges identified throughout the research.
- **Chapter 5 Opportunities and policy actions** provides a discussion on potential policy actions and opportunities (including new technologies) for UK defence.
- **Chapter 6 Discussion and areas for further research** provides further food for thought on potential policy actions and suggests potential avenues for further research.

The report is complemented by a full bibliography and two annexes including a list of interviewed stakeholders (Annex A) and a more detailed explanation of the methods used in this study (Annex B).

2. Climate change and defence logistics

This chapter presents a high-level summary of the relevance of climate change to defence logistics. First, it describes the implications of climate change on domestic and global defence and security. Second, the chapter explores how climate change is expected to increase the risk of national disasters, which could lead to an increased expectation of military involvement in crisis response. Finally, the chapter describes how climate change is likely to increase the rapidity, frequency and concurrency of logistics activity.

2.1. Climate change will affect both domestic and global defence and security, with the impact on defence being felt across all DLODs

There has been broad acknowledgement of climate change as a prominent driver of security threats across international organisations, national and local governments, and individual ministries of defence. The United Nations (UN) Security Council and the NATO Secretary General have both recognised climate change as a threat multiplier for peace and security issues[17] and NATO's 2017 Strategic Foresight Analysis report has acknowledged the potential of climate change to challenge governments' ability to provide for their populations.[18] The MOD's 2018 Global Strategic Trends (GST6) analysis has also recognised the increasing disruption and costs of climate change.[19] Crucially, GST6 noted that the cost of mitigation measures to tackle its effects will become increasingly complex and expensive, underlining the need for defence and security planning assumptions to be reviewed.[20]

In early 2020, a GSP study commissioned by the MOD found that climate change will likely have strategic implications for all DLODs.[21] The study found that climate change will affect international defence and security in a number of ways and recognised wider security implications, as well as concrete implications on the MOD's activities across concepts and doctrine, training, personnel, infrastructure, equipment, information, organisation, logistics and interoperability.

[17] UN News (2019); NATO (2020a).

[18] NATO (2017).

[19] MOD (2018).

[20] MOD (2018).

[21] Cox et al. (2020).

2.2. The risk of natural disasters is projected to increase, leading to an increased expectation of military involvement in crisis response

There is considerable evidence that climate change is already occurring.[22] The temperature of the Earth's surface has risen up to twice as much as the global average temperature, increasing by 1.5°C, while the global mean surface (land and ocean) temperature has increased by 0.9°C from 1850–1900 to 2006–2015.[23] The observed global warming over the past century has been affecting the natural world, triggering changes in species distribution, changes in rivers and lakes, and ice and glacier retreat.[24] Over the past 30 years, the Intergovernmental Panel on Climate Change (IPCC) has reported ocean and cryosphere thresholds of change (e.g. ocean warming, acidification and deoxygenation, ice sheet and glacier mass loss, and permafrost degradation) that are abrupt, long-term, unavoidable and irreversible.[25]

Although natural disasters precede climate change, human activities such as the burning of fossil fuels and deforestation are increasingly shown through the science of attribution to have significantly contributed towards extreme climate events.[26] Recent extreme weather events such as the spring cold wave in the UK (2013), the northern Europe summer heatwave (2018), the California wildfires (2020), the precipitations in the mid-Atlantic United States (2018), and the precipitation in Mozambique, Zimbabwe and Zambia (2018), as well as the late spring drought in South China (2018), have all been demonstrated to have a climate change fingerprint. Attribution science, using advanced statistical techniques, now routinely shows that climate changes in specific regions have exacerbated extreme climate events.[27] Hence, extreme events such as Super Typhoon Haiyan/Yolanda (2013), Superstorm Sandy (2012), the California drought (2013–2016), the Colorado floods (2013), Louisiana floods (August 2016) and Hurricane Matthew (2016), as well as the Atlantic hurricanes (2017), illustrate how the accumulation of global warming's effects increased the severity of extreme events.[28] Indeed, recent science evidence have considered whether threshold changes in various climate processes have meant the world is approaching a 'planetary boundary' on climate change: that is to say, further changes in the biophysical processes of the Earth that humans can safely operate in may lead to irreversible and highly significant shifts in climate stability.[29]

There has been a significant rise in documented economic damage from weather-related hazards, both insured assets and non-insured assets. The significant growth is partially a function of the combination of continuing population shifts to hazardous areas such as coastal strips[30] and urbanisation[31], meaning that there are more people and assets that could be impacted by climate-related hazards today than 30 years ago.

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[22] Herring (2020); MOD (2018); PWC (2021); MOD (2015); NATO (2017); Vautard et al. (2020).

[23] IPCC (2019).

[24] Rosenzweig et al. (2008).

[25] IPCC (2019).

[26] Herring (2020); Trenberth (2018); Vautard et al. (2020); Rosenzweig et al. (2008).

[27] Herring (2020).

[28] Trenberth (2018).

[29] Steffen et al. (2015).

[30] OECD (2016); MOD (2018); NATO (2017).

[31] European Commission (2017); PWC (2021); NATO (2017).

Some evidence shows that an increase in climate hazards may be expected to correspond with an increase in economic losses, and there is no significant upward trend in normalised economic damages caused by natural disasters.[32] Yet there is a strong consensus that changes in extreme weather intensity are generating increased economic losses and major social disruption and impacts on health globally.[33] All projections of future climate, including those with sustained global action to reduce fossil fuel related emissions, suggest greater magnitude from the impact of natural disasters on societies in all regions, including the UK, over incoming decades.

2.3. In addition to increasing the demand for HADR operations around the world, climate change poses direct risks to the UK homeland

Evidence of the rapidity, frequency and concurrency of natural disasters increasing in the UK has grown in recent years. In the UK, an increase in the severity of rainfall was detectable ten years ago and is projected to increase further by seven per cent or more each time there is a degree increase of global warming.[34] Flooding is expected to be one of the most prominent risks to the UK's people, communities, buildings and historic landmarks in the next five years.[35] By 2050, the UK population expected to live in areas that are at risk of flooding has been projected for the UK's climate change risk assessment to increase from 1.8 million to between 2.6 and 3.3. million.[36]

The MOD and the armed forces have already been called upon to support flood relief efforts in recent years. Significant floods in Somerset in 2014, Lincolnshire in 2019 and Yorkshire in 2020 required the Royal Air Force and British Army to support flood relief efforts.[37] In 2015, Storm Desmond caused 149 flood warnings across the country leading to the government's emergency Cobra committee to have to convene and the deployment of 500 service personnel in Yorkshire and Lancashire.[38]

Given the risks to human security, the UK economy and critical national infrastructure that climate change presents, it is reasonable to expect that there may be an increased demand for UK defence to increase its involvement in crisis response in the future. As climate change increases the frequency and severity of extreme weather and depleting water, minerals and land resources[39] creates volatility, drivers of conflict and risks to human security across the globe, defence's commitments to homeland security and humanitarian conventions and agreements could increase UK defence's involvement in climate emergency response. As expressed in the internal analysis of GST6 conducted by Concepts and Force Development within the Defence Logistics considering the impact of climate change on military operations, 'There is likely to be an

[32] Neumayer & Barthel (2011); Bouwer (2007); Bouwer (2011); Pielke (2014).

[33] Neumayer & Barthel (2011).

[34] Fowler et al. (2010).

[35] Kovats & Osborn (2017).

[36] Schaller et al. (2016); Climate Change Committee (2017a).

[37] Interviews with RAND Europe, September–November 2020. Forces.net (2019); MOD (2014).

[38] BBC News (2015).

[39] OECD (2016); Deloitte (N.d.); European Environment Agency (2020); MOD (2018); EPRS (2018); MOD (2018); NATO (2017).

increase in the rapidity, concurrency and frequency of logistics activity (especially on and between non-discretionary-type operations) and a concomitant requirement for increased levels of assured support and resilience/reversionary capability'.[40] Moreover, given the unique capabilities and skillset that defence could offer as part of its operational experience in emergency response (e.g. HADR and MACA), and the perception of defence as a major contributor to greenhouse gas emissions,[41] public pressure on defence to be a more active participant in climate response could further increase in the future.

2.4. Much of this operational demand will fall on defence logistics, with increased rapidity, frequency and concurrency of logistics activity

The MOD's GST6 analysis anticipated that climate change is likely to require a review of MOD's planning assumptions for logistics, including basing, routes, access and the operational requirements for ships, aircraft and land vehicles.[42] Based on the views of serving armed forces stakeholders consulted throughout this study, a prime concern for military planners and decision makers is the potential increase in the rapidity, frequency and concurrency of climate emergency events both at home and abroad.[43] This could subsequently increase the number of concurrent HADR and MACA operations, and thereby the complexity of logistics planning.[44] Between 2001 to 2011, the number of people affected by natural disasters every year has increased by 232 per cent in comparison to 1991 to 2000.[45] In effect, this has meant that international government organisations' (IGOs) and non-governmental organisations' (NGOs) own climate emergency response has often been stretched by multiple ongoing extreme weather events and relief efforts.[46] This increases the pressure on the military to step in to make up the shortfall. Defence's ability to ensure the necessary speed and efficiency of logistics will therefore remain critical but will likely become more challenging.[47] Some relevant high-level considerations that would need to be taken into account in defence logistics include resourcing logistics support to the scale required,[48] capability planning to adapt to the new operating environment,[49] and the need for greater understanding of the prevalent risks to existing and future areas of military activity.[50] A more in-depth discussion of the challenges climate change is likely to pose for defence logistics in crisis response operations is covered in Chapter 4.

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[40] Internal analysis of Global Strategic Trends 6 (which looks out to 2050) conducted January 2019 by Defence Logistics, Concepts and Force Development considering the impact of climate change on military operations, including HADR (Defence Logistics, Concepts and Force Development, 2019).

[41] Parkinson (2020a); Parkinson (2020b); Makin-Isherwood (2020).

[42] MOD (2018).

[43] Interviews with RAND Europe, September–November 2020.

[44] Interviews with RAND Europe, September–November 2020.

[45] Smith (2018).

[46] Smith (2018).

[47] GSP workshop on the impacts of climate change on defence logistics, 7 October 2020.

[48] Interviews with RAND Europe, September–November 2020.

[49] Interviews with RAND Europe, September–November 2020.

[50] Interviews with RAND Europe, September–November 2020.

3. Recent relevant UK policy developments on climate change

This chapter highlights the relevant developments in UK policy on climate change, focusing primarily on those that have occurred after the publication of the phase one report in June 2020 to minimise overlap.[51]

3.1. Since the first GSP study, the UK government's climate adaptation agenda has gained momentum domestically

The UK government has continued its efforts to prepare for climate adaptation since the publication of the first GSP study on the strategic implications of climate change for UK defence and security. In 2020, the UK government announced plans to issue its first sovereign green bond, which will be employed as part of Covid-19 stimulus financing in pursuit of 'green jobs'.[52] Activities that can be funded through the new green bond are activities that are aligned with the UK's long-term climate targets.

The UK government has also appointed senior responsible owners to drive domestic climate adaptation forward. Prime Minister Boris Johnson has appointed the former secretary of state for international development, Anne-Marie Trevelyan MP, to be the UK's international champion on adaptation and resilience for the Conference of the Parties 26 (COP26) presidency.[53] Additionally, Prime Minister Johnson has appointed Andrew Griffith MP as the UK's net zero business champion, whose objective will be to support industry throughout the climate adaptation transition.[54]

The Committee on Climate Change published its 2020 Progress Report to Parliament reporting on the UK's progress on reducing emissions, setting plans for a resilient recovery following the Covid-19 crisis, and reinforcing the importance of Fusion Doctrine in climate adaptation strategies.[55] The report also highlighted investment priorities and identified opportunities for the transition of the country towards lower-carbon behaviours and innovation.

Moreover, the National Preparedness Commission was established to coordinate disaster preparedness and response in the UK.[56] Although the committee does not solely focus on climate-related emergencies, it will be instrumental in coordinating flood relief efforts in addition to other potential shocks such as cyberattacks.

[51] Cox et al. (2020).

[52] Milliken (2020).

[53] FCDO (2020).

[54] BEIS (2020).

[55] Climate Change Committee (2020).

[56] Whannel (2020).

The committee is comprised of a consortium of government, industry and NGOs (e.g. Amazon, the NHS Confederation, the Serious Organised Crime Agency, Tesco, the British Red Cross, Google Cloud, Unilever, the Bank of England and the National Grid) and may promote more cohesive societal action on climate emergency response.

The new Foreign, Commonwealth and Development Office (FCDO) was established, which could potentially streamline official development assistance, including in the context of HADR operations. The merging of the former Foreign and Commonwealth Office (FCO) and Department for International Development (DFID) is likely to consolidate governmental resources, which could enable more decisive action on the UK's climate change-related developmental and diplomatic efforts, if this becomes one of the government's priorities going forward. At the same time, the FCDO is being set up in an unprecedented time of crisis with the Covid-19 pandemic, which could cause further delay to the ability of the new department to officially begin its work,[57] and subsequently further contribute towards delays in international climate adaptation efforts. The merger has also been criticised by three former prime ministers,[58] and by leaders of Labour, Liberal Democrats, Scottish National Party and Greens, as well as NGOs as an action that will diminish resources for overseas development assistance (ODA) overall.[59] Moreover, in light of the Spending Review announcement reducing the UK's ODA from 0.7 per cent of gross national income to 0.5 per cent,[60] net funds available for international climate adaptation action will be smaller than in the past.

3.2. The UK plays a pivotal role on climate change in international initiatives, but sustained leadership will require firmer commitment

The government has announced a ten-point plan releasing direct funding (£12 billion) to support efforts to put the UK on a path to achieve 'net zero' by 2050, as the first country in the world to translate this pledge into law.[61] 'Net zero' essentially means that the UK government pledges to remove an equivalent amount of greenhouse gas emissions as those produced by industry, transport and other sources. Notably, part of the plan includes £1.2 billion in nuclear, hydrogen and carbon capture technologies investments.[62] The UK was the first major economy to put legally binding measures in place to reflect its 2050 carbon neutrality pledge,[63] but the new announcement ensures there will be direct funding available to begin to put low-carbon industry research plans into action.

The UK has also shown a more assertive posture and renewed emphasis on taking leadership in international climate adaptation. For example, the UK is planned to host COP26 UN Climate Change Conference in November 2021 in Glasgow, in cooperation with Italy (having been delayed from its original 2020 date

[57] Durrant (2020).

[58] Cowburn (2020).

[59] Bond (2020).

[60] Dickson (2020).

[61] Harrabin (2020).

[62] Farrand (2020).

[63] Farrand (2020).

due to the Covid-19 pandemic). Given the delay of COP26 to November 2021, the UK is co-hosting a virtual Climate Ambition Summit with the UN, France, Italy and Chile in December 2020[64] to maintain momentum on international climate action.

The event is significant, given it is the first time that nations will be convened since the Paris Agreement and will be delivering updates on their nationally determined contributions (NDCs) to decarbonisation.[65] The opportunity for Paris Agreement signatories to take ambitious and effective action in COP26 is also greater than it may have been, given the election of the US President Joe Biden,[66] who announced plans to reaffirm US commitment to the Paris Agreement, overturning former US President Donald Trump's withdrawal. The election of Biden could become an opportunity for the UK to gather momentum behind the UK and US' shared priorities in terms of tackling climate change, or could generate competition for the UK's apparent bid to take on a leadership role in climate change adaptation.

The UK has also sought to elevate climate change on the NATO agenda, co-hosting a seminar on 'NATO and Nature, a changing climate: why the environment matters to NATO, and what to do about it' with Italy.[67] During the seminar, NATO Secretary General Jens Stoltenberg alluded to an internal discussion led by the UK and Italy, inviting allies to consider the consequences of climate change for security and NATO joint operations.[68]

In September 2020, the UK also convened a virtual ASEAN-COP26 Dialogue in collaboration with the Association of Southeast Asian Nations (ASEAN) and the International Renewable Energy Agency, which discussed long-term low emissions development strategies in ASEAN countries.[69] The Pacific region is not only one of the most vulnerable regions to climate change,[70] but also a region of contestation where China has increasingly sought to exercise influence and has also postured as a global climate change mitigation champion.[71] Notably, the UK's net zero by 2050 ambition was followed by an announcement by President Xi of Chinese aims to achieve carbon neutrality by 2060.[72] The UK's convention of the ASEAN-COP26 thus reinforces the UK's demonstration of leadership, at the same time that China's slowing economy has pulled back government investment in renewable energy by 39 per cent between 2018–2020, contributing to the perception in some quarters of China as a laggard in environmental policies.[73] In actuality, China has surpassed its existing climate targets and has emerged as a world leader in areas such as solar power generation. For example, the Chinese pledge to cut carbon intensity by 40 to 50 per cent by 2020 was reportedly achieved three years before plan (though some international observers dispute the reliability of

[64] UN News (2020)

[65] Energy and Climate Intelligence Unit (2021).

[66] Davenport and Friedman (2020).

[67] NATO (2020b).

[68] NATO (2020c).

[69] UK Mission to ASEAN (2020).

[70] Prakash (2018).

[71] Engels (2018).

[72] McGrath (2020a).

[73] Hook (2019).

official figures provided by Beijing).[74] Nonetheless, UK demonstration of leadership on climate change through ASEAN-COP26 may contribute towards the UK's regional influence in the Pacific and could enable the UK to establish partnerships that will be crucial for HADR operations in the region. The People's Liberation Army Navy (PLAN) is also placing greater emphasis on HADR, at least in the near abroad,[75] and may expand further abroad in future as part of 'wolf warrior diplomacy' and Xi Jinping's stated ambitions to have a fully modernised military by 2035 and world-class force by 2049.[76]

Although the current environment sets the scene for the UK to take leadership on climate change, the window of opportunity may be closing. Other major economies' agendas may mean that there are opportunities in terms of partnerships that the UK could strike but may also mean that other global leaders are ready to take ownership of the climate change agenda. The UK will need to demonstrate sustained commitment to climate change objectives in order to solidify its position as a leader in global efforts.

3.3. The recent Integrated Operating Concept provides impetus for greater collaboration, with high relevance for future crisis response

In September 2020, the MOD published the Integrated Operating Concept (IOpC) 2025, which emphasises the importance of both vertical integration through the strategic, operational and tactical levels and horizontal integration across government and with the UK's international allies and partners, as well as industry, NGOs and broader society. A crucial aspect of the IOpC is the notion of promoting integration and cohesion across these different actors to enable the UK to drive the conditions and tempo of strategic activity and to maximise its competitive advantage in security and societal resilience matters. In the context of climate change, this could presage an increase in coordination across these actors on HADR and MACA response, potentially to identify where the various stakeholders involved could better pool resources and where the MOD could potentially divest its efforts.

The IOpC also emphasises national integration, including with industry, academia and civil society, to leverage opportunities in all instruments of national power (i.e. diplomatic, informational, military and economic).[77] This highlights defence's commitment to working with the UK's national defence technological and industrial base to meet strategic objectives and pursue capabilities that would enable the achievement of operational advantage and freedom of action, as well as reduce the cost and logistics footprint of equipment. Indeed, the IOpC already explicitly acknowledges the pursuit of solutions that are 'markedly less dependent on fossil fuels' as being a priority.[78] The JCN1/20 Multi-Domain Integration concept also highlights the need for 'multi-domain integration' across capabilities; future procurements that seek more interoperability and multi-domain integration may also generate opportunities to incorporate design requirements that enable the UK to meet its net zero pledge.

[74] Hook (2019).

[75] CGTN (2020).

[76] Westscott and Jiang (2020).

[77] MOD (2020).

[78] MOD (2020).

4. Challenges for defence logistics

This chapter summarises the findings on challenges that are likely to emerge as a result of climate change for the delivery of the military's response to future crises, either globally or domestically.

4.1. Climate change has identifiable challenges for the delivery of defence logistics in future HADR and MACA operations

To build a picture of climate change's potential implications for defence logistics, the study team first focused on gathering evidence on challenges that are likely to emerge, particularly in the context of HADR and MACA operations. A longlist of 22 challenges was initially identified from desk research and 13 interviews with relevant stakeholders (see Annex A). This longlist was narrowed down during two expert workshops where the study team facilitated a scoring exercise, seeking to prioritise those challenges associated with the greatest costs of inaction and greatest urgency of response (see Annex B). This chapter presents the shortlist of 12 challenges grouped under strategic, operational and tactical to differentiate the levels at which they are likely to be experienced. An overview is presented in Table 4.1.

Importantly, while the focus of this phase two study has been on HADR and MACA operations, several interviewees noted that many if not most of the challenges would also be relevant for combat operations, stabilisation operations and other deployments that may in future take place in increasingly inhospitable environments. As such, actions taken to ameliorate these challenges to the benefit of future HADR and MACA operations may also enhance the operational effectiveness and resilience of defence logistics more generically, and consequently contribute to a more robust UK defence and deterrence posture.

Table 4.1. Overview of challenges

Strategic-level challenges	
	Coordination between government departments, allies and partners, local authorities, industry and others (i.e. integration across the Whole Force and Fusion Doctrine)
	Concurrency of operations
	Resource constraints (e.g. personnel, skills, equipment, infrastructure)
	Deteriorated command and control in affected areas at all levels
Operational-level challenges	
	Greater quantities of supplies required and greater cost of logistics
	Accessibility of points of embarkation and disembarkation
	Erosion of defence infrastructure and disruption of supply chains
	Equipment not fit for purpose
	Incapacitated local response
Tactical-level challenges	
	Critical equipment and supplies may be destroyed
	Challenges with water supply
	Food supply disruptions

Source: RAND Europe analysis

4.2. At the strategic level, coordination and command and control are likely to come under increased stress from concurrent operations

Since the end of the Cold War, the military's involvement in peace support, humanitarian aid and crisis response operations has increased significantly, whether under the authority of the UN and its agencies or

under regional, intergovernmental or national governments.[79] Arguably, there has been an increased acceptance – indeed, in many cases an expectation – that the military should become involved in peace support, humanitarian aid and crisis response.[80] Different schools of thought argue over whether the military should focus on its primary purpose of protecting a nation and not expend its resources on crisis response, where other actors could fulfil that role instead; or whether this constitutes a valuable use of the military instrument to fulfil international and moral obligations, as well as to promote UK influence, prosperity and ultimately security by contributing to a safer and more stable world.[81]

It is worth noting that while the military is often not the only actor involved in a crisis response, it is often seen as an efficient and effective 'early responder' to whom governments and other organisations look for help. This reflects the military's readiness, efficiency and access to certain valued capabilities (including for logistics and supply) and ability to surge capacity at short notice.[82] In most cases, the military's crisis response will be part of a coordinated response led by a civilian agency, government department or responsible agency within an international or intergovernmental organisation. The deployment of military assets for natural disaster relief is governed by the Guidelines on the Use of Foreign Military and Civil Defence Assets in Disaster Relief (the 'Oslo Guidelines'),[83] with deployment of assets for other humanitarian crises and complex emergencies covered by the Guidelines on the Use of Military and Civil Defence Assets to Support UN Humanitarian Activities in Complex Emergencies (the 'MCDA Guidelines').[84]

It is estimated that the frequency of military interventions in humanitarian relief operations is going to increase as the number of disasters – both natural and human-made – is expected to rise in the next fifty years.[85] With a greater frequency of crisis response operations, the likelihood of concurrent operations requiring the use of similar (or same) assets is likely to increase as well. This increased demand for military involvement is likely to exacerbate the already stretched resource allocation of UK defence and will put an increased pressure on the coordination mechanisms between the military and other actors involved in response.

The strategic-level challenges that will likely emerge as a result are summarised below.

4.2.1. Coordination between stakeholders is likely to become more complex and also more urgent

With projections for an increased number and frequency of HADR and MACA operations in future, vertical and horizontal integration and coordination may need to be strengthened at all levels – within the MOD and between OGDs, with allies and partners, and with NGOs, industry and wider society. A deeper, more cohesive and better integrated response to a range of threats, risks and hazards facing the UK is already envisaged in the IOpC and as part of the UK's Fusion Doctrine; a similar call for greater integration in

[79] Antill (2018).

[80] Antill (2018).

[81] This debate has come into prominence during the Covid-19 pandemic in particular. See: Wavell Room (2020).

[82] Weiss & Campbell (1991); Doel (1995); Fischer (2011).

[83] UN OCHA (2007).

[84] UN OCHA (2006).

[85] Sebbah, Boukhtouta & Ghanmi (2012).

response to climate change-related threats and crises has been voiced by the stakeholders and experts consulted for this study.

Beyond a better and more integrated response from within the UK government, there is also untapped potential in improving collaboration with regional and multilateral partners, particularly for HADR operations. These include, for example NATO, the Joint Expeditionary Force (JEF), the Combined Joint Expeditionary Force (CJEF) (with France), the Five Power Defence Arrangements (FPDA) and other collaborations. Working with allies and partners could help mitigate some of the resource constraints on unilateral action, as well as building on other actors' knowledge of the operational area in question and expertise in HADR more widely. Similarly, in the context of MACA, untapped potential may exist in better collaboration with volunteers, charities and civilian agencies, drawing on reservists and industry, and building greater societal resilience and preparedness.

While stakeholders consulted for this study unanimously identified coordination challenges among the most prominent challenges facing crisis response, overcoming them was also recognised to be a gradual process. An integrated response to future crises, underpinned by effective coordination between stakeholders, will require a shared understanding of the situation, drivers and obstacles faced, a common set of training, education and skills, and standard operating procedures. Also, effective coordination will require coordination 'champions' with appropriate skills and experience to bring together a range of potential disparate actors, placing a premium on the importance of clear leadership as well as networks, a collaborative mindset, and a shift in culture and process to break down stovepipes within or between organisations. As collaborative crisis response will continue to be ever more visible to the public via media and social media in particular, actors involved may also find greater demands for accountability.

4.2.2. The UK is likely to face concurrent operations at home and abroad, which is bound to stretch resources and the readiness to address other contingencies

Having to respond to multiple concurrent HADR or MACA operations, on top of other operations and standing commitments, may expose a compounding of risk resulting from committing the same logistics assets and enablers to multiple tasks without sufficient logistics provision and/or without full assessment of the risks involved. As logistics assets become increasingly overcommitted on parallel tasks, the risk of not being able to deliver one or more tasks increases as well. Inability to deliver on HADR or MACA tasks could be costly for the UK, potentially resulting in diplomatic ramifications abroad or loss of political capital at home. Failure to adequately support the British Overseas Territories, some of which are located in areas with high risk of climate disasters, would be particularly damaging in this regard. This, in turn, could pose further challenges to the military's ability to deliver on its tasks, potentially resulting in greater financial or political costs when finding alternative solutions (for example procurement/leasing of commercial assets to fill the gaps).

An ability to increase logistics capability and capacity at short notice to improve flexibility may be required to overcome concurrency risk, with potential mitigation measures including the use of contractors or commercial assets, if possible. This may require decision makers to spend money upfront to reduce the risk in the long run. While this comes at a cost, it brings the added strategic and operational benefits of greater depth and redundancy in the event defence is called to address a sudden and unexpected contingency (e.g.

a crisis or conflict affecting the UK or NATO) while many of its finite logistics assets are deployed on HADR or MACA operations. Enhancing defence's ability to manage multiple such operations concurrently would thereby also contribute to the UK's freedom of action and boosts the credibility of its deterrence posture, discouraging adversaries from taking aggressive courses of action that exploit windows of opportunity where they believe the UK will be too overstretched to respond.

4.2.3. Existing resource constraints in terms of funding, people, skills and equipment are likely to become exacerbated by the pressures of climate change

While the demand for deployments on HADR/MACA operations is foreseen to increase in the future, the supply side encompassing personnel, equipment and infrastructure is going to remain the same, if not smaller.[86] As a result, a mismatch between demand and supply will lead to shortages and constraints that will have to be taken into account when planning, tasking and deploying for operations. A speedy reprioritisation of military tasks may be required as well as proactive risk management. Operational capacity (personnel, equipment, infrastructure) may be strained and current shortages may be exacerbated particularly in the context of concurrent operations, as explored above.

Particular challenges are foreseen in terms of having sufficient number of people with the right skillsets and experience to deploy in HADR/MACA contexts or in areas affected by extreme weather events and changed climatic conditions. Some of the skills that may become highly sought-after in this context include civil and mechanical engineers, electricians and translators, as well as more specialised skills such as navigation (e.g. in areas with degraded communications, networks and energy provision). Training or recruiting people with appropriate skills takes time, making this challenge difficult to address in the short term; more intelligent use of reservists and partners in industry with specialist skills may serve to mitigate this challenge but would also take time to implement via a genuine Whole Force approach. In addition, other agencies, organisations and the private sector also involved in crisis response will be looking for the very same skillset, often placing UK defence in competition for the same pool of potential candidates.

4.2.4. Command and control could deteriorate in climate-degraded areas, posing challenges for coordination of efforts including with other agencies

As experienced on numerous past crisis response operations, environmental degradation and destruction of power sources can often result in degraded communication, posing challenges for effective command and control (C2) at all levels: strategic, operational and tactical. In both HADR and MACA operations, coordination between multiple respondents (e.g. civil society, NGOs, government organisations, emergency services, the military) may be hampered by degraded C2 infrastructure. Flooding and hurricanes have, so far, posed the biggest threats in this respect: in 2015–2016 floods in the UK, for example, a number of key telecommunications assets were damaged or destroyed, cutting off thousands of households, businesses as well as critical services such as the police.[87] In the Caribbean, Hurricanes Irma and Maria caused vast damage to telecommunications infrastructure, with over 90 per cent of mobile sites destroyed in Puerto Rico, St.

[86] BBC News (2019a).

[87] McKinsey Global Institute (2020).

Martin, Dominica, and Antigua and Barbuda.[88] The unfortunate reality is that natural disasters of this kind disrupt the communications systems just when they are needed most for disaster recovery.

Alternative solutions have often been adopted by the respondents (e.g. using local NGOs' radio frequency for communication), presenting opportunities for an increased role of grassroots organisations that could help build communities' resilience for the future. A range of possible alternative solutions may need to be explored and practices from past operations to enable swift measures to be put in place to respond to this likely challenge; new and emerging technologies (e.g. use of small satellites to provide 5G signals) also provide potential new solutions for the military, though their use by other respondents may be constrained by lack of funding and reliance on legacy systems.

4.3. At the operational level, the very delivery of logistics support is likely to become more complex and challenging, particularly for HADR

In general, delivering logistics support to an expeditionary operation follows the same generic model regardless of whether this operation is a combat operation, stabilisation operation or crisis response. Of course, specific plans will have to be prepared to account for the nature of the operating environment (ranging from benign to very hostile) and the specificities of the physical environment (e.g. the geography, local population, climate, etc.), along with the UK's objectives and available resources. However, delivering logistics for military operations broadly follows these steps[89]:

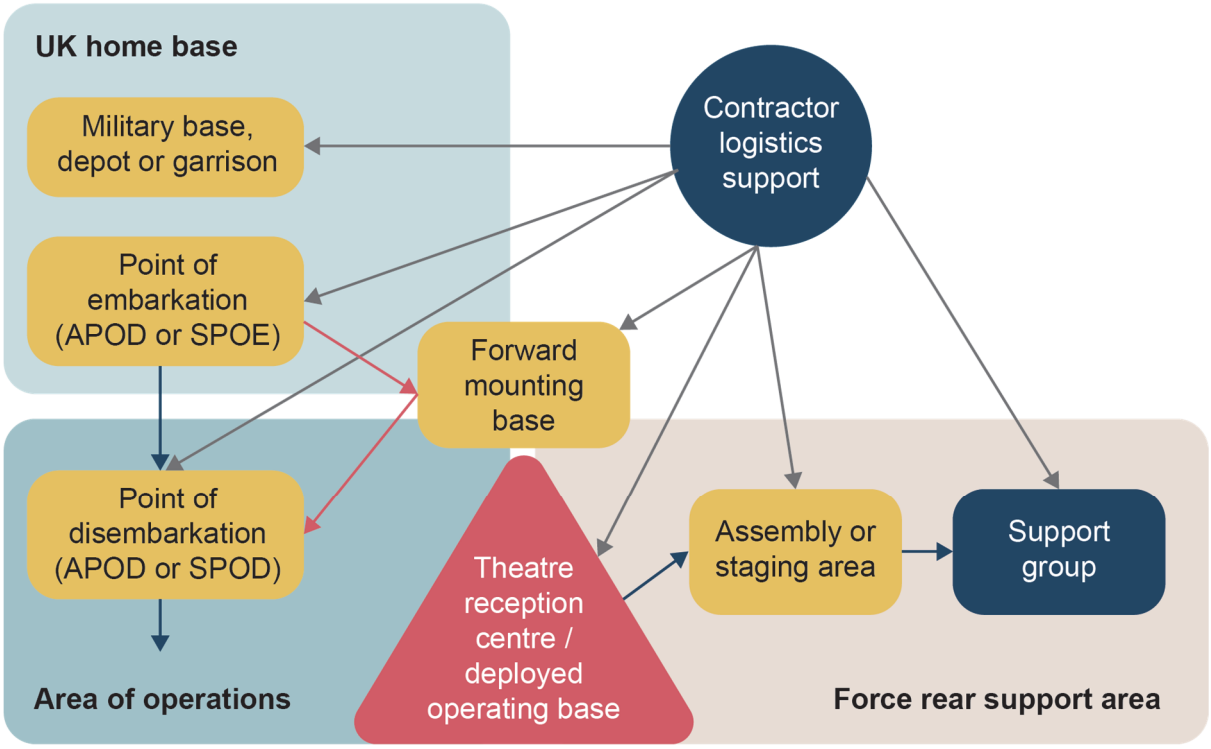
- The military force, equipment and materiel to support are moved from the base and depots in the home base to sea and airports of embarkation (SPOE and APOE), with heavy, bulk equipment and supplies primarily transported via sea routes and rapid response personnel primarily transported by air.
- At the SPOE and/or APOE, personnel, materiel and equipment are loaded onto the relevant transport and moved to the sea and airports of disembarkation (SPOD and APOD).
- Logistics support elements for the deployed force in the theatre of operations are housed in the force rear support area (FRSA), the size and type of which will vary depending on the type of operation, geographic location and the nature of the operating environment.
- The FRSA would normally have a number of assembly areas, staging areas, deployed operating bases and in some cases a theatre reception centre.
- In the last two decades, there has been an increase in the use of contractors to support delivery of logistics in deployed areas far from the home base, meaning their role must also be accounted for.

This generic model is depicted graphically in Figure 4.1 and serves to provide the context for understanding how logistics is delivered in expeditionary operations, including HADR.

[88] McKinsey Global Institute (2020).

[89] Antill (2018).

Figure 4.1. Generic model for logistics support of an expeditionary operation



Source: adapted from Antill (2018)

As shown in the following paragraphs, it is likely that climate change-related developments will result in challenges being experienced at most, if not all, these stages of logistics delivery.

4.3.1. Greater quantities of supplies required will likely generate greater costs and place pressure on finite stores, with consequences for readiness

With a greater number and frequency of HADR and MACA operations expected, it logically follows that a greater quantity of supplies may be needed to ensure appropriate resourcing of these operations both for the military personnel deployed and for communities that require assistance in the wake of the crisis in question. Interviewees for this study identified the following items as likely to be required in greater quantities in particular: equipment for transportation, medical technology, civil engineering, reconstruction and clean-up, communications, energy storage and transmission, food, fresh water and other consumables (e.g. water purification tablets), and boots. For HADR operations, the potential challenges of sourcing sufficient supplies are likely to be compounded by an inability to source these locally. As has always been the case in HADR operations, the scarce resources should be prioritised to support the host nation and therefore the military forces will need to plan to bring everything they require with them. This increases the logistics burden and ultimately the cost of the operation. Without appropriate resourcing, there is a risk that depletion of defence stores will increase the risk of shortfalls on other operations or contingencies.

4.3.2. Deteriorating climatic and environmental conditions may make access very difficult or impossible, while also prompting insecurity that threatens UK forces

As shown in Figure 4.1 above, delivering logistics to areas of operation is predicated upon accessible ports of embarkation and disembarkation (POEs/PODs). It is possible that trends precipitated by climate change such as rising sea levels, hotter temperatures and frequency and severity of extreme weather events could limit the future accessibility of APOEs and SPOEs in the UK as well as APODs and SPODs in areas to which the military is called to deploy. In addition, roads and other local infrastructure may become damaged, complicating further the intra-theatre delivery of logistics to areas where crisis response is required – be it in the UK for MACA or abroad for HADR. In the UK, previous underinvestment in infrastructure and reductions in military bases may compound this challenge, with certain individual bases becoming single points of failure (e.g. RAF Brize Norton as the UK's single APOE), particularly where such infrastructure is located in areas at risk from climate change impact (e.g. flooding, drought, etc.).

In addition to climatic and environmental conditions hampering access to areas of crisis response, movements can also be complicated by legal and procedural bottlenecks, often resulting from a large number of actors involved, each with their own perspectives, goals, procedures and agendas.[90] Similarly, access to some countries may require passing through the territory of another, requiring special permissions and creating bureaucratic challenges (as seen, for example, in Operation TRENTON in South Sudan, when access had to be granted by the Kenyan government).[91] As the nexus between climate change and conflict strengthens,[92] it is also likely that the UK military will be asked to conduct an increasing number of HADR operations in or around contested operating environments, presenting further challenges to safe and timely access to sites of climate emergencies. While a given crisis response may begin in a period of relative calm, the situation may quickly deteriorate on the spectrum of conflict, requiring peace support or possibly even combat operations. Indeed, in some cases, the deterioration could be caused or accelerated by the very presence of a military deployment.

4.3.3. Beyond POEs/PODs, the wider effects of climate change on infrastructure across the defence enterprise are likely to disrupt the delivery of logistics

Defence infrastructure is a key enabler of military capability and a key component in the delivery of logistics and support for military operations. As noted in the first GSP report on the impact of climate change on defence, the entire defence estate, both UK-based and overseas, is likely to become more vulnerable to climate-related events, with flooding, wildfires, drought, storms and cyclones highlighted in particular.[93] Disruption to defence infrastructure can affect not only the ability of the military to access and use ports of embarkation and disembarkation as noted in Section 4.3.2, but can also disrupt the delivery of supplies, personnel and equipment to those ports in the first place. Overheating of military installations, for example, will render some processes, such as the movement of personnel and critical equipment, far more challenging,

[90] Antill (2018).

[91] Interviews with RAND Europe, September–November 2020.

[92] DCDC (2018), GST 6.

[93] Wade et al. (2015); Tucker & Herrera (2019); Resetar & Berge (2016); Spanish MOD (2018).

with implications for delivery of logistics support to HADR and MACA operations, as well as many other military tasks. Climate change-related increases in temperature are likely to increase the demand for air conditioning and cooling equipment (especially to ensure proper functioning of computers and related systems), resulting in higher energy costs and potentially further negative impact on the environment.[94] More broadly, degradation of civilian infrastructure that offers support to military operations and the armed forces (such as energy grids, railroads, water systems) may also be disrupted, directly affecting the delivery of logistics. Finally, depending on its location, critical infrastructure owned and/or operated by defence industry (e.g. manufacturing or repair facilities, or test and training ranges) is likely to see some of the same vulnerabilities to climate-related events, which can lead to disruptions in delivery of equipment, spares, maintenance, training or other support to the military.

Conscious mitigations of these risks will be required to ensure a seamless delivery of defence logistics, whether in the HADR and MACA context, or other operations. Such mitigations would need to address any potential single points of failure and the compounding of risk by committing the same resources to multiple concurrent tasks. These risk mitigations are likely to require complex assessments and plans as relocation of critical defence assets and infrastructure would be slow and politically sensitive, given the local economies built around them.

4.3.4. Some of the UK's equipment may not be fit to operate in climate-degraded environments, requiring a change in approach to capability development

Planning the delivery of logistics in a military operation follows a structured format, focusing around considerations of the so-called four 'Ds': destination, distance, demand and duration.[95] Environmental and climate-related considerations play an especially important part when thinking through the destination and demand aspects of planning. Depending on the environment in which the deployment is to take place, appropriately resilient equipment and suitable materiel should be used to ensure successful delivery of the desired effect (whether this is a military effect, delivery of aid, rebuilding of local infrastructure or any other effect). The reality is, however, that some of the current equipment held by the UK armed forces is not sufficiently resilient to operate effectively, reliably and safely in extreme conditions, be it very high or very low temperatures, humidity, dust or other parameters.

As highlighted in the phase one report on climate change and its impact on defence, maritime and rotary wing assets may need to be better adapted for operation in very cold waters (e.g. in the Arctic), while other equipment such as fixed-wing aircraft or helicopters may need to be adapted to more frequent operations in high temperatures (as seen, for example, in Afghanistan, limiting the load-bearing capacity and thus multiplying the number of resupply trips required).[96] The Defence Logistics internal analysis of the implications of GST6 for logistics also highlight the need to test and adapt equipment and the associated operating concepts for future missions across different environmental conditions.[97]

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[94] Cox et al. (2020).

[95] Moore & Antill (2011).

[96] Cox et al (2020).

[97] Defence Logistics, Concepts and Force Development (2019).

Equipment may also come under increased strain due to a higher number of operations, which could affect maintenance periods, shorten equipment life, limit platform availability and increase demand for new equipment that complies with new operational requirements. While there may not be scope to introduce major changes into ongoing equipment programmes in the short term (next five years), in the longer term (ten+ years) 'designing for resilience and sustainability' will become necessary if the UK is to remain capable of deploying with the right equipment at the right time to whichever locations are so required.

In addition, it is important to note that acquisition of the right equipment that is resilient vis-à-vis the new environmental and climatic conditions will be predicated upon having appropriately skilled personnel to both design the right military requirements and technical specifications and also to regularly work with defence industry in embedding any new relevant technological advancements into the capability solution. Without training and analysis (including modelling, simulation, gaming) and access to niche skills to understand climate change's implications and necessary adaptations for military capability, decision makers may procure further equipment that is not fit for purpose, limiting operational effectiveness and ultimately driving up through-life costs while reducing value for money.[98]

4.3.5. Local responses to crises may be incapacitated as extreme weather events are set to become more intense, frequent and damaging

In areas prone to extreme weather events (e.g. hurricanes, storms, flooding), local responses may quickly become incapacitated if the impact of these events surpasses previous events in intensity and scale of damage. In such cases, host nations or local authorities may become fully reliant on external support, be it foreign militaries in the context of HADR or emergency services from another part of the UK for MACA. Having a greater number of actors involved is likely to bring challenges for C2 and coordination (as noted in Section 4.2.1 and 4.2.4); while grassroots initiatives may start to emerge to fill the gap, these expedient but ad hoc solutions may not prove sustainable or optimal in the long run.

Second order challenges may also emerge in relation to the erosion of public trust vis-à-vis local authorities if these show themselves to be unable or incapacitated to provide a timely response to the unfurling crisis, creating vulnerabilities for hostile actors to exploit via information operations and influence campaigns aimed at undermining public confidence in the crisis response (as has been the case with attempted Russian and Chinese disinformation around the Covid-19 pandemic). In some cases of HADR, there may arise greater reliance on external support (e.g. other nations' armed forces) that could generate a harmful political narrative characterised by dependence on external aid; similarly, any perceived inability to address domestic crises through MACA would also undermine the UK's influence and deterrence overseas.

4.4. Tactical challenges are likely to complicate the delivery of logistics and necessitate creative alternative solutions

On a tactical level, climate change-related events and trends are likely to complicate the day-to-day delivery of supplies, people and equipment to the right place at the right time. Most of the time, these challenges

[98] Interviews with RAND Europe, September–November 2020.

will be a product of one or a combination of the strategic- and operational-level challenges discussed above, particularly due to the erosion of infrastructure and supply chains and the degraded environmental conditions present in the area of operation. Nonetheless, the study identified other pressures worth highlighting at the tactical level, as outlined in the paragraphs below.

4.4.1. Harsh environments may erode or destroy critical supplies or critical infrastructure, requiring alternative solutions to be found

The built environment, including warehouses for critical supplies, energy grids, telecommunications infrastructure and roads, as well as the local population's housing and businesses, may be eroded or destroyed due to climate disasters, whether domestically or abroad. This may incapacitate or reduce effectiveness and speed of response for HADR and MACA operations, increase the cost burden of logistics, disrupt tactical C2 and impede coordination efforts on the ground; it may similarly place an increased burden on supply chains and production lines to recover the situation, which may result in supplies being directed away from other tasks, shortages in critical materials or delays in delivery elsewhere. Alternative solutions may be required to provide energy generation, restore communications and deliver supplies, among other tasks. Technological advances in areas such as alternative energy generation, battery technologies, satellite communication, robotics and autonomous systems may offer opportunities to address some of these tactical-level challenges. These and other technologies are explored in detail in Chapter 5.

4.4.2. Water contamination may increase the need for drinking water supply, posing additional supply challenges for both the local population and the military

Climate degradation may contaminate water supplies or disrupt local distribution networks, increasing the difficulty of procuring drinking water locally for long periods of time. In 2005 when Hurricane Katrina hit New Orleans and surrounding areas, two weeks after the event 70 per cent of affected drinking water facilities were still not operational.[99] In developing countries where water contamination is more common to begin with, exacerbated water shortages may result in increased consumption of contaminated water, potentially leading to disease outbreaks such as cholera, E. coli and others at a time when public health and medical resources are already stretched by a crisis.[100] While the military, as a default, seeks to deploy in a self-sustainable manner to not impose additional burden on local resources, there may be a growing need to not only secure potable water for the deployed personnel but also to provide it to the affected local population. As a result, there may be a greater need to transport bottled water, which may then lead to greater costs.

Additionally, there is an environmental impact to increasing the use of bottled water, undermining the environmental sustainability of the disaster response. Interviewees consulted for this study differed in their views on whether popular support for military crisis response would remain even if this response was not conducted in an environmentally sustainable way.[101] Some argue that the most important factor to consider was saving lives and livelihoods, while others suggested there may be increasing challenges for the military

[99] McKinsey Global Institute (2020).

[100] McKinsey Global Institute (2020).

[101] Interviews with RAND Europe, September–November 2020.

to retain full public support if its crisis response is conducted in a manner that exacerbates the very reasons why the crisis happened in the first place.

4.4.3. Crop destruction as a result of climate-related hazards may disrupt food supply chains, affecting food costs and resulting in food shortages in some places

Climate change-related developments are likely to affect agricultural production, resulting in losses from extreme weather and drought in major food producing regions. While the UK's overall food supply and absolute availability of food is unlikely to be affected, the price of food is likely to fluctuate, with a disproportionate impact on lower income households and some businesses.[102] The risk related to food price volatility and its potential to affect the military (particularly in relation to the cost of food supply) will demand greater attention as food supply chain disruptions become more likely. It is also possible that popular unrest and conflict may rise in relation to food shortages resulting from disrupted supply chains given past experiences in 2000 and 2011, including the Arab Spring. This is especially true of those emerging market economies that may be most at risk from environmental degradation and climate effects, given the heavy reliance of much of the population on the agrarian economy, including subsistence farming for those closest to the poverty line.

[102] Climate Change Committee (2017b).

5. Opportunities and policy actions

This chapter summarises the opportunities and proposed policy actions suggested during four expert workshops attended by MOD, armed forces, OGDs, academia and industry stakeholders in October 2020. It includes an overview of relevant technologies that could present opportunities for delivering logistics in a more resilient and environmentally conscious way and presents a handful of concrete examples. Finally, this chapter presents several concrete recommendations for policy action.

5.1. The momentum behind the climate change and sustainability agenda offers opportunities to transform crisis response delivery

There is a unique momentum behind the climate change and sustainability agenda within the UK government generally and in defence specifically, under firm leadership and structured around a uniting effort behind the CC&S strategy. As detailed in Chapter 3, the IOpC with its focus on integrating efforts across defence domains, the whole of government, allies and partners as well as drawing on wider UK talent to deliver a more competitive set of capabilities and actions provides a useful framework for defence's response to a wide range of threats, including climate change. Indeed, given the likely increase in climate change-related emergencies to which the UK military will be asked to respond, there is opportunity for genuinely integrated approaches, drawing on people, equipment, knowledge and information from across a range of actors, each of which can bring added value to the overall response. Greater coordination with the recently merged FCDO, Defra, the Met Office, local authorities, NGOs, industry and charities might open opportunities to share scarce funding, distributing it in a way that capitalises on the added value brought to the table by each actor.

On an international level, the UK has an opportunity to lead in this area within multinational forums, such as NATO or the UN. Here, the UK is now more likely to gain support of the US as well, with the new Biden administration keen to devote significant resources to addressing the challenges related to climate change.[103] But the UK would need to act quickly and with a credible commitment of political, intellectual and financial resources to build up its leadership position. Hosting the COP26 UN conference in November 2021 will be an important milestone in this effort but it should not be the last.

In relation to HADR operations specifically, the UK has a range of opportunities to build on the strong existing links with allies and partners by conducting joint HADR missions, sharing training, transferring

[103] McGrath (2020b).

lessons learnt from previous operations, or even identifying geographic areas of responsibility for each country to focus upon. For example, the UK could focus on areas surrounding Permanent Joint Operating Bases (PJOBs) and the US could take the lead in emergency response in the Asia-Pacific region. Another example could be linking with US Indo-Pacific Command (USINDOPACOM) to identify any HADR exercises to which UK personnel could be sent to participate and share best practice.

5.2. Participation in past and ongoing emergencies has yielded many generalisable practices that could improve future crisis responses

A review of past and ongoing emergencies can help to identify generalisable practices for future HADR and MACA operations. The UK's participation in various such operations in recent years has helped develop the skills and expertise of the personnel involved. Examples of recent operations include:

- 2013 Operation PATWIN, military aid after Typhoon Haiyan in the Philippines
- 2015 Operation GRITROCK in Sierra Leone
- 2019 Delivery of aid in the Bahamas by RFA Mounts Bay
- 2020 Royal Navy RFA Argus and HMS Medway training exercises in the Caribbean
- 2020 UK (and global) Covid-19 response.

In addition, much can be learnt also from other countries' responses to natural disasters. Boxes 2 and 3 summarise two concrete examples of the most recent crisis response operations related to natural disasters.

Box 2. Support to British Overseas Territories during hurricane season

The Royal Navy (RN) has extended its permanent Atlantic Patrol Tasking to provide additional support to the Caribbean region during its hurricane season.

Although the Caribbean region has been affected by hurricanes regularly in the past, the last decade or so has seen an increase in the frequency and intensity of the hurricanes. To support British Overseas Territories in their response to the hurricanes, the RN has incorporated hurricane response into its regular taskings in the region, as part of its permanent Atlantic Patrol Tasking.[104]

Since Operation RUMAN in 2017, RN vessels have deployed to the area during the hurricane season (June–November) to ensure affected British Overseas Territories are supported in their disaster response.[105] The RN personnel work alongside local emergency services to re-establish law and order, restore power and water supply, and repair infrastructure such as hospitals, schools, airports and roads.[106]

Source: RAND Europe analysis

[104] Royal Navy (2021).

[105] Save the Royal Navy (2017).

[106] Save the Royal Navy (2017).

Box 3. Australian bushfires 2019–2020: example of increasing crowdsourcing of crisis response

The 2019–2020 Australian 'Black Summer' saw a significant rise in crowdsourcing of disaster response, with grassroots initiatives sometimes supplanting official emergency response.

Between June 2019 and May 2020, Australia was hit severely by the bushfire season in what is today known as the Black Summer. During this period, an estimated 12.6 million hectares burned and over 3,000 homes were destroyed. The bushfires claimed 33 lives, including volunteer firefighters.[107] Moreover, the biodiversity of the region received a devastating blow as billions of animals and plants perished across the Australian territory.

To supplement and in some cases to supplant the national or regional emergency response, a range of grassroots initiatives emerged to respond in situ, raise awareness of the scale and nature of the disaster, and raise funds for affected communities. Enabled by the use of social media and mobile technologies in particular, many of these initiatives immediately reached global dimensions. Australian comedian Celeste Barber, for example, managed to raise over A$20m (£10.6m) in just 48 hours, with many other celebrities joining the crowdsourcing movement for disaster management.[108]

In addition to raising funds for disaster relief, nationwide rallies also represented part of the social response to the actions taken by the Australian government as some believed these were insufficient.[109] Internationally, activists organised protest rallies to demand greater commitment by the Australian government towards addressing climate change, perceived to be strongly linked to the bushfires, and towards better management of a large-scale disaster of this kind.[110]

Source: RAND Europe analysis

5.3. Advances in technology offer opportunities to reduce the logistics trail and enhance self-sustainment

In addition to learning the lessons of past operations, new technological innovations could also help to improve the delivery of defence logistics, contributing towards operational effectiveness and mission endurance, improving force protection and delivering cost savings. Although there is great variation in technological maturity across the different potential solutions on offer, there has been rapid progress in maturing many of these technologies and much research and development effort and funding is being allocated to this end. Some of the most relevant technologies and examples are summarised in Table 5.1. An in-depth exploration of these technologies is beyond the scope and focus of this present study but further work on technologies relevant for defence logistics as well as those relevant for defence deployment in general is ongoing within the Defence Science and Technology Laboratory (Dstl) and across other parts of the MOD.

[107] Australian High Commission UK (2020).

[108] BBC News (2020).

[109] The Guardian (2020).

[110] The Guardian (2020).

Table 5.1. Illustrative examples of technologies with potential to reduce logistics burden

Technology	Applications	Illustrative examples
AI-enabled logistics solutions, optimisation and planning tools	Automated warehousing and inventory management; supply chain management; route optimisation; predictive maintenance; optimisation of energy consumption; driverless resupply and many others.	**DHL Connected Transport Management System** connects all customers, drivers and subcontractors throughout DHL's logistics network. The system provides drivers with optimised routes, tracking their journeys and providing real-time status updates and alerts to customer service teams.[111]
Advanced and additive manufacturing (AM)	AM for in-theatre repairs or production of replacement parts in operations may offer considerable logistical advantages, as well as environmental benefits; by reducing warehousing (thanks to on-demand printing) and the need to transport replacement parts, AM may not only reduce emissions, but also increase the availability of equipment.	Research is being conducted to develop **sustainable AM techniques** that could capitalise on materials available in areas of deployment. Researches at Maine State University, for example, recently used AM to produce a mould for the roof of a boat, based on a composite made from cellulose fibres and a maize-based resin.[112] Researchers at Texas A&M University, in turn, have developed **AM techniques** to print building material **using local soil**.[113]
Energy generation, storage and harvesting	Alternative and renewable energy generation (e.g. solar, wind, water); improved battery technologies and supercapacitors; energy conversion technologies; energy harvesting (particularly for low power applications).	The US Naval Surface Warfare Center (Carderock Division) has developed the **Ground Renewable Expeditionary Energy Network System** (GREENS), a 300-watt, photovoltaic/battery solar power technology that provides continuous power to US Marines in the field. This combines a new packable framework array with lightweight, efficient solar technology.[114] The solution provides reduced weight, reduced noise and reduces the need for fuel supply convoys.
Robotics and autonomous systems	Surveying of damaged areas or infrastructure; autonomous resupply missions (particularly in hazardous environments to minimise risk to human respondents).	**Autonomous resupply and delivery** using unmanned aerial vehicles (UAVs) are starting to be used by the US Navy and Marine Corps particularly for delivery of small-to-medium weight supplies like water, beans and ammunition to forward operating bases, minimising the risk to life and ensuring targeted and timely delivery.[115]
Water purification and water harvesting	Water treatment to deliver clean potable water; harvesting water from external ambience.	**Water harvesting from the air**: scientists from UC Berkeley have developed a water harvester designed to extract drinkable water at very low humidity and cost using only ambient sunlight and at ambient temperature.[116] A global research team designed a **new energy-efficient method to desalinate seawater** with metal-organic frameworks and sunlight.[117]

Source: RAND Europe analysis

[111] DHL (2018).

[112] The Economist (2019).

[113] American Chemical Society (2020).

There are operational benefits to more energy-efficient and environmentally sustainable solutions: enhanced self-sufficiency, for example, is likely to reduce the logistics trail by reducing the need for fuel, food or water resupply convoys. Also, increased energy efficiency may provide a tactical advantage by enabling more persistent intelligence, surveillance, target acquisition and reconnaissance (ISTAR) missions, with self-sufficient forces also able to operate covertly for longer with a reduced signature due to the lack of need for resupply or repeated ingress and egress from the operational area to repair and rearm. Boxes 4, 5 and 6 provide further examples of how self-sufficiency may be operationalised in practise.

Box 4. French Defence Infrastructure Service's Eco Camp 2025

The French concept of Eco Camp 2025 seeks to demonstrate how greater autonomy and self-sufficiency can be delivered while maintaining quality provision of logistics and support to deployed forces.

As elaborated upon in the new Energy Defence Strategy presented by the minister of the French armed forces in September 2020,[118] the French military is exploring a range of options for military capability and camp design that would reconcile energy and environmental objectives with the constraints of a military operation. The Defence Infrastructure Service (Service d'infrastructure de la Défense, or SID) is currently working on a concept for an Eco Camp 2025, with the objective of ensuring greater self-sufficiency while maintaining quality support to the armed forces. Specific measures envisaged within Eco Camp 2025 include[119]:

- **Reduction of fossil fuel consumption to reach 40 per cent in 2030** by using renewable energy sources and improving efficiency of equipment and terminals.
- **Achieving self-sufficiency in water and energy**, by reducing the consumption of fossil fuels (e.g. generators) and, instead, developing new hybrid and photovoltaic equipment.

The concept is still in very early stages, with deployment in 2028 at the earliest. It has three stages overall[120]:

1. Develop the technological building blocks of a camp tending towards self-sufficiency in water and energy by relying on civilian technologies between 2020–2022.
2. Experiment with these devices in outdoor operation between 2023–2025.
3. Have a digital model of this camp to allow planning deployment and operational maintenance of camps deployed by 2028.

Some of the technologies tested by the French military include small modular reactor (SMR) and micro modular reactor (MMR) technologies, the use of hydrogen as an alternative energy source, studied by the SID, the development of an ultraviolet treatment produced by light emitting diodes to treat water.[121]

Source: RAND Europe analysis

[114] Gardner (2017).

[115] Defence Procurement International (2020).

[116] Sanders (2018).

[117] Ou et al. (2020).

[118] Gutperle (2020).

[119] Ministère des Armées (2020).

[120] Ministère des Armées (2020).

[121] Ministère des Armées (2020).

Box 5. Royal Netherlands Army (RNLA): Fieldlab Smart Base

The Dutch Smart Base concept is capitalising on innovative ideas from a range of stakeholders including industry, education institutions and the military to help reduce the environmental footprint of military bases.

In 2016, the RNLA invited knowledge centres, industry and educational institutions to come up with ideas on how to reduce the military bases environmental footprint. This initiative is driven by the Concept Development and Experimentation (CD&E) department of the RNLA.

As part of their defence program called Smart Base, a field lab in Ede-Driesprong was set up to test the capabilities of innovative solutions to reduce the use of fossil fuels as energy sources and to reduce water and energy consumption. The army wants to drastically reduce the footprint it leaves on the environment and achieve an **80 per cent water reduction on military camps**.[122]

Four themes are being studied in particular: protection, energy, water and logistics (support and services). One of the most prominent ideas being tested in the Fieldlab Smart Base is the **water purification unit** developed by Pure-Tech that uses X-Flow membrane technology to turn toilet waste into clean water and energy. This technology, with the unit processing 300 litres per hour,[123] was to be sent to the military base in Mazar-e-Sharif, Afghanistan for field testing, but this has been postponed due to the Covid-19 pandemic.[124] Another example is the 'Shaded Dome', a **lightweight dome that protects the user against harmful external influences** and which has a low energy consumption and is easy to transport.

Source: RAND Europe analysis

Box 6. Partially unmanned convoy systems for defence logistics

French defence company Arquus has introduced a new line of tactical vehicles, Armis, with advanced automation functions enabling remote control of a multi-vehicle convoy by a single driver in defence logistics.

Armis trucks are currently available in 6x6 and 8x8 configurations with a 4x4 version also under development. The vehicles are currently minimally manned and fitted with advanced technologies including Advanced Driving Assistance Systems, Anti-Lock Brake Systems, Electronic Stability Programme, Automatic Traction Control, and a Health and Usage Monitoring System, for improving automation, stability, energy efficiency, maintenance and repair.[125]

While still under development, the trucks' automation functions could be further improved to enable partially unmanned capabilities such as platooning and automatic convoys. A single driver could maintain control of a multi-vehicle convoy from a single lead vehicle. In case of a breakdown, a guidance system would designate the second vehicle in the convoy as the lead vehicle, allowing the convoy to stay on course. Details of the underlying vehicle-to-vehicle communications structure and navigation means are not available, but reports suggest the system would not rely on GPS or Wi-Fi.[126]

If fully implemented, such a remote convoy control capability may result in various advantages stemming from the ability to deploy convoys of multiple vehicles in a tactical environment with reduced risk to human life, with a potential operational advantage by automating logistics and improving force protection in theatre.

Source: RAND Europe analysis

[122] Smart Industry (2020).

[123] Wolting (2020).

[124] Pentair (2020).

[125] Mackenzie (2020) and Arquus (2020).

[126] Mackenzie (2020).

5.4. In considering policy actions to address climate-related challenges, it is important to understand any caveats related to their feasibility

A core component of this study has been to outline concrete policy actions that have the potential to help address some, if not most, of the challenges identified (see Chapter 4). Stakeholders consulted via the four expert workshops identified a wide range of potential such policy actions; these have been logically grouped and further expanded upon by the research team and are presented in the following sections. Each workshop had nine participants and there was minimal overlap between participants at each (see Annex B). Before elaborating on the specific actions, it is important to note a few caveats that help better frame the context in which these should be understood, most of which have been explained in more detail in earlier chapters:

- While governments often look to the military to provide a response in a HADR or MACA operation, these types of operation are not mandated military tasks, do not represent the military's primary purpose and are not core missions which only the military can deliver (unlike combat operations).
- The military has certain attributes and resources that can help provide an effective HADR or MACA response (e.g. readiness, equipment, standard operating procedures, speed) but other actors retain authority and coordination over the response (e.g. international organisations, regional organisations, national governments).
- With limited financial resources on the one hand and rising demand for crisis response on the other, there is increased need to understand and optimise the added value brought by each actor involved in a response.
- While there may be debates about the extent to which the military should get involved in operations that do not constitute its core missions, it is worth noting that the majority of the challenges, opportunities and policy options identified in this study are valid for defence logistics in general, including when deploying into harsh environments or those affected by natural disasters.

5.5. Improving coordination, information and resource sharing has great potential to increase efficiency and effectiveness of crisis response

There was near unanimous agreement among stakeholders participating in the study workshops that one of the most effective ways to address the rising demand for HADR and MACA operations would be through **better coordination and cooperation among stakeholders** already involved, as well as drawing on additional stakeholders and networks outside of these traditional participants.

The UK government and defence specifically already have many linkages and collaborations established with a range of different partners; these could be capitalised upon to specifically enhance crisis response. **For HADR, multinational coordination could be established or, more often, strengthened** (as many coordination mechanisms are already in place, particularly at the non-military level) with a range of allies and partners, for example via the following mechanisms: the UN Office for Coordination of Humanitarian Affairs (UN OCHA), the Lancaster House Treaty (with France), bilateral coordination with key allies such as the US (e.g. in the Caribbean). At the operational level, coordination could be fostered through the Multinational

Caribbean Coordination Centre, the Movement Coordination Centre Europe (MCCE), the European Air Transport Command (EATC)'s Air Transport & Air-to-Air Refuelling and other Exchange of Services (ATARES), the European Union Movement Planning Cell (EUMPC) within European Union Military Committee (EUMC) and others. Strategic-level training could be strengthened as part of these efforts; for example, through a more frequent use of the UN OCHA Humanitarian Civil-Military Coordination course or exploring joint training and good practice sharing with other militaries (e.g. with USINDOPACOM). **For MACA, joint exercises coordinated via SJC** could, for example, regularly draw on wider expertise (e.g. reservists, NGOs or commercial actors that may offer new technologies, and others) and a broader range of partners to promote and test national preparedness and resilience.

A necessary enabler of a better coordination comes through **improved information and intelligence sharing**, particularly of climate and environmental data between the actors involved in crisis response. Timely access, fusion, analysis and understanding of relevant data will be critical in enabling appropriate risk assessments to be made and plans put in place. It may be worthwhile exploring options for the development of an early warning risk map and modelling to be able to identify where climate change-related disasters are most likely to hit in the short to medium term. There may be concrete opportunities to capitalise on and expand some of the existing warning mechanisms such as the Humanitarian Early Warning Note, the Global Risk Overview and Risk Watch produced by the FCDO's Conflict Humanitarian and Security Department (CHASE), or the Met Office climate outlooks provided for different regions and globally. The use of horizon scanning capabilities to identify stress factors, use of social media, big data and other sources could also be explored.

As HADR and MACA crises often unfold very quickly with little forewarning, early warning and risk assessment tools will become increasingly more important given greater anticipated frequency and intensity of these events in the future. Information sharing could also involve developing an integrated risk index for cumulative risk associated with concurrency of events. Private insurance and re-insurance in particular have statistical models that may provide some examples.[127] Past work by the Met Office also includes analyses of concurrent risks of specific events occurring (e.g. crop failure simultaneously occurring in China and the US as two major global suppliers),[128] which could form the basis for more complex, globally oriented models in the future. As well as being useful for early warning and as an operational planning support tool, such models might also support more realistic exercises and simulations to enhance joint training for HADR/MACA.

Closely related to the points above is the need to ensure effective **capacity building** of all actors involved in crisis response. This is most often achieved through joint training and regular exercise with OGDs, NGOs, multinational partners and others, where experience can be shared and good practices identified. Building capacity could include increasing the number of liaison officers in OGDs. One workshop participant also suggested creating permanent posts with experience in professional response to climate-related emergency (e.g. hurricane/flooding, etc.) to mitigate the risk of knowledge loss due to regular posting cycles. To ensure that joint exercises and training are conducted using the most up-to-date possible scenario planning and

[127] Discussions at expert workshop, October 2020.

[128] Discussions at expert workshop, October 2020.

estimates, **PJHQ's and SJC's contingency plans could be stress-tested**, reviewed and updated to assess risks to the infrastructure that forces would be expected to use, to see the risks to their availability as a result of climate change impact and to stress-test underlying assumptions (e.g. using wargaming, modelling, simulating methodologies).

Another enabler of effective coordination would be a more proactive identification of opportunities where **specific assets and resources (financial, people, equipment) can be pooled and shared** between different actors. A specific example discussed at one of the workshops involved the option of a multirole ship being procured by a government department other than the MOD but operated by the military. While many participants judged the practicalities of this set-up to be perhaps too complex to be implementable quickly, a proactive assessment of where assets can effectively be shared will be needed if limited resources available for crisis response are to be distributed most effectively. This could draw on the lessons of the joint working and funding between different departments involved in the Stabilisation Unit or the cross-government working of the various thematic National Security Secretariat Implementation Groups (NSSIGs).

Finally, a sound collaborative approach to crisis response will necessarily involve the development of a **coherent communication strategy** that is shared among all actors involved. This will need to be underpinned by aligned goals between local and national leaders and a coherent political narrative tailored according to a robust understanding of different target audiences, both local and global. Factors enabling a coherent communication strategy for all HADR/MACA events include effective internal communication between liaison officers and an effective media training for relevant staff tasked with external communications, the use of social media and guidelines for its use, for example drawing on the expertise of the Joint Information Activities Group (JIAG).

5.6. With greater demand for crisis response, building resilience and self-sufficiency will be important to enable effective deployment

Throughout the workshop discussions, several participants placed much emphasis on the importance of building resilience, whether within the armed forces and other crisis respondents, within UK society as a whole, as well as within those foreign governments and societies that are most likely to be affected by climate change-related natural disasters.

As such, resilience quickly emerged as a multidimensional concept covering a range of areas. In the past, (systems) resilience was usually understood reactively as adapting, responding and recovering after a disruptive event. However, the contemporary understanding of resilience is more proactive, focusing on preparing for, anticipating (where possible), and then absorbing, adapting and restoring in relation to disruptions.[129] Resilience understood in this way ensures that even when disruptions do occur, all those affected by disruption (be it equipment, supply chain, logistics infrastructure and in some respect, also societies themselves) will continue working through changing themselves in appropriate ways to maintain performance and seeking to restore 'business as usual' following the resolution of the disruptive event.[130] At

[129] Summers (2018).

[130] Summers (2018).

the international policy level, risk reduction and resilience building actions that can be adopted by UN member states are covered by the Sendai Framework for Disaster Risk Reduction 2015–2030 (the 'Sendai Framework').[131]

The following aspects are important to consider when thinking about resilience:

- **Monitoring and enhancing the resilience of logistics infrastructure, supply chains and capabilities** – this will involve both a proactive risk assessment of inherent vulnerabilities at various stages of logistics delivery and an identification of possible mitigation strategies which may involve drawing on alternatives (e.g. using commercial warehousing capacities where appropriate or synergising logistics with commercial providers such as DHL, Fedex, Amazon or others).[132]
- **Relocating defence logistics infrastructure and hubs from areas that are vulnerable** to climate change-related hazards such as flooding, drought or other extreme weather events to minimise potential disruption of logistics delivery. This measure would apply to UK soil as well as PJOBs and deployed forces operating abroad.
- **Increasing resilience of equipment** to ensure that it can withstand extreme weather and climatic conditions and that it can be operated to achieve the desired effect in a range of environmental conditions. This may involve adapting existing equipment in the short run and setting up appropriate warehousing capacities to ensure equipment is stored at the right temperatures, humidity and other conditions. In the long run, 'designing for resilience' for all new capabilities would present a robust approach to ensure the UK armed forces have the right capabilities available whose performance will not be compromised by environmental and climate-related factors.
- **Fostering a closer partnership between MOD and industry** (including not only traditional defence industry but also others innovating new green technologies) to design future capabilities for sustainability, supportability and maintainability, embedding climate resilience and regenerative design requirements in future defence capability planning and development. Intersections where technology areas could contribute towards multiple objectives could be communicated as research objectives for industry. While this approach may require changes to the way defence acquisition processes are set up at the moment, the potential long-term benefits were recognised by several workshop participants as significant both in terms of operational effectiveness and environmental sustainability. Incentivising the adoption of 'greener', all-weather defence equipment could be done via a range of novel approaches, for example by initiating prize competitions to drive innovation. This could have other indirect benefits in terms of innovation and spillovers into other sectors of the economy, as well as promotion of green exports and jobs in line with the UK government's agenda for a green technological and industrial revolution.
- **Enhancing the self-sufficiency of deployed forces and equipment** – A related point to equipment resilience was raised in relation to the need for greater self-sustainment of UK forces when deployed.

[131] United Nations Office for Disaster Risk Reduction (2015).

[132] An in-depth discussion of supply chain and logistics resilience is available in Summers (2018).

Practical efforts are already underway to design camps that are more self-sufficient in terms of fuel, energy production, water and waste management (see Box 4 and 5); however, these are still early stage developments. Adopting technological and behavioural solutions aimed at self-sustainment does not only bring benefits in terms of eliminating the need to draw on local resources but also has the potential to significantly reduce the logistics tail, especially the need to re-supply bases. Indeed, despite the upfront cost of procuring appropriate technologies (e.g. solar panels for energy generation), there could be long-term cost savings on logistics on top of the operational benefits.

- **Increasing societal resilience** – The IOpC strongly advocates for greater societal resilience, underpinned by cohesion, trust, shared values, social habits and behaviour as a means to respond to the threat of sub-threshold attacks on UK society and political decision making.[133] In addition to human-made threats, societal resilience is also vital vis-à-vis natural disasters, including those directly linked to climate change. A range of societal resilience models could be reviewed to identify good practices that could be translated into the UK context, including for example, the Nordic countries (Finland, Norway, Sweden), Australia and New Zealand and others.[134] As climate-related emergencies are set to become more frequent and intense, a proactive building of societal resilience could be an important step towards an effective handling of these emergencies.
- **Building resilience through global engagement with partner nations and communities** – Similar to domestic resilience building, the UK could also use its well-established diplomatic connections to support resilience building and disaster preparation in partner nations and communities. Since 2017, the UK has been deploying to the Caribbean on an annual basis to ensure disaster preparedness; such regular engagements with other nations and communities likely to be affected by frequent natural disasters could help build local response capacity and resilience ahead of time.[135]

5.7. Innovative approaches to accessing key skills and expanding surge capacity in a crisis could offer great returns but have long lead times

The final set of measures proposed and discussed at the expert workshops included actions that would have long lead times for successful implementation but would also be likely to have the greatest positive impact on the delivery of crisis response in a changing climate.

Identifying and investing in the right capabilities for use in HADR/MACA was seen by stakeholders consulted as a prerequisite for ensuring there are enough suitably adapted capabilities to deploy to disaster-affected environment in the future. There are some assets that are critical for the delivery of logistics in crisis response (e.g. airlift) but are also in high demand for other types of military tasks. In the future, with greater concurrency of operations, demand for the same assets could result in pinch points, slowing down effectiveness of the overall response. Future spending reviews and equipment programmes should

[133] IOpC (2020).

[134] An ongoing RAND-led GSP study on societal resilience for DCDC focuses on exploring a range of different models of societal resilience and their potential application for the UK.

[135] Foreign, Commonwealth & Development Office (2020).

specifically consider the likely increase in demand for HADR and MACA operations and the consequences for the defence's portfolio of relevant equipment. Finally, identifying the right mix of capabilities to invest in should also include identifying where other actors are better placed and better equipped in a joint HADR/MACA type operation (e.g. identifying what NGOs, OGDs and multinational partners might be able to bring to the operation, be it assets, information, people, funding or connections).

To address shortages in capacity for HADR and MACA responses, workshop participants suggested it may be useful to explore how broader society could contribute to climate emergency response. Besides drawing on warfighters, the option of setting up a dedicated HADR force could be explored, building on the skills and expertise of armed forces personnel with recent HADR deployment experience, perhaps considering lessons learnt from the Canadian Disaster Assistance Response Team (DART).[136] Outside of the regular armed forces, there could be untapped potential to **increase capacity by drawing on volunteers, reservists, use of external contractors** (including establishing flexible enabling contracts to speed up procurements in a crisis) and **making greater use of societal resilience models** (see Section 5.6). In recognition of the long lead times for skills development, participants highlighted that it would be important to set up the structures that would enable defence to begin to build or access the required capacity as soon as possible.

Another enabler with potential to bring significant long-term benefits but with long lead times for impact would be the **introduction of education and training courses on climate change risks** for military and civilian personnel to inform requirements specification, acquisition, logistics planning and delivery. Specific recommendations for enhanced educational provision could include courses run by the Defence Academy (particularly the Capability and Acquisition, or CAPAC, courses) that should have appropriate content on the risks from climate impacts. This would help to ensure that desk officers (military and civil servants) who will be involved in developing future concepts and requirements, writing business cases and delivering project outputs and programme outcomes are better able to take those risks into proper consideration at the right time in the defence acquisition process.

5.8. Crafting an effective policy response requires a mix of incremental improvements and more disruptive change to achieve lasting impact

This chapter has presented an overview of twelve policy actions identified by stakeholders during workshop discussions in October 2020. Table 5.2 lists all policy actions.

[136] The Disaster Assistance Response Team (DART) was created in 1996 by the Canadian government. It is a team of 200 Canadian Forces personnel that can be deployed rapidly to provide assistance to disaster-affected regions for up to 60 days. Canada sends the DART to help when natural disasters and emergencies happen in other countries. This can be done on request when local forces are stretched and cannot manage the situation. The DART is made up of Canadian Forces (CAF) and civilian experts trained and ready for deployment within short notice. Source: Government of Canada, 2018.

Table 5.2. Overview of policy actions

Improving coordination, information and resource sharing	
	**Improve collaboration with multilateral and regional partners** (e.g. via UN OCHA, Lancaster House), OGDs (e.g. via PJHQ; SJC) and NGOs, drawing on liaison officers; firm ownership and leadership
	**Improve information sharing** of climate and environmental data to enable risk assessment and prioritisation; developing an integrated risk index
	**Build capacity** through joint training and regular exercises with OGDs, NGOs and multinational partners and sharing experience to mitigate loss of knowledge due to regular posting cycles
	**Share assets/resources** required for disaster response between different government departments (e.g. a multirole ship procured by an OGD, operated by the military)
	**Develop a coherent communication strategy** for HADR/MACA events, underpinned by aligned goals between local and national leaders and effective communication between liaison officers, coherent political narrative and effective media training
	**Review PJHQ's and SJC's contingency plans** to assess risks to the infrastructure that forces would be expected to use, to see the risks to their availability as a result of climate impact; stress-testing through wargaming, modelling, simulation
Building resilience and self-sustainment	
	**Enhance self-sustainment and resilience of UK deployed personnel and equipment** to minimise reliance on resources in disaster locations
	**Increase resilience** of logistics infrastructure and hubs using other organisations' logistics infrastructure and capabilities where appropriate (e.g. warehouses, DHL, Amazon)
	**Relocate defence logistics infrastructure and hubs** from vulnerable areas (e.g. prone to flooding) to more resilient areas to minimise potential disruption to delivery of logistics
Investing in capabilities, enablers and training	
	**Identify and invest in the right capabilities** for use in HADR/MACA, focusing on effective delivery of effect as well as minimising logistics footprint
	**Expand capacity to respond to MACA events** via greater recruitment of reservists, volunteers, use of external contractors (including establishing enabling contracts); greater use of societal resilience models (e.g. Finland, Sweden)
	**Introduce education and training courses on climate change risks** for military and civilian personnel to inform requirements specification, acquisition, logistics planning and delivery

Source: RAND Europe analysis

The policy actions summarised in Table 5.2 represent a mix of different measures, with several focused on making marginal improvements of existing processes and structures, while others represent much more

disruptive proposals with longer lead times. For example, extending collaboration with allies and partners to include HADR operations may be a marginal change in cases where such close collaboration is already present in other areas (e.g. with France via the Lancaster House Agreement). Similarly, stress-testing PJHQ's and SJC's contingency plans to ensure that there is appropriate understanding and mitigation of risk of relying on the same assets and people for concurrent operations represents more of a marginal improvement and need not be resource intensive. However, there are also a handful of more disruptive proposals, including, for example: the relocation of logistics hubs to areas less prone to climate change hazards; setting up avenues to draw on a greater pool of reservists, volunteers and broader society to respond to MACA events in the UK; and making greater investment in technologies and other enablers of self-sufficient deployments.

5.9. The study team proposes recommendations to boost the delivery of military crisis response, offering an initial list of prioritised actions

The policy actions presented above present a longlist of activities and measures that have been identified during stakeholder workshops and further discussions within the study team. These represent a mix of measures, some of which could be described as 'quick wins', while others would require long implementation timescales and would likely encounter many barriers in this process. Below, the study team puts forward a set of practical recommendations that have been identified by the workshop participants as those with the greatest potential to directly address the upcoming climate change-related challenges for military crisis response (presented in Chapter 4).

Recommendation 1: Create a generalisable plan or template for delivery of HADR operations

In light of the expected increase in extreme weather events and other natural disasters, some of which will be directly linked to climate change, it is likely that the military will be called upon to assist in HADR operations more frequently. As noted earlier, the UK military has substantial experience in assisting in HADR operations and, crucially, there is significant recent experience. While each individual crisis is unique and there is much that is unpredictable about a crisis, there are also opportunities to draw on the knowledge and detailed plans that have been developed for recent HADR operations and explore how they may be adapted. Much discussion at the workshop revolved around the valuable plans and experience from Operation CARIBBEAN in particular; these could be leveraged to prepare a more generalisable plan for the delivery of HADR operations for the future.

Since Operation RUMAN (2017), the UK annually stands up force elements to a level of readiness and preparation for deployment if needed to assist during the hurricane season in the Caribbean as part of Operation CARIBBEAN. Given that many of the processes and force elements of the Operation CARIBEEAN plan would be the same for any HADR event, the plan for this operation could serve as a basis for developing a more generalisable/generic template for HADR operations in the future. Such a template could be adapted to different circumstances, while retaining a core set of assumptions and taking into account the complexities of collaboration between civil and military actors involved. The Operation CARIBBEAN plan has various tiers of response, starting with immediate response force, which are those

already in theatre and arrive almost before the event takes place, relying on provision of reliable weather data. In addition, rapid response forces can be deployed within 48 hours to assess the initial damage on the ground and reach back to the UK to the tailored response force, which can be adapted depending on the unique requirements of the situation. In a sense, this is a sort of menu of forces to choose from, should the situation so require. Alongside outlining the required force structures and readiness levels, the plan could also help identify areas where the MOD may be able to disinvest and where alternatives may be found (e.g. by incorporating a greater role for volunteers or reservists brought in to assist with HADR operations, or by sharing assets with OGDs and others). This may also highlight where there is a need to contract in capability where it is in short supply, such as through an enabling contract.

Furthermore, there is a concrete opportunity to combine existing doctrine publications into a single HADR doctrine, which could be formulated to cover strategic, operational as well as tactical level. This could involve combining relevant elements of JDP 3-52 Disaster Relief Operations, AJP-3.4.3 Allied Joint Doctrine for the Military Contribution to Humanitarian Assistance, AJP-3.4.9 Allied Joint Doctrine for Civil-Military Cooperation and AJP-4.10(B) Allied Joint Doctrine for Medical Support.

Recommendation 2: Strengthen the role and network of liaison officers in key organisations involved in HADR response across UK government as well as exchange officers placed in other national governments

There is already a well-established network of military liaison officers in key organisations involved in MACA, such as, for example, the RAF regional liaison officers (RAFRLOs). These are longer term posts and tend to have a regional remit. For HADR, on the other hand, such networks tend to be set up in an ad hoc manner as and when the need emerges. As such, there may be missed opportunities for embedding lessons captured from previous operations. As the demand for HADR is set to increase, a more permanent set of networks may become necessary to ensure greater efficiency of response, perhaps also drawing on the generalisable HADR plan discussed in the previous recommendation.

Similarly, a more permanent network of liaison officers embedded in other nations, regional combatant commands (e.g. the US INDOPACOM) located in regions with greater likelihood of HADR events (such as tsunami, typhoons, earthquakes) or international organisations (e.g. the UN) could provide opportunities for learning from allies and partners. The liaison officer role could combine domestic liaison responsibilities with some international exchanges. A broad remit of the liaison officer would likely require setting up a permanent post, perhaps similar to the full- or part-time reservist post that is currently in place for MACA. However, given the extensive resource requirements, this role could be created in stages. In the short to medium-term part-time posts could be created (e.g. 0.6 or 0.4 FTE), taking on liaison officer tasks in addition to the officers' primary roles. In the long-term, further consideration should be given to creating a full-time network of permanent liaison officer posts.

Recommendation 3: Explore and understand the costs and benefits of setting up enabling contracts for HADR/MACA operations

To maximise the efficiency of limited resources available for HADR and MACA operations across MOD and OGDs, there are likely to be situations in which the use of enabling contracts would be beneficial. Such contracts would be used to increase the capacity outside of the regular armed forces, for example, by

providing contractor support in delivery of supplies or commercial airlift capabilities. The option to increase capacity at short notice, acting almost like an insurance policy, could be particularly useful during concurrent operations, several of which would need to draw on the same logistics assets. The MOD has used similar enabling contracts in the past with considerable success in support of short notice operations.

Of course, there will be many situations when enabling contracts do not provide a value-for-money solution. However, with the projected increase in climate change-related events in which the military may be called upon to assist, there is merit in exploring in greater detail in which circumstances and in what ways enabling contracts would provide a cost-effective option for increasing capacity. A cost-benefit analysis could help identify both the circumstances where enabling contracts would be relevant and also the specific way in which they should be set up to ensure a cost-effective upfront risk reduction. In logistics terms, the greatest risk is associated with the possibility of the UK government being unable to support and protect people in British Overseas Territories or partners and allies in HADR emergencies due to an insufficient number of logistics assets, particularly enabling capabilities. These may be either unavailable due to a concurrent ongoing operation or because there are insufficient quantities or types of logistics capabilities available to start with. The risks here are both operational failure and a reputational risk to the UK government.

A cost-benefit analysis of the use of enabling contracts could help provide a solid evidence base for better understanding where such contracts could minimise these risks and should thus be considered, despite the upfront costs of putting them in place. Such a cost-benefit analysis could be done by gathering evidence on past performance in the use of enabling contracts as well as evidence on the counterfactual, i.e. events when they were not used and understanding whether they could have provided a valuable cost-reducing option. There is also an opportunity to explore how enabling contracts have been used effectively by other militaries, perhaps by means of international case studies.

Recommendation 4: Design a roadmap for enhancing resilience of defence infrastructure for the future

As noted in Chapter 4, there are parts of the UK defence infrastructure and estate that are already vulnerable to the effects of climate change and that are likely to become even more so in the future. The need to enhance the resilience of infrastructure (both MOD- and industry-owned) and the estate goes beyond their use for logistics purposes within crisis response situations. Rather, it is a critical step in embedding climate resilience across the defence enterprise. Once specific vulnerabilities of the infrastructure and estate have been identified, the next step would be the creation of a roadmap for enhancing their resilience. Such a roadmap would include both timeframes for implementation of resilience-building measures as well as specific technical, process, behavioural and organisational changes that may be required.

Recommendation 5: Set up education and training courses with specific climate change content for junior and senior defence staff or incorporate this content in existing curricula

Much discussion at the stakeholder workshops centred around the need to embed the knowledge an understanding of climate change and its potential implications for defence across the defence ranks. Knowledge and understanding are critical to ensure climate change considerations are routinely taken into account in defence planning, acquisition, mission planning and other decisions. Initial steps could include integrating climate change content into existing courses, for example, via setting up climate change modules

within existing course syllabi of internal (e.g. the Defence Academy, Defence Leadership Centre and phase one and two training) and external (e.g. university-provided) staff courses, courses on defence acquisition and bespoke courses for personnel that are specifically going to work in HADR roles or be part of a contingency force (e.g. for Operation CARIBBEAN). Acknowledging the pressure that training and education courses are under to continually add material, it might be possible to adapt existing modules to incorporate climate change concepts. For example, the constraints and restraints climate change issues might impose on planning, longer term strategy and diplomatic engagement as well as more tactical-level activities.

As a next step, full courses could be set up which systematically cover the issues related to climate change as well as its implications for defence and for society more broadly. It is possible that this might have a natural home in the area of Resilience which is attracting more interest across defence. An integrated approach to climate change education and training would not only provide immediate benefits for the MOD in terms of increasing understanding of the issues but would also ensure that the implementation of the CC&S strategy is underpinned by solid education and training of MOD staff at all levels.

It is beyond the scope of this short study to provide implementation plans for each of these recommendations. Instead, this study offers a menu of options with varying ease and cost of implementation and varying degree of effectiveness vis-à-vis the challenges summarised in Chapter 4. In the final chapter, the team offer some strategic-level insights which could help guide potential prioritisation of these policy actions and recommendations in the future.

6. Discussion and areas for further research

This chapter presents some concluding food for thought and ideas for further research which have not been covered in previous chapters. This chapter draws out more strategic-level themes and offers them as reflections to consider in future crisis response planning in a changing climate.

6.1. With the projected steep rise in the demand for crisis response, a shift in approach might be needed from 'emergency' to 'resilience'

As climate change-related hazards and disasters increase in frequency and intensity and become visible all around the globe, a reactive response to them will no longer suffice. Crisis response will likely need to change from a focus on responding to one-off emergencies to more proactive planning for regular, periodic events which demand a different approach: one focused on long-term resilience. As seen by the recent introduction of a permanent UK maritime asset presence in the Caribbean during the hurricane season, recurrent crises will require proactive management and the readiness to respond. Part of such proactive management is resilience building across the entire crisis response delivery enterprise: from the organisations involved, to the people, equipment and materiel, and to the societies affected by these disasters. Resilience should be understood as the ability to absorb, adapt and restore in relation to disruptions and will be critical in face of the rising number and intensity of such climate-related disruptions in the foreseeable future.

Aside from a conscious shift in mindset and approach, practical tools will be required to enable the shift from an 'emergency' to 'resilience' paradigm. These could include, for example early warning systems and risk indices to enable early identification of where crisis response may be required over different time horizons, relying on meteorological and climate data as well as statistical models incorporating probability and risk calculations. Qualitative and quantitative research approaches, including for example horizon scanning, big data analytics (e.g. of crop yields, food prices, etc.) and social media analysis, could similarly provide useful methods for building knowledge and understanding about emerging stress factors that may result in a crisis either globally or domestically.

Resilience building, by necessity, will involve a coordinated planning effort on behalf of all actors involved in crisis response, underpinned by effective training and exercises. Various approaches could be used to stress-test the planning assumptions and support delivery of exercises, for example gaming, scenario-based assumptions planning, simulation or red teaming, to name a few. This should include stress-testing the ability of different actors (e.g. armed forces, MOD, OGDs and international allies and partners, or NGOs) to work together and identify and overcome seams in joint decision-making or delivery, in line with the principles of both Fusion Doctrine and the IOpC.

Finally, resilience is likely to involve the whole of society. Therefore, planning and coordination efforts should also include research into appropriate models of societal resilience, or aspects thereof, and identification of concrete actions for enhancing this resilience both in the UK and overseas.

6.2. Technology is a natural ally of sustainability and self-sufficiency and thus a powerful enabler of an environmentally sustainable logistics

Emerging technologies represent a vast array of opportunities for setting up a more environmentally sustainable delivery of logistics. While there is varied progress and technological maturity of solutions across different environmental parameters (e.g. fuel, energy, water, waste), significant resources are being dedicated to research and application of these technologies. Rapid progress is being made in battery technologies, alternative fuels, solar energy, electric vehicles, robotics, waste recycling and others, many of which have direct relevance for defence applications (see Chapter 5 for examples).

In some respect, it can be said that technology represents one of the fundamental enablers of an environmentally sustainable defence enterprise in general and defence logistics in particular. Understanding the types of solutions available on the market, the type of research projects undertaken and the technology roadmaps of relevant technologies (including the timeframes for implementation involved) is already a necessary prerequisite for defence logistics planners as they look to find solutions that do not compromise operational effectiveness and yet enable a shorter logistics trail, greater efficiency and force protection. Equally important is understanding any barriers to implementation of these technologies and wider enablers that would make their application in defence logistics feasible and value for money. As these technologies reach maturity and competitive solutions start to proliferate, this up-to-date understanding (enabled, for example, by horizon scanning and technology watch activities) will become critical.

Yet it is not technology on its own that will have transformative effect on how defence logistics is delivered in the future; it is important to avoid seeing technology as a panacea or 'silver bullet' solution to complex problems of the kind posed by climate change-related HADR and MACA operations. Behaviours and human creativity will be just as important, if not more, to bring about creative solutions that enable the military to plan, deploy and operate in a more environmentally sustainable way. Creating the right environment within the MOD and armed forces to foster sustainable behaviours on an individual as well organisational level and to enable greater innovation and its rapid adoption will require an agile set of processes alongside a fruitful dialogue with industry, academia and other relevant actors, including OGDs and government agencies. Specifically, there is an opportunity to foster a closer partnership between MOD and industry (including not only traditional defence primes but also newer players active in developing green technologies or commercial logistics solutions) to design future capabilities for sustainability, supportability and maintainability at the same time. Intersections where technology could contribute towards multiple objectives could be communicated as research objectives or innovation challenges for industry and academia, many of whom are already in the process of adapting their ideas, products, services and processes to cut emissions and provide solutions that are environmentally sustainable.

There is furthermore an opportunity here for defence to align its innovation priorities and investments with related technology and industry programmes being pursued across UK government as part of a wider effort

to promote a green industrial revolution, with benefits in terms of access to funding and engagement with a wider audience of non-traditional suppliers, including small and medium enterprises. Any technological developments that contribute to new capabilities for defence logistics may also contribute to national prosperity, including through exports, employment and wider beneficial spillovers.

6.3. Climate change affects the whole planet and requires a global response, in which the UK should have a powerful voice

All the preceding analysis has looked at crisis response (HADR and MACA) from the perspective of the UK and has focused on what defence and the UK government generally can do to adapt most effectively to the changing climate. As shown in Chapter 2, however, the impact of climate change is likely to be felt all around the globe. Thus, it is clear that the growing demand for crisis response type interventions will land on the shoulders of the UK alongside other nations, including allies and partners as well as strategic competitors and adversaries. Given its unprecedented scale and complexity, the issue of climate change represents one where there is an opportunity to build trust and cooperation with nations who are otherwise competing with the UK, recognising the need for collective climate action and to treat such as a positive sum rather than zero sum game. The UK should therefore continue to engage widely in building support for action on emissions and the environment. Similarly, sustainability goals will need to be actively pursued not just by the UK but the global community as a whole if the negative impacts of climate change are to be mitigated. As such, any policy actions adopted by the UK should always be conscious of this global dimension of climate change and the shared responsibility that the global community has in this respect.

The government's vision of a 'Global Britain' encompasses an outward-focused UK that is active in its response to global challenges and ready to take up a confident role in pursuit of opportunities.[137] Arguably, it is simultaneously one of the greatest challenges and opportunities of our time to lead global adaptation to climate change and help to lead the global community in building greater resilience vis-à-vis the increasing climate hazards and risk of other disasters. Supported by its international allies and partners, the UK has an opportunity to champion a constructive approach to adapt to and mitigate the impacts of climate change, drawing on its well-established climate and environmental science research base and favourable current policy framework with its emphasis on a green recovery from the Covid-19 pandemic and related recession. Defence has an important role to play in supporting this agenda to the benefit of military operations, the security, influence and prosperity of the UK, and the stability of the world at large.

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Annex A. Interviewees

This annex provides more detail on the conduct and participants of the interviews. The study team conducted semi-structured interviews with stakeholders with backgrounds in:

- Climate resilience and defence
- Capability development
- Logistic support
- Humanitarian aid and disaster relief missions
- Military aid to the civil authorities.

The list of interviewees is presented in Table A.1. Interviews were conducted between September and November 2020. The purpose of the interviews was to:

1. Collect inputs on the challenges and opportunities faced by the MOD with respect to defence logistics in the context of climate-related HADR and MACA operations.
2. Discuss potential policy actions for adaptations and opportunities for future crisis response, including emerging technologies and enablers to reduce the logistic burden for future operations.

The interviewees were identified through the client's and GSP team's networks as well as through an open search on the Internet (particularly relevant for publication authors on relevant topics). Interviewees were also identified through the snowballing technique, which refers to the recruitment of further interviewees through the recommendations and networks of interviewees contacted initially. The interviews were designed to be semi-structured 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 video call and lasted for approximately one hour.

Table A.1. List of interviewees

Interviewee	Country	Organisation
GP Cap Sue Binns	United Kingdom	MOD
Clive Murgatroyd	United Kingdom	Cranfield University
R Adm (ret) Neil Morisetti	United Kingdom	University College London
Maj Mark Player	United Kingdom	MOD
Col Orlin Nikolov	Bulgaria	CMDR COE
Prof Declan Conway	United Kingdom	London School of Economics
John Conger	United States	Centre for Climate and Security
Frances Pimenta	United Kingdom	Defra
Liam Robson	United Kingdom	Defra
AVM Richard Hill	United Kingdom	DST
RAF Regional Liaison Officer London & SE (2012–2017)	United Kingdom	RAF
Maj Gen Robert Walton-Knight	United Kingdom	MOD
Sq Ldr Richard Garston	United Kingdom	RAF

Source: RAND Europe

Annex B. Methodology

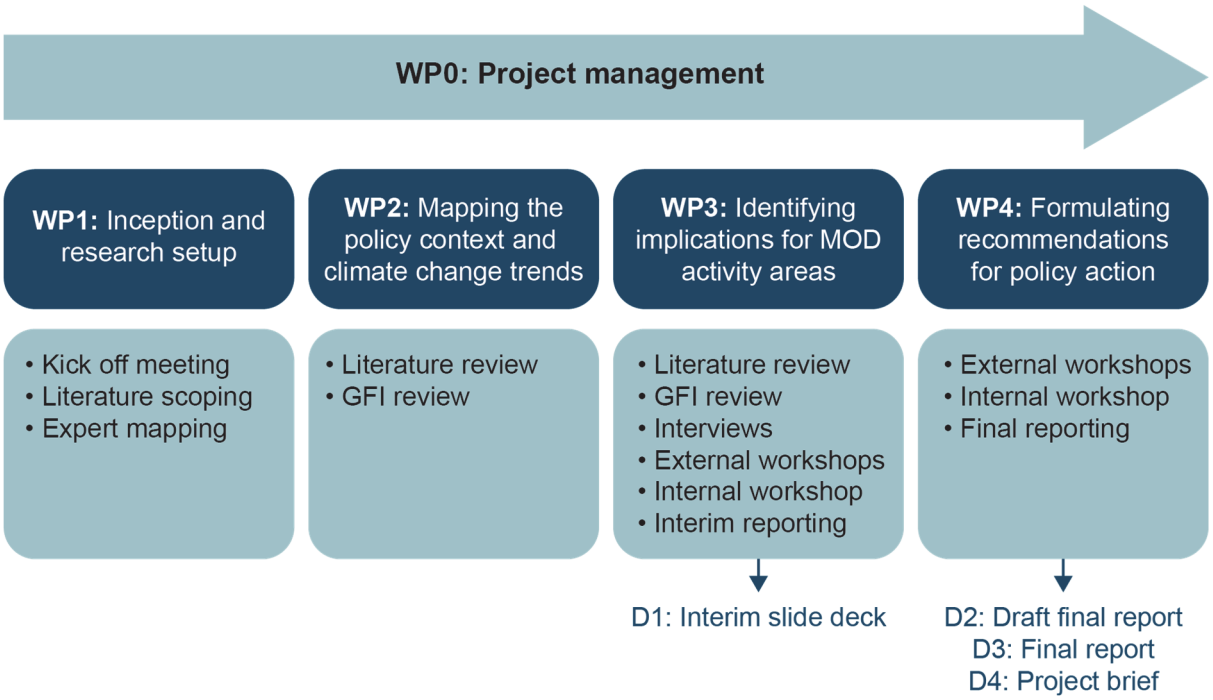
This annex provides a brief explanation of the methodological approach underpinning this study.

The study was conducted using a series of mixed methods drawing on literature and expert input

While much research has been done on the potential impact of climate change more generally, research and analysis of specific implications for defence (including defence logistics) are only just emerging. As such, there is limited written evidence on the topic of interest. To mitigate this, the study team designed a research approach that focused heavily on input from experts and practitioners, gathered via semi-structured interviews (see Annex A for detail) and a series of four expert workshops.

A schematic depiction of the approach to delivery of this study is shown in Figure B.1.

Figure B.1. Schematic overview of the methodology



Source: RAND Europe

The detailed descriptions of each workpackage (WP) are presented below.

WP1: Inception and research set-up

The first WP was centred around confirming the scope, objectives, approach, methods, outputs and envisaged outcomes with the client and identifying sources for further review. The study team held an initial kick-off-meeting in early September with Development, Concepts and Doctrine Centre (DCDC) to agree these.

Following the kick-off meeting, the study team assembled relevant literature from open sources and government-furnished information to review for WP2 and WP3. Simultaneously, the study team, together with DCDC, identified a longlist of experts to contact for interviews and participation in workshops.

WP2: Mapping the policy context and climate change trends

The second WP consisted of literature review to map the relevant context on climate change and UK policy related to climate change, focusing on any new actions and strategies adopted since the publication of the first GSP report on climate change and defence. This literature review considered academic literature, grey literature, past GSP work on defence strategy, relevant UK government strategy and policy documentation, international publications and news articles. A full list of literature referenced in this report is included in the References section.

WP3: Identifying implications for logistics

The core research activities focused on WP3 and WP4, with WP3 focusing on a targeted literature and document review to identify implications of climate change for defence logistics in the context of HADR and MACA operations.

Given the paucity of literature on this topic, however, the study team focused the bulk of its efforts on an extensive engagement with stakeholders via interviews and workshops: one set of workshops with stakeholder representing the defence establishment, and one with a broader group of stakeholders including OGDs, academia and industry. Interviewees are listed in Annex A and the design of individual workshops is described further in this annex.

WP4: Formulating recommendations for policy action

The primary research activities underpinning WP4 consisted of convening further two expert workshops with defence, OGD and academic stakeholders to identify and discuss potential policy actions in response to the challenges identified in WP3. The detail of these workshops is presented further in this annex.

Once all evidence from literature review, interviews and workshops was assembled, the study team convened two internal workshops to discuss the key emerging findings and critically assess the outputs from workshops. Based on the discussions at the internal analysis workshops, the study team then prepared the interim slide deck summarising key findings. This was delivered to DCDC on 2 November 2020. Building on this skeleton structure provided in the slide deck, the study team expanded on its content in this final report.

Four workshops gathered expert insights on challenges and policy actions

The first series of two workshops held over MS Teams in early October 2020 focused on the challenges and opportunities faced by the MOD with respect to defence logistics in the context of climate-related HADR and MACA operations. As outlined in Annex A, the workshops were attended by different participants:

- Defence-related personnel (nine participants)
- Non-defence-related personnel (nine participants) – OGDs, academia.

The participants assessed a longlist of challenges and opportunities gathered by the GSP study team, using a structured scoring methodology. This produced a shortlist of challenges and opportunities. These focused on three categories: strategic, operational and tactical.

The other two workshops held over MS Teams in mid-October 2020 focused on policy actions and responses to address the short list of challenges and opportunities that were produced during the first two workshops. These workshop groups were also separated into:

- Defence-related personnel (nine participants)
- Non-defence-related personnel (nine participants) – OGDs, academia.

The participants discussed policy actions for the shortlist of challenges. An assessment on the ease of introduction (i.e. quick win or hard to sell) and time to effect (i.e. short, medium and long term) for each of these challenges was discussed.

A longlist of challenges was prioritised during the first set of workshops

Prior to the first set of workshops, the participants were sent a longlist of challenges identified through desk research and interviews (see Table A.2). During the first set of workshops, these were prioritised using a structured methodology designed in the phase one GSP study, with scoring criteria shown in Figure B.2.

This scoring exercise consisted of scoring each challenge along the three dimensions:

1. Time sensitivity of the challenge
2. Time sensitivity of adaptation
3. Cost of inaction.

A numerical value ranging from [-2,2] was to be assigned to each challenge and each scoring dimension. Scores from individual participants were aggregated and an overall map of challenges produced to enable identification of the most urgent challenges and those where inaction would result in significant financial and/or strategic costs.

Table B.2. Longlist of challenges

Strategic challenges
Coordination speed and efficiency of joint efforts responding to climate change-related crises across government departments (MACA) and with allies and local authorities (HADR) may need to increase.
Intelligence transfer (e.g. climate forecasting tools) **across government departments is not efficient** with some duplication of efforts and potentially decreasing the speed of the response to emergency incidents. The level of detail in climate intelligence is not equal for all regions of the world that may become relevant in the future (for potential future UK HADR operations).
Resource and personnel constraints experienced by the UK as well as its allies, making them potentially less able to contribute to UK HADR and MACA operations.
Regional influence of UK's adversaries may increase if their delivery of aid is perceived as more effective than the UK's efforts, decreasing UK's influence in the region and potentially leading to increased tensions and conflicts.
Delays in communicating future operating requirements to industry may prevent timely development and production of equipment and supplies for a climate-degraded environment.
Process impediments and delays due to legal requirements in the UK for MACA or in overseas operating areas for HADR may hamper speedy logistics delivery at scale.
Operational challenges
Greater quantity of supplies and increased cost of logistics for acquisition, repair and maintenance of critical equipment and supplies
Accessibility of operating areas may become more difficult, given cascading critical national infrastructure and transport infrastructure failures caused by individual or compounded climate disasters, which then destroy airfields, ports, roads, energy grids, interrupt communications and prevent critical emergency medical support from reaching vulnerable populations. For UK MACA operations, the accessibility of rural areas of the UK may be more difficult than urban areas.
Crop destruction as a result of hotter temperatures, leading to food supply disruptions to feed populations in the UK, including both UK-based food producers and countries that import food to the UK. This may interrupt the security of food supply for HADR and MACA operations.
Erosion of industry infrastructure and disruption of equipment supply chains due to climate disasters, generating further costs and delay to the delivery of military capabilities.
Local and state response capabilities for HADR/MACA operations may be simultaneously incapacitated (e.g. as in Puerto Rico's Hurricane Maria).
Equipment not fit for purpose to operate in harsh environments or may have to operate in higher altitudes, reducing the efficiency of engines. The reduction in efficiency and capacity of helicopters, for example, could require more trips to supply operating areas.

Shortages in supplies of critical equipment and supplies could emerge, such as:

- **Transportation equipment (e.g. aircraft for transportation of personnel and equipment to HADR operations and of helicopters, small naval vessels and UAVs in theatre).**
- **Medical technology and equipment (e.g. X-rays, lab and preventive medical equipment).**
- **Civil engineering, reconstruction and clean-up equipment (e.g. forklift trucks, cutting equipment, 4x4s).**
- **Communications equipment (e.g. radios, Wi-Fi).**
- **Energy storage and transmission equipment (e.g. generators).**
- **Shelter for service personnel and vulnerable populations (e.g. temporary shelters, blankets).**
- **Food, fresh water and other consumables for service personnel and vulnerable populations (e.g. water purification tablets).**
- **Other support services (e.g. kitchen staff, IT support).**

Skills shortages may emerge, particularly in civil and mechanical engineers, electricians, and translators.

For HADR operations, there may be challenges in striking mutual support agreements with overseas national or local governments to enable immediate response to climate emergencies. Mutual support agreements may be required, for example, to enable access to disaster struck areas and for logistics planners to supplement supplies of food and water by engaging with local suppliers.

Tactical challenges

Setting up base camps in harsh environments could become more difficult (e.g. in Sierra Leone, setting up camps in areas covered in water was challenging).

The constant need for repair of camps and bases (e.g. water and flood damage to camps can be difficult to manage due to magnitude of destruction).

Critical equipment and supplies may be destroyed or eroded by harsh and hostile environment (e.g. flooding inside or overheating of aircraft/naval/ground-based equipment; damage to electronics and computing hardware and other humidity sensitive equipment).

Service personnel may contract diseases in close contact with harsh environments and diseases within the UK for MACA and in tropical climates abroad.

The physical performance of service personnel may be suboptimal in harsh environments.

Bottled water supply requirement is likely to increase significantly as salt water intrusion into coastal areas and changing weather patterns could compromise or eliminate fresh water supplies in many parts of the world.

Command and control could deteriorate due to destruction of communications or power sources.

Source: RAND Europe analysis

Figure B.2. Scoring criteria for prioritising challenges

Time sensitivity of the challenge
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

Time sensitivity of adaptation action
Would mitigation measures need to be applied urgently (i.e. next 1–5 years) 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

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

Source: Cox et al. (2020)