NATO
OTAN

The Secretary General's Report

NATO Climate Change and Security Impact Assessment

Second Edition 2023

Foreword

Climate change is a defining challenge of our time, with a profound impact on Allied security. It is a 'threat multiplier' that can exacerbate conflict, fragility, and geopolitical competition. It also makes it harder for the military to do its job. If NATO wants to safeguard the security of its almost one billion citizens, it cannot be indifferent to the challenge of climate change. It must understand and adapt to it, it must play its part in mitigating it, and it must reach out to other actors, including the scientific community, to develop common approaches to meeting this challenge.

This second edition of NATO's Impact Assessment, which includes advice by NATO's Military Authorities, focuses on analysing the consequences of climate change for our security. The conclusions are sobering. There will be more extreme weather and natural disasters putting our citizens at risk. More conflicts will erupt over access to resources. Coasts will be flooded, putting civilian populations, military facilities and critical infrastructure under threat. Our armed forces will increasingly be required to operate under extreme weather conditions.

For almost 75 years, NATO has demonstrated an enduring ability to adapt. Climate change may pose a particularly difficult adaptation challenge, but NATO has already started to respond. The Climate Change and Security Action Plan, agreed at the 2021 Brussels Summit, provides us with an ambitious but realistic blueprint for progress. We will enhance our analytical capabilities, adapt by mainstreaming climate change considerations into all of NATO's work, and reduce the greenhouse gas emissions of our enterprise. As our armed forces become part of the global transition to low-carbon energy sources, we will preserve our interoperability and military effectiveness, while avoiding new dependencies on unreliable suppliers.

This Impact Assessment seeks to raise awareness on climate change and security challenges, both within NATO and beyond. I hope it reaches a wide audience.

Jens Stoltenberg
Secretary General, NATO


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Executive Summary

Climate change is a defining challenge of our time, with a profound impact on Allied security. At the 2021 Summit in Brussels, NATO Heads of State and Government (HOSG) endorsed a Climate Change and Security Action Plan (CCSAP) and agreed that NATO should aim to become the leading organization when it comes to understanding and adapting to the impact of climate change on security.

The following second edition of NATO's Climate Change and Security Impact Assessment (CCSIA) responds to the demand for increased Allied awareness of the impact of climate change on security. It sets out the effects of various climatic hazards on NATO's strategic environment. Furthermore, it includes regional assessments and specific case studies, outlining the consequences of climate change on NATO installations and assets, as well as on its missions and operations.

Impact of climate change on NATO's key tasks

Climate change is a 'threat multiplier' that significantly shapes the Alliance's strategic environment, both in the Euro-Atlantic area and in its broader neighbourhood. The effects of climate change will be felt across NATO's operating domains. Military forces will need to operate in more extreme climate conditions, facing new and demanding operational requirements. Infrastructure and assets are vulnerable to the effects of climate change. Furthermore, geostrategic competition, wider emerging environmental threats, and natural resource competition could have implications for missions and operations. As climate change-induced natural disasters increase in severity and frequency, armed forces will increasingly be called upon to provide humanitarian assistance and disaster relief. Climate change also challenges the Allies' capacity to provide critical services to their populations and military forces in vital sectors, including communications, energy, transport, and food and water.

Regional assessments and case studies

To enhance NATO's situational awareness and strategic anticipation, this report focuses on four regional analyses: Europe, North America, the Middle East and North Africa / the Sahel, and the High North. Three case studies look at the impact of climate change on selected NATO assets, installations and missions, ranging from extreme heat impacting the NATO Mission Iraq (NMI) to rising sea levels and storms threatening the Norfolk Naval Station in the US, to flooding affecting the Naval Air Station in Sigonella, Italy.

The Changing Climate

In its Sixth Assessment Report (AR6), the Intergovernmental Panel on Climate Change (IPCC) set out that "it is unequivocal that human influence has warmed the atmosphere, ocean and land" and that 'widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred." The past four decades have been warmer than any decade since accurate global temperatures began being recorded after 1850s. Global surface temperatures were on average 1.09°C [0.95 to 1.20°C] higher in 2011–2020 than they were in 1850–1900. The year 2022 was the sixth warmest year on record, continuing the trend of the top 10 warmest years recorded, having occurred from 2010 onwards.

Other relevant conclusions, drawn from AR6, include:

a) an average global precipitation increase over land since 1950;
b) a global mean sea level increase by 0.20 [0.15 to 0.25] meters between 1901 and 2018;
c) a global retreat of glaciers since the 1990s and a decrease in the Arctic sea ice area;
d) an observed change in near-surface ocean salinity;
e) the warming of the global upper ocean (0–700 meters) since the 1970s; and
f) changes in the land biosphere since 1970, with a shift of climate zones poleward in both hemispheres.

These and other climate trends are prompting climate hazards such as droughts, heatwaves, heavy rainfall and floods to occur at an increased intensity and frequency. Changes to the biosphere, such as rising sea levels, land erosion, deforestation and desertification, are also accelerating. When such hazards intersect with one another, vulnerability is compounded further. Entire ecosystems could collapse, prompting the breakdown of agricultural systems.

The AR6 recognised that "greenhouse gas emissions over the last decade are at the highest levels in human history", and in the absence of urgent action across all sectors, the goal to limit global warming to 1.5°C will be beyond reach. The report asserts that human-induced climate change is a consequence of over a century of greenhouse gas (GHG) emissions from unsustainable energy sources, land use, and patterns of consumption and production. The report also recognizes how climate change continues to threaten the health, livelihoods and security of people around the globe, ecosystem health and biodiversity.

Some of the key findings include:

a) average annual GHG emissions during 2010-2019 were higher than in any previous decade;

b) global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases;

c) reducing GHG emissions requires major transitions across all sectors, including reducing fossil fuel usage, deploying low-emission solutions, as well as adopting ambitious mitigation and adaptation measures.

In the context of these trends, the 2023 Synthesis Report of the AR6 found that climate change has already caused:

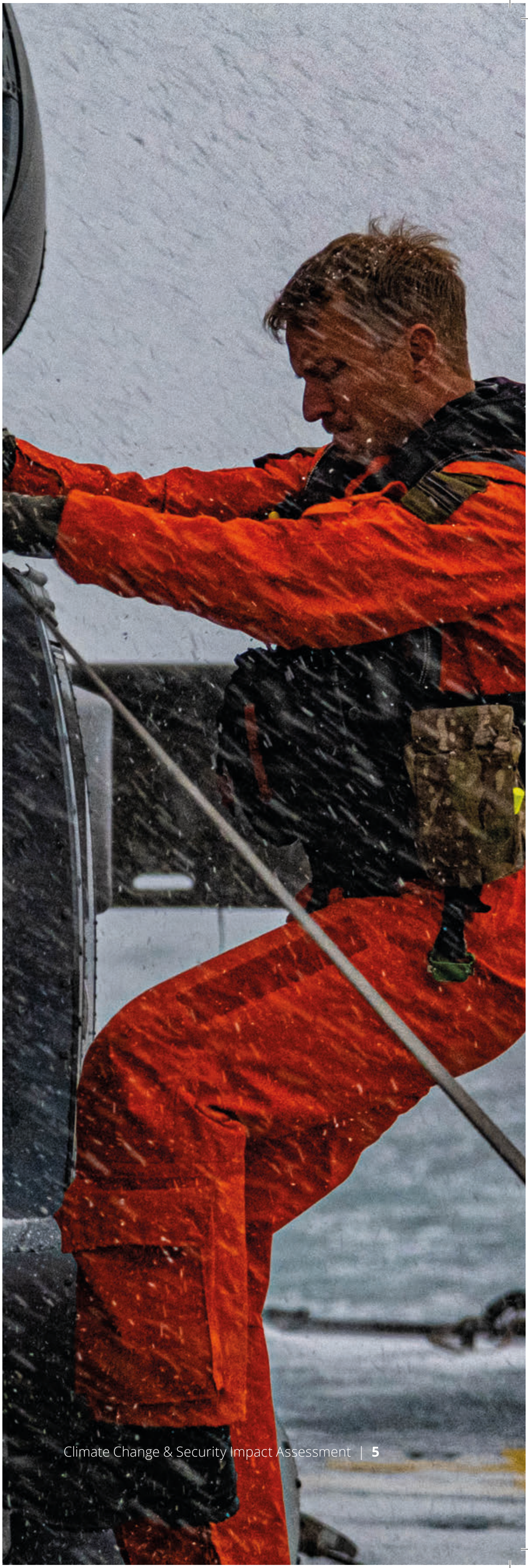
- widespread adverse impacts and damage to nature and people, beyond natural climate variability;
- an increased frequency and intensity of climate and weather extremes;
- substantially damaged terrestrial, freshwater and coastal and open ocean marine ecosystems;
- severe impacts on food and water security;
- increased displacement of people and involuntary migration due to weather extremes, thus contributing to humanitarian crises.

In this context, the 2023 Global Risks Report by the World Economic Forum included 5 "Environmental Risks" among the top 10 global risks in the short term (2 years), and 6 out of 10 in the long term (10 years). The report recognised climate and environmental risks as among those for which the world is least prepared.

The World Economic Forum also recognized that there are positive signs and increased evidence of climate action, including:

- the availability of options across sectors that can at least halve emissions by 2030;
- costs for renewable energy have fallen, granting further opportunities to incorporate these as part of the circular economy;
- the use of renewable energy sources and technologies continues to be in an upward trend, with potential for large reductions in GHG emissions;
- innovation has enabled further cost reductions and supported global adoption of low-emission technologies – with the opportunity to leverage digitalization for emission reductions when appropriately governed.

Based on this systematic evaluation of impacts, evidence-based action, both in terms of adaptation and mitigation, is feasible. For NATO, this means analysing the risks and required actions from a defence and security perspective.



Methodology

This second edition of NATO's Climate Change and Security Impact Assessment (CCSIA) expands on the key findings of the 2022 edition. Building on the qualitative risk-based approach from the first edition, this Assessment makes an initial step to combining both qualitative and quantitative analyses, to incorporate climate change modelling data, to develop scenarios, and to draw risk-based conclusions. To develop this improved approach, NATO worked with the support of key partner organizations (including the World Bank Group and the World Meteorological Organization), to identify and apply the latest and most relevant climate change data and science. The revised methodology can be found in the Annex.

The aim of the CCSIA is to increase the Alliance's awareness of the current and future impacts of climate change on security and improve NATO's adaptive capacity. The CCSIA can be used to inform a more proactive approach to the Alliance's short, medium- and long-term decision-making on appropriate responses to the climate challenge. This analytical capability will gradually expand, including through the development of a NATO Climate Change and Security Risk Management Framework (CCSRMF), as tasked by Allies in 2022.

Impact of Climate Change on NATO

NATO's Strategic Environment

NATO's 2022 Strategic Concept reiterates the core purpose and greatest responsibility of the Alliance as collective defence, against all threats, and from all directions. At the same time, the Strategic Concept also characterises climate change as a "defining challenge of this century".

Climate change significantly shapes the Alliance's strategic environment, both in the Euro-Atlantic area and beyond. Direct hazards associated with climate change include drought, extreme heat, soil erosion, desertification, flooding, rising sea levels, changes in precipitation and storm patterns. These may prompt second- and third-order consequences, including loss of land and livelihood, as well as food-, water- and energy insecurity. These could in turn exacerbate social, political and economic tensions in already fragile settings, prompt migration and increase the likelihood of violent conflict. These impacts can have a disproportionate impact on poor, vulnerable or marginalized populations, and are particularly prevalent where there is a correlation with state fragility. Climate change-induced instability, particularly in cases where the state is already lacking resources or legitimacy, can create an environment in which non-state armed groups thrive and recruit more successfully.

Overall, climate change risks are relevant to all components of NATO's deterrence and defence posture, including situational awareness and strategic anticipation; training, exercises and operations; infrastructure and installations; capability development and equipment; as well as resilience and the enablement of the Area of Responsibility (AOR) of the Supreme Allied Commander Europe (SACEUR).

Assets and Installations

Environmental hazards, such as droughts, wildfires, dust storms and extreme temperatures may disrupt military capabilities and facilities, including military bases and training ranges. Damage to a military installation could potentially have implications for the readiness of armed forces, including as a result of the need to divert resources.

To maintain operational effectiveness, military equipment will need to be suitable for the changes in the operating environments. When exposed to heat-stressed environments, clothing and land equipment, including communications, night vision devices, weapons, and ammunition used by dismounted soldiers, may suffer technical failures resulting from, for instance, overheating or dust ingress. Aircraft are subject to decreased capacity for lift and thrust in extreme high temperatures. Naval assets face cooling challenges in warming waters, and fluctuating salinity in water affects the buoyancy of submarines. The Alliance's armed forces may need to be able to operate in extreme climatic conditions with increasing frequency. All of these climate change-related impacts place greater operational stress on military systems and platforms. This shortens life cycles and may result in frequent maintenance regimes and equipment replacements, leading to increased through-life costs. This could also collective defence and operational capability.

Gender, Climate and Security

"The compounding risks of gender inequality, conflict and climate change for women and girls underscore the urgent need for integrating gender perspectives in climate change and security policies and actions. NATO's commitment to addressing these interconnected challenges reflects the Alliance's recognition that a comprehensive and people-centered approach is essential for effective and sustainable responses to global threats in today's world."

Irene Fellin, NATO Secretary General's Special Representative for Women, Peace and Security

The impact of climate change is felt by everyone, but not equally. Climate change has a distinct impact on women and girls. The intersections between gender, power dynamics, socio-economic structures, and societal expectations determine how women and men from different backgrounds experience and manage risks of exposure and climate change impacts.

Climate change impacts can compound existing grievances and exacerbate pre-existing vulnerabilities, including those linked to gender, ethnicity, race, religion, sexual identity and socio-economic status. Gender is also a factor in relation to risks of exposure. Second- and third-order consequences of climate change can include a deterioration of livelihood conditions and food insecurity, a decrease of life expectancy and deterioration of health, an increase in displacement and sexual and gender-based violence.

Particularly in contexts marked by high gender inequality, factors such as lower socio-economic status and limited access to information and technology hinder women's agency and exacerbate their vulnerability to disasters. This may lead to women's increased mortality rates. In contexts affected by conflict and fragility, climate hazards such as drought that lead to increased time and distances for women and girls to secure water, food, and firewood may expose them to higher risks of sexual and gender-based violence, including conflict-related sexual violence. Migration patterns between men and women also tend to differ. Furthermore, displacement caused by climate shocks erodes community networks, necessary for everyday survival, placing women and their children at much greater risk.

Responses to climate change may impact women and girls, and men and boys in different ways. To understand this impact better, sex-disaggregated data should be collected. Furthermore, adaptation measures need to be designed inclusively, acknowledging the different needs and higher vulnerability, but also distinct experiences and knowledge, of specific groups through a range of intersectional factors.

Missions and Operations

Military forces will need to operate in a rapidly changing environment. Geostrategic competition, wider emerging environmental threats, and natural resource competition could have implications for missions and operations. Armed forces may be deployed more often to regions facing extreme environmental conditions. At the same time, it is likely that operational energy requirements will increase as a result of the increased heating, ventilation, and cooling requirement for military systems and personnel. Exploiting the ongoing energy transition to low-carbon sources could help manage such operational needs. The impacts of climate change will also require enhanced meteorological assessment tools, including climate change and security modelling, artificial intelligence and big data analytics. NATO will seek to harness these tools in the Climate Change and Security Risk Management Framework as it develops.

Training and exercises, together with peacetime operations, are essential to maintain the interoperability and readiness of Allied forces. However, climate change could cause disruptions to the conducting of training and exercises in certain areas.

Furthermore, as climate change-induced natural disasters increase in severity and frequency, armed forces are increasingly called upon to provide civil authorities with humanitarian assistance and disaster relief (HADR). US forces have for example provided HADR following disasters in Japan, Haiti and Chile. In 2021, the Canadian Armed Forces responded to seven requests for HADR for disaster relief operations from its provinces and territories. This compares to an average of almost four requests for assistance per year between 2017 and 2021, and twice per year between 2010 and 2016. Altogether, Canadian military involvement in response to natural disasters has broadly doubled every five years since 2010.

Maritime Operating Domain

Naval forces and maritime operations are impacted by climate change in a number of ways. The detected increases in ocean acidification and changes of sea surface temperatures may lead to maritime vessels requiring more frequent maintenance regimes. Since water temperature also affects sound velocity, which has implications for the detection, localization, and identification of submerged objects, NATO's science and technology community has already highlighted the potential impact on conducting future submarine operations and anti-submarine warfare. At the same time, the increase in ocean temperatures has important implications for the cooling requirements of ship propulsion systems and other essential systems that may otherwise overheat.

The International Maritime Organization (IMO) stated that, as of 1 January 2020, marine sector emissions in international waters should be reduced to mitigate further climate change.[1] Sulphur emissions will have to be reduced by over 80%. Furthermore, the IMO's environmental protection committee has approved a draft of new mandatory measures for a 40% reduction in carbon intensity compared to 2008 across the global shipping fleet by 2030. This will be a key factor in warship design within the Alliance, while also making the research into alternative fuels a priority work strand for the NATO naval armaments community.

Land Operating Domain

In the land operating domain, while flooding can affect freedom of manoeuvrability, the greatest impact is caused by heatwaves, for example in North America, the Mediterranean, and the Middle East. They affect human health and ecosystems. At the same time, heatwaves and wildfires disrupt training and logistic activities, causing certain training exercises to be moved to the evening or avoided altogether during the summer months. Drought conditions exacerbated by heatwaves, and - in extreme cases - desertification have a direct impact on water availability for land forces, particularly those depending on surface water and ground water for sustaining operations. Such an increase in water scarcity raises operational costs and risks, and jeopardizes the ability of the Alliance to conduct successful operations. In this way, water security also places additional demands on logistics, as supply convoys may need to deliver water to remote locations, sometimes moving across hostile terrain. Drought additionally reduces load capacity for ships on inland waterways, resulting in increased disruption of supply chains, energy production and the transportation of military equipment via ships. On the opposite side of the spectrum, with the decreasing amount of snow cover and alpine glaciers melting, there is a possibility of losing cold-weather training conditions for alpine troops.

Air Operating Domain

The impacts of climate change affect both the safety of infrastructure and of the personnel working on the air stations, as well as to all phases of flight. Changes in weather patterns and characteristics (e.g. lightning and turbulence) can affect the full spectrum of military air activities. For example, aircraft could be subjected to re-routing due to rapid changes in the atmosphere (e.g., wind speed and direction, and the increasing frequency of extreme weather events, including thunderstorms) which could result in increased fuel demand and compromised mission success. Another challenge is an increase in clear-air-turbulence (CAT) due to rising temperature gradients, pressure field migration, changing weather patterns and a stronger jet stream. For example, there has been an observed increase in CAT over the pan-Arctic domain, Eastern Europe and the Black Sea. Also, hotter, less dense air has a direct detrimental impact on available helicopter torque. Widespread adaptive measures, ranging from runway length extensions, reduced payload capacity, rescheduling of flight plans to engineering modifications and upgrades will need to be considered.[2]

Space Operating Domain

The space operating domain is not immune to the impacts of climate change. Since launch facilities are typically located in low-lying areas close to shorelines, sea-level rise may impair space launch operations. In addition, wildfires have previously disrupted rocket launch schedules. The Canyon Wildfire in 2016, for instance, burnt down around 10,000 acres of land in close proximity to the space launch complexes in Vandenberg. Unpredictable and erratic winds in the upper or lower levels of the atmosphere could influence launch trajectories for satellites and missiles.

Resilience and Civil Preparedness

Climate change puts pressure on the resilience of each individual Ally and, thus, on the resilience of the Alliance as a whole. It challenges Allies' ability to provide critical services to their populations and military forces. A whole-of-government approach is key to comprehensively understand and address climate-change related aspects of civil preparedness and civil protection. A number of intersectional factors shape the adaptive capacity and resilience of different groups in society. Conflict and instability also weaken communities' capacities to adapt to changes in the availability and distribution of natural resources, which, in turn, can reinforce drivers of conflict.

Climate change can have an impact on resilience and civil preparedness in various ways:

- A potential disruption of civilian transport infrastructure and traffic management systems, whether caused by heat, heavy precipitation, or long periods of snow accumulation. This could also have a direct impact on the Alliance by hindering transit and military mobility.
- An increase in extreme weather events, as well as rising sea levels, can cause more frequent and severe damage to critical infrastructure, including undersea cables.[3]
- More frequent and severe extreme weather events may overwhelm national civil preparedness and civil protection capabilities and resources, with a potential corresponding increase in demand for military assistance to civil authorities. This could stretch military capacity and readiness.[4]
- Extreme weather events can impact the security of Allies' food supply and distribution infrastructure.[5] Furthermore, in the long-term, systemic shifts (e.g., desertification) causing changes in agricultural land use and crop harvest will have an impact on food security. The availability and quality of water will also be affected. This will also have an impact on human health.
- Climate change may also trigger the large-scale movement of people between or within countries. This can strain national capabilities, such as health care, food and water, sanitation and hygiene, sheltering, security, and transport and may have cascading impacts on the Alliance.

Regional Assessments and Case Studies

The effects of climate change vary across different geographic regions, impinging upon countries and regions in different and increasingly unpredictable ways. To enhance NATO's situational awareness and strategic anticipation, this report focuses on four regional analyses: Europe, North America, the Middle East and North Africa / the Sahel, and the High North.

Europe

The World Meteorological Organization has reported that temperatures in Europe are increasing at more than twice the global average, at about +0.5°C per decade over the past three decades – the highest of any continent.[6] The Mediterranean basin is predicted to become one of the most vulnerable areas in Europe to the impacts of climate change. This will be explored further in the case study on Naval Air Station Sigonella, Italy.

Global warming will increase the frequency and severity of heatwaves in Europe. In the event of a global average temperature increase of 3°C, an intense heatwave may occur almost every year in Southern Europe, whereas such events may happen every 3 to 5 years in Northern and Eastern Europe.[7] Such temperature extremes increase the risks of severe droughts, which many European states are already witnessing more frequently. Extreme temperatures coupled with dry conditions have exacerbated the frequency and intensity of wildfires. In 2022, wildfires caused significant disruption, with over 130,000 hectares burnt in the South-Western region of France, Northern Spain and Portugal. Military training camps and exercise areas are particularly affected. More frequently, the military may also have to provide assistance to civilian authorities in response to environmental hazards such as wildfires and floods. In summer 2022, more than ten European states deployed their forces to fight fires, including in neighbouring countries.[8]

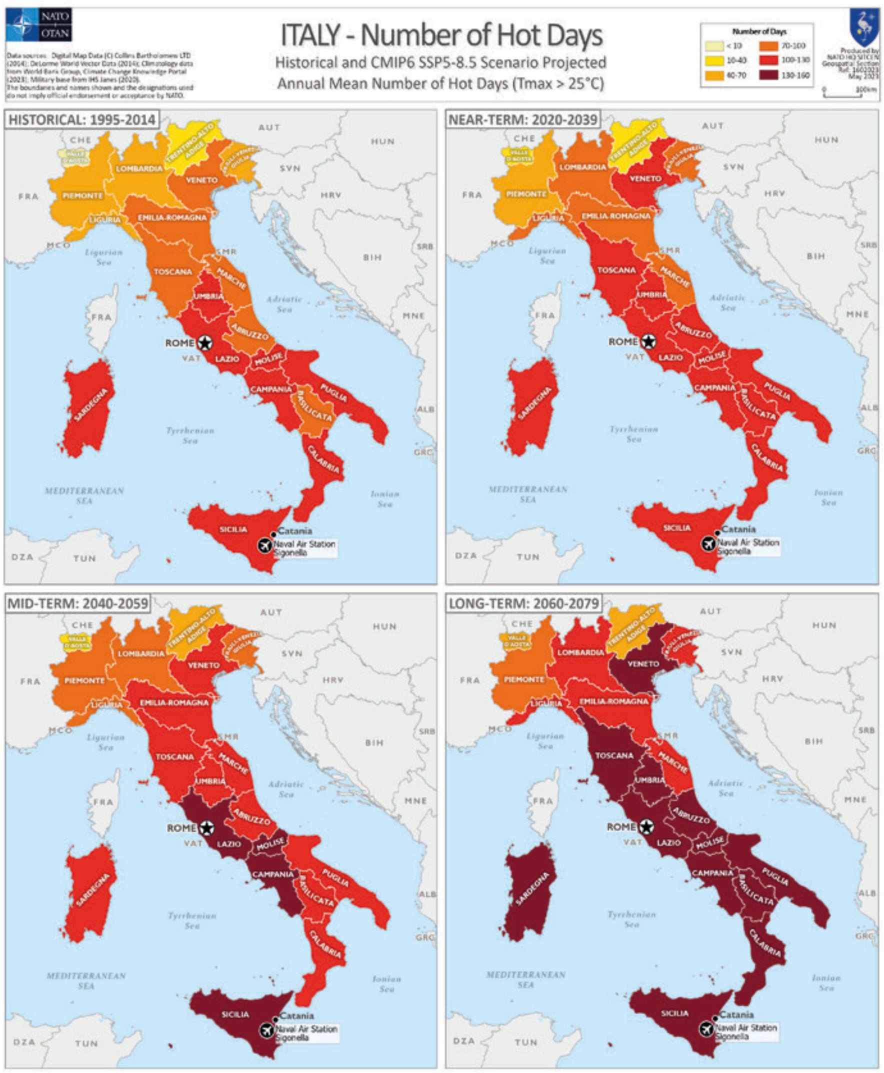
Case Study: Naval Air Station Sigonella

The Naval Air Station (NAS) Sigonella is located in the western part of Sicily, approximately 18 km south-West of the city of Catania and 40 km south of Mount Etna, an active volcano. The island is located roughly in the middle of the Mediterranean Basin, an area of the world that is already experiencing rising temperatures above the global average and that has already surpassed the 1.5°C surface temperature increase above pre-industrial levels.

The Air Station covers over 1,300 acres across four main sites: NAS I and II, the Niscemi Naval Radio Transmitter Facility, and a support capability at the NATO pier in Augusta. NAS Sigonella is home to more than 4,000 US service members, civilian personnel, and family members and is the US Navy's hub of operations in the Mediterranean Sea. It supports the US 6th Fleet headquartered in Naples, serving as a major stopover point for US aircraft that are bound for Southwest Asia and the Indian Ocean.[9]

The Air Station hosts a series of tenant commands; including the Aircraft Intermediate Maintenance Detachment; the Naval Hospital; the Naval Computer and Telecommunication Station Sicily; and the Naval Supply Systems Command Fleet Logistics Center. It is home to the Commander of Task Force 67, an element of the US 6th fleet with maritime patrol, rotary wing, and electronic attack aircraft that operate over the Mediterranean in anti-submarine, anti-surface, reconnaissance, surveillance, and mining roles.[10]

The base is also home to the NATO Alliance Ground Surveillance (AGS) system, which is composed of five NATO RQ-4D "Phoenix" remotely piloted aircrafts providing a state-of-the-art Intelligence, Surveillance



and Reconnaissance capability to NATO. The AGS provides support to the full range of NATO military and civilian-military missions, including peacekeeping and humanitarian disaster relief operations.[11]

An analysis of the land area of Sicily and the sea surrounding the region was conducted, with a view to improving understanding of how the future climatic conditions could affect assets and facilities deployed at NAS Sigonella. The exact methodology can be found in the Annex.

It is expected that Sicily is the Italian region that will suffer the most from rising temperatures, as shown in Figure 2. For example, the number of days with temperatures above 25°C will constantly increase from 110 in the historical reference period to an estimated 124 days in the short-term, 138 days in the medium-term, and 153 days in the long-term. Data suggest that mean annual temperatures will increase by approximately 1°C every 20 years. The average annual maximum temperatures will also increase by approximately 1°C every 20 years.[12]

The phenomenon of heatwaves, as defined by the IPCC as a "period of abnormally hot weather" "lasting from two days to months"[13] has the potential to impact the operations at NAS Sigonella. During a heatwave in 2021, the city of Siracusa – located approximately 50 km away from the air station – reached 48.8° C, one of the highest temperatures ever recorded in Europe. The frequency and intensity of heatwaves could increase incrementally with global warming.

Regarding precipitation, according to historical data (1995-2014), Sicily is already the second lowest region in Italy with an average annual level of precipitation of 386 mm. This is projected to drop to an estimated 374 mm in the short-term, 346 mm in the medium-term, and 329 mm in the long-term, making Sicily the driest region in Italy. The maximum number of consecutive dry days per year for the historical reference period was 224. Projections are 229 days in the short-term, 246 days in the medium-term, and 250 days in the long-term.

Increased heat will also worsen the evaporation of water from all surfaces. Combined with the expected decrease in precipitation, the terrain might become impermeable to water. Where there are volumes of high rainfall over a short period of time, flash floods might become more frequent and more disruptive.[14] Increased evaporation would also impact water reserves, causing shortages and leading to droughts and even desertification, as well as increased levels of sand and dust. While it is estimated that 70% of Sicily's territory is at risk of desertification, a study carried out by the Italian National Institute of Geophysics and Volcanology indicated that the coasts of South-Eastern Sicily, particularly the Catania Plain, could undergo progressive submersion, with a presumed loss of about 10 sq km of surface by 2100, due to climate change.[15]

Over the last 50 years, Sicily's 1,600 km coastline has made the island particularly vulnerable to intense storms ("medicanes").[16] Medicanes remain relatively rare – with an annual average of 1.6 events in the overall Mediterranean basin – but their intensity may be increasing.[17]

While the topography of the lowlands of the Catania plain is well suited for an airfield, heavy precipitation events and the existence of two rivers nearby makes it particularly vulnerable to localized flooding. The operation of the air station is particularly vulnerable because the facilities are located on either side of the river Dittaino. Sigonella's first flood occurred in 1959, the year the air station was established; the bridge linking the two sides of the facility was under almost 2 meters of water and the traffic had to be diverted through Catania.[18]

Similar events have occurred periodically, with the floods of 2005 being particularly disruptive. Despite the existence of levees, pumps, regular maintenance of drainage systems and a coordinated emergency response, the heavy storm was overwhelming. In one of the residential complexes supporting the Air Station, electricity and water supplies were cut off, and roads and sewers became temporarily unusable.[19] In October 2021, NAS Sigonella was in the path of a major medicane. It discharged over a year's worth of rain in 48 hours, and on the evening of the 24^{th} October, around 400 mm of rain fell in a 2-hours period.[20]

In the decades to come, extreme weather events and increasing temperatures could directly impact Allied capabilities, presence and force projection in the Mediterranean Sea, the MENA region and beyond. Other areas within and beyond NATO Allies' territories will be affected by the above-mentioned environmental hazards. For this reason, the deployment of the NATO AGS System will likely become more important for humanitarian disaster relief and the broader monitoring of weather events. This, in turn, makes it important that appropriate adaptation measures are identified and implemented at NAS Sigonella.

North America

Average temperatures in North America have increased by around 1.3°C to 1.9°C since record keeping began. Most of this warming has, however, occurred in the last 50 years with the most recent decade being the warmest on record.[21] Temperatures are expected to continue rising, though such warming will not be uniform, given that anthropogenic warming is superimposed on a naturally varying climate. Rising average temperatures in North America have significant effects on ground conditions in the northernmost latitudes, causing permafrost to thaw and affecting the sustainment of Canadian and U.S. infrastructure within this region.

In North America, heat waves have become more frequent and intense, particularly towards the West. This trend is projected to continue, with droughts in the Southwest of the US becoming more severe. As an example of the risks associated with hot and dry conditions, in March 2018, due to live fire training, two wildfires broke out in Colorado during an infantry and helicopter training exercise for an upcoming deployment of the US military. Gusty winds and dry conditions allowed the fire to spread, reaching about 3,300 acres in size, causing the evacuation of 250 homes. Moreover, a 2019 report by the Pentagon highlighted that nearly half of the 72 examined US bases should consider wildfires as a risk. As conditions become hotter and drier, wildfire intensity and frequency is exacerbated.

From a hazard perspective, Canada and the US are at particular risk from extreme storm surges. NASA reports that the intensity and frequency of the strongest North Atlantic hurricanes (category 4 and 5), have increased since the early 1980s. Scientists have highlighted how warmer oceans lead to more evaporation, amplifying the global water cycle and increasing the energy which the air holds, leading to the formation of high intensity storms.[22] Hurricane-associated storm intensity and precipitation rates are projected to magnify as the climate continues to warm.

Hurricane-associated precipitation rates are projected to magnify as the climate continues to warm. Average precipitation has increased since 1900, with some areas like the Southwest witnessing much less than the regional average. At the same time, severe inland storms have shifted northward.

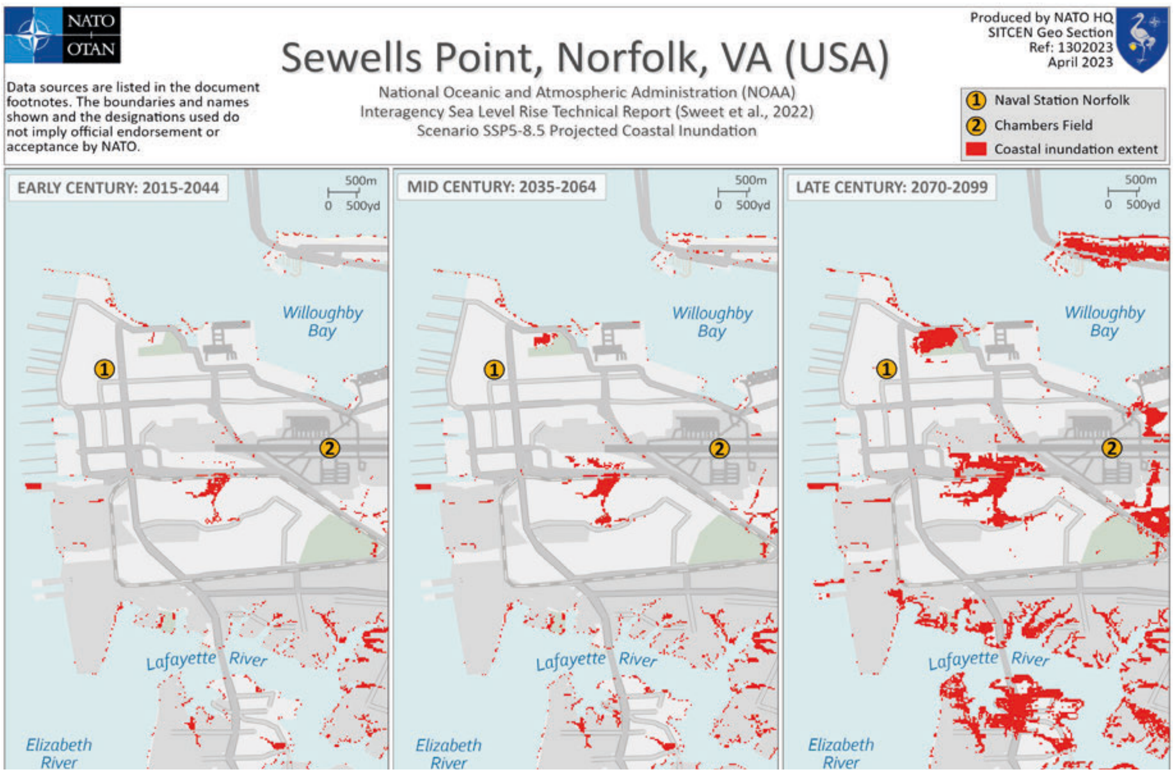
By the end of the 21st century, the shape of many coastlines across North America will have transformed. NATO builds on, trains at and launches activities from these coastlines, including at Norfolk, Virginia. The impact of climate change on the military installations in Norfolk will be further explored in the case study below. By 2050, the low-lying parts of some bases along the East and Gulf coasts of the United States could be underwater for 10-25% of the year which would have a substantial impact on the ability to support military operations.[23]

Case Study: Naval Station Norfolk, Virginia

Naval Station Norfolk (NSN) is an important asset to NATO. It provides facilities and services to the US Atlantic Fleet. It occupies 4,300 acres (approximately 1750 hectares/17.5 square kilometres) in the South Eastern corner of Virginia, in an area populated by over 1.5 million people. It is the largest naval complex in the world, hosting some 30 subordinate and tenant commands including Commander Naval Surface Force Atlantic, Commander Naval Air Force Atlantic, Commander Submarine Force Atlantic and Commanding General, and Fleet Marine Force Atlantic. Additionally, Norfolk is a major logistical hub for personnel and cargo heading to other US military facilities around the world and it is also where NATO Allied Command Transformation has its headquarters.

The Naval Station is extremely vulnerable to climate change. Over the past century, the average sea level rise – as measured by the National Oceanic and Atmospheric Administration (NOAA) tide gauge – has risen 18 inches (45.7 cm)[24]. According to NOAA climate projections, the sea level at Norfolk is expected to rise between 1-3 feet (30.5-91.4 cm) by 2050[25]. Widening the scope, the IPCC projections for the East Atlantic Coast of the United States expects a sea level rise of 0.4 metres by 2050 and 0.9 metres by the end of century under the worst-case scenario SSP 5-8.5. Local projections for Southern Virginia are even more extreme. To exemplify, in 2019, there were 14 days where high tides were half a meter above the daily average. This is projected to increase by up to 25 days by 2030 and 65 days by 2050[26].

The area of Norfolk has the highest rate of sea-level rise on the East Coast of the United States and has been ranked by the Organisation for Economic Co-Operation and Development as the 10th among the world's port cities whose assets are at risk from rising seas[27].



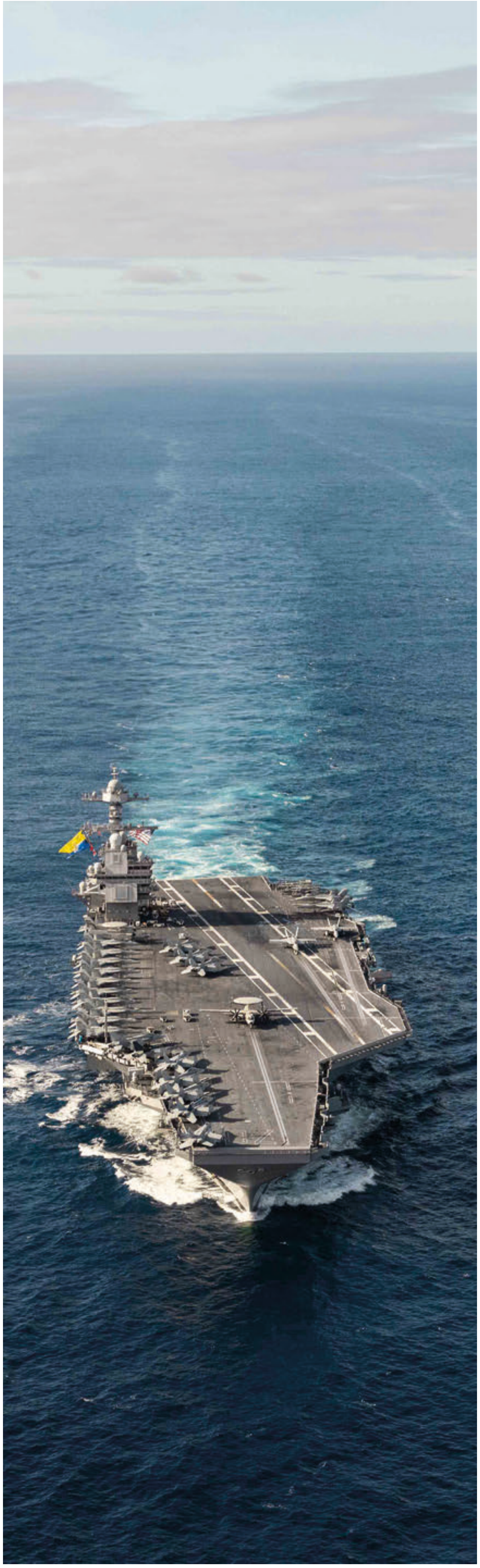
While ships can still leave the harbour and planes can still operate, flooding affects the Navy's readiness. Rising sea levels will also have an impact on the Navy's normal contingency plans. Furthermore, flooding can hamper or stop administrative, maintenance and logistical support operations, utilities such as electricity coming off-base could stop working or roads leading to the base could be blocked, directly affecting support operations.

The increase in sea level coupled with more frequent extreme weather events poses a risk to the Navy's ability to conduct and support operations in the Atlantic out of its largest base. Flooding from sea level rise has adverse impacts on both NSN's assets and installations and training and readiness. As seen in the map above, NOAA climate projections under SSP5 – 8.5 show that coastal inundations will directly affect NSN points of interest and the surrounding area.

According to NOAA, in 2022, there were fifteen weather and climate disaster events in the US, each with losses exceeding $1 billion, including ten severe storm events and two tropical cyclone events. One of these storms was Hurricane Ian, which intensified to a Category 4, making it one of the strongest hurricanes to make landfall in Florida – causing casualties and catastrophic flooding. Extreme storms wreak havoc on infrastructure, disrupting energy supplies, food and water resources, and communications and transportation systems.

To respond to these challenges, the US Navy and the Department of Defense have identified a series of measures to ensure that the Naval Station can continue fulfilling its role and that the Navy can continue to operate in an increasingly challenging environment. These measures – which carry a significant budgetary weight - are mostly about making infrastructure more resilient, for example constructing berms and floodwalls to prevent erosion, retrofitting critical infrastructure and building new facilities taking into account climate change risks. Moreover, pre-emptive climate change and sea-level rise provisions were incorporated into a current pier construction project to elevate shore support for Norfolk-based submarines.

Ultimately, NSN is an example of how the vulnerability of critical defence infrastructure to climate change threatens the US' and, consequently, the Alliance's ability to maintain its deterrence and defence posture in the Euro-Atlantic area.



Middle East, North Africa and the Sahel

An IPCC report highlighted how the range and intensity of desertification has increased over the past several decades in the MENA and Sahel region.[28] For example, on 6 June 2021, the UAE recorded its highest-ever June surface air temperature when a heatwave hit 51.7°C. During the same week, five other countries in the Gulf exceeded 50°C.[29] The situation in the broader MENA/Sahel region is further aggravated by less predictable rainy seasons, more frequent extreme weather events, wildfires, shortage of water supplies,[30] soil and land degradation, and lower agricultural productivity. A history of armed conflict in many parts of the region has increased vulnerabilities and hindered adaptation efforts due to weakened governance systems and existing damage to the environment and infrastructure.[31]

As a threat multiplier, climate change can also be an aggravating factor for conflict, instability and terrorism, as in the crisis-stricken Lake Chad region where resource scarcity and livelihood insecurity has made local communities more vulnerable for recruitment by Boko Haram.[32] Increasing rates of irregular and forced migration, caused by a variety of factors including population growth, poverty and poor governance and a lack of rule of law, could be further exacerbated by climate change. Migration related to climate change often occurs in situations of greater vulnerability, disproportionality affecting those who have already been subjected to discrimination, marginalization and systematic inequality.[33] The destabilizing effect of these tensions raises security risks along NATO's Southern Flank. At the same time, extreme weather has wide effects on military effectiveness. Military assets and installations such as air bases and compounds are exposed to dust and extreme heat, requiring additional cooling across installations and equipment platforms and systems. In addition, routine training and testing activities could pose the risk of ignition in hotter and drier operating environments. Therefore, the inclusion of climate change considerations in the mid-life upgrade of capabilities or the acquisition of new capabilities should become a requirement.

Case Study: NATO Mission Iraq

NATO Mission Iraq (NMI) was launched in 2018, following a request from the government of Iraq. It is a non-combat advisory and capacity-building mission that assists Iraq in building more sustainable, transparent, inclusive, effective and resilient armed forces and security institutions. NMI was greatly affected by climate change in 2022.[34] In recent years, Iraq has suffered periods of extreme heat with temperatures over 50°C lasting for several days. One senior Iraqi military official was quoted as saying that climate change could cause more deaths than Covid-19 and that the threat could be more significant than ISIS.[35] The maps in figures 6 and 7 provide a visualization of the projected climate change scenarios. When the effects of climate change are coupled with pre-existing vulnerabilities, it increases the risk of a further deterioration of the security environment.[36]

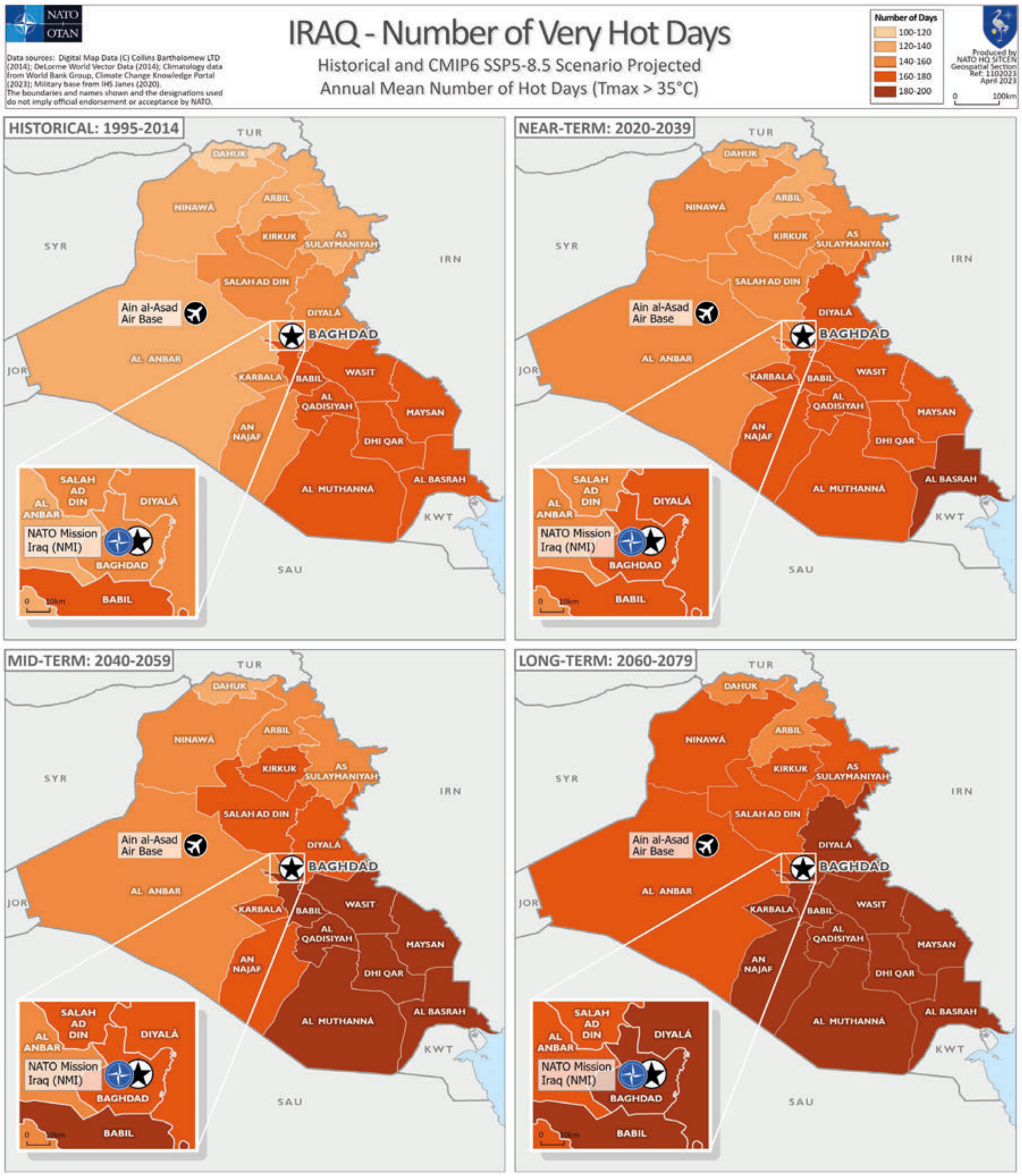
The United Nations has listed Iraq as the world's fifth most vulnerable country to climate change[37], while the Notre Dame Global Adaptation Index (ND-GAIN)[38], which measures a country's resilience and vulnerability to climate change, places it at 120 out of 181 countries. Climate change risks are compounded by pre-existing vulnerabilities caused by war, political and economic instability and an oil driven development and growth model.[39] The volatile state of security has led to a lack of national investment in adaptation and development measures, resulting in reduced societal resilience to external shocks, including climate change.[40]

Further, amid the global energy transition, Iraq's dependence on oil revenues could leave it economically vulnerable to new risks as the world moves away from fossil fuel use.[41] Additionally, the deterioration of socio-economic, political and environmental considerations has affected migration and displacement in Iraq. At the end of 2022, over 1.1 million people were identified as internally displaced in Iraq.[42] Internal migration often involves the movement from rural areas to cities, putting further pressure on already strained systems. The population of Baghdad is projected to grow more than any city in the Middle East, with up to 13 million inhabitants by 2050, an increase of 71% from 7.6 million in 2022.[43] In addition, the World Food Programme reports that 2.4 million Iraqis are currently in acute need of food and livelihood assistance; this number is projected to grow.[44]

According to IPCC projections, under the worst-case scenario SSP5-8.5, the number of days with extremely hot temperatures will consistently grow.

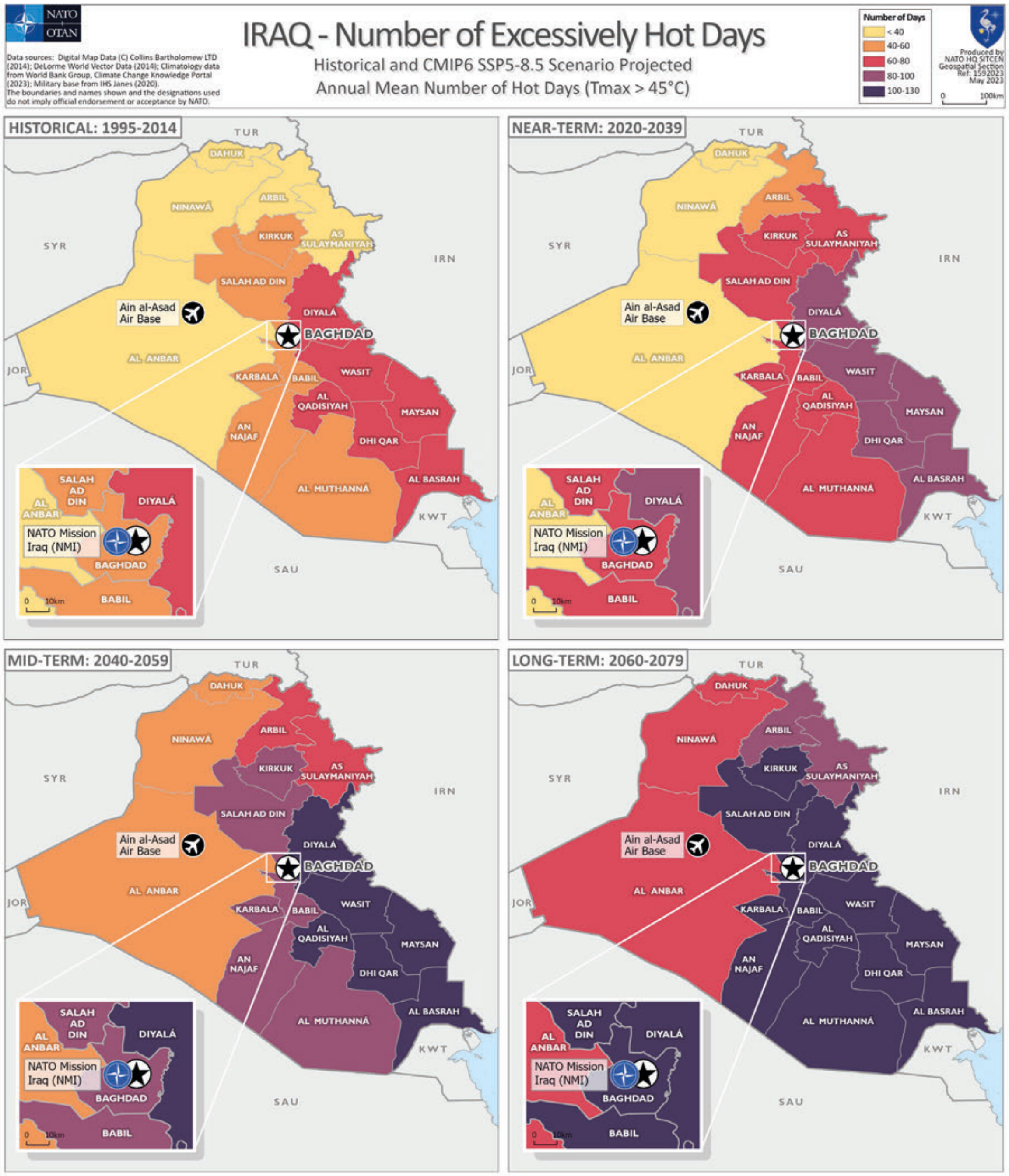
The first indicator analysed was Days with Maximum Temperature above 35°C (Tx35), which is shown in the map at figure 6. When the temperature exceeds 90°F or 32°C (Wet Bulb)[45], the military labels this a "black flag weather day", and operations are ceased or restricted for health and safety reasons[46]. Looking at the data, in the near term (2020-2060) there will be between 160 – 170 days with Tx above 35°C per year[47]. In the long term (2060-2079), that number will grow to between 180 – 190 days compared to the baseline reference period (1995-2014) of 140 days. Therefore, according to global climate modelling predictions, in the near term, 45% of the year will have temperatures equivalent to or exceeding the threshold of black flag weather days while in the long-term, this will be 51% of the year in Iraq.

The second indicator is the Number of Hot Days (Tmax > 45°C), visualized in figure 7. For this indicator, Baghdad was the reference point as the location of NMI. From the data, in the historical reference period (1995-2014) there were 54 days annually with temperatures above 45°C. In the near-term (2020-2039) the number increases to 72 days. In the medium-term (2040-2059) it is 95 days per year, while in the long-term (2060-2079) it is 111 days per year.



For the indicator Maximum of Max Daily Temperature, Baghdad was modelled during the hottest period of the year (June, July and August). From the data, during the historical reference period the hottest temperature was 49°C. In the near-term (2020-2039) a temperature of 50°C was projected. In the medium-term (2040-2059) the maximum daily temperature is 52°C, while in the long-term (2060-2079) it is up to 54°C. In the beginning of SSP5-8.5, there would be a temperature increase of a steady 1°C, increasing to 2°C in the medium to long term. For the Number of Hot Days (Tmax > 45°C), in the medium-term, there could potentially be 95 days per year, as well as temperatures up to 52°C.

For the hazard "Dry", the climate indicator Projected Number of Consecutive Dry Days was considered. This indicator monitors how many days in a row there will be without any form of precipitation, directly linking it to the risk of drought and dust storms. The number of consecutive dry days remains fairly consistent in the near-term, medium-term and long-term under the worst-case scenario. Iraq will have approximately 319 consecutive days per year with no precipitation. Narrowing the scope to the Baghdad region, it is around 330 consecutive dry days, or about 90% of the year.

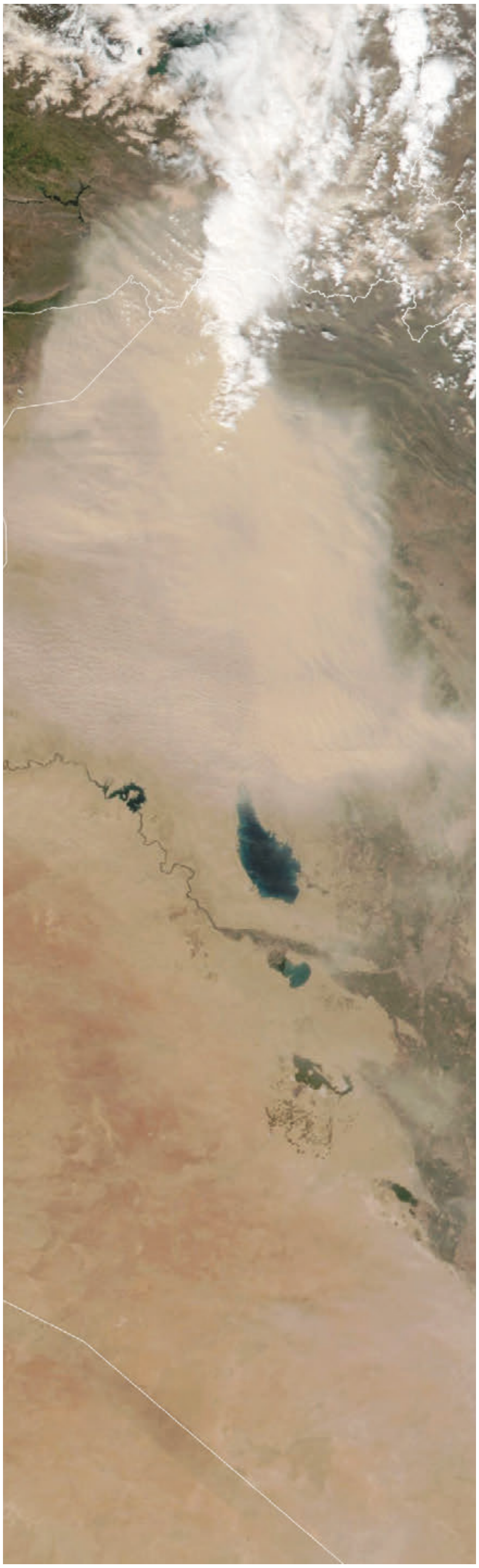


Climate change disrupts equipment, assets and installations. When temperatures reach 50°C, helicopters cannot take off due to hotter and less dense air. Looking at the projections, temperatures could exceed 50°C approximately 72 days per year (Tx>45°C) in the worst-case scenario in the near-term (2020-2039). That means that for about one fifth of every year, air operations would be at risk from heat, causing operational disruptions.

Low soil moisture due to water scarcity and extreme heat has led to an increase in frequency and intensity of dust storms over recent years.[48] In 2022, dust storms reduced visibility to less than 1600 meters, disrupting both air and road transportation, while causing significant health consequences and affecting operations.[49] In Iraq and Afghanistan, due to hot and dusty conditions, armoured vehicles repeatedly experienced technical problems.

As outlined in a Climate Change and Security Operational Impact Assessment Report by Allied Command Operations (ACO), in 2022 NMI faced frequent bouts of extreme heat with maximum temperatures remaining near 50°C for several consecutive days during the months of July and August. The situation was made worse due to the concurrent increase in dust storm frequency linked to extensive areas affected by desertification and salinity. With reference to the maps of Iraq showing temperatures above 35°C and 45°C, days with extreme heat could increase dramatically both in the near- to long-term. Baghdad faces a steady growth in black flag weather days, approximately 160 days per year in the near-term, directly impacting operations. Operational activities on black flag weather days increase the risk for heat exhaustion and potentially life-threatening heat stroke. As the number of black flag weather days increases, training and readiness could be compromised. Further, training under such conditions could lead to higher risks for personnel, equipment, and preparedness.

To help address these challenges, the Iraqi government, supported by NMI, has created a Climate Change and Security Coordination Group, bringing together key stakeholders, such as the UNDP (United Nations Development Program), IOM (International Organization for Migration), UNICEF, and HRW (Human Rights Watch).



The High North

The High North remains a strategically important region for the Alliance. After the end of the Cold War, the Arctic had become an area of low tension. However, this is changing due to rapid global warming and increasing strategic competition. Melting ice makes the region increasingly accessible. The circumpolar Arctic as a whole continues to experience warming at four times the global average. Last year saw record-high temperatures in the High North, with 2022 as the Arctic's 6th warmest year on record.[50]

Disappearing sea ice also has economic implications. Shipping lanes and trade routes between North America, Europe and Asia become accessible for longer periods of the year. This can provide a source for future economic growth but also contributes to strategic competition. Every year ship traffic increases, including through the Northeast Passage and the Northwest Passage. Commercial activities may also increase the risk of maritime accidents, as well as the demand for emergency response (Search and Rescue) capabilities.

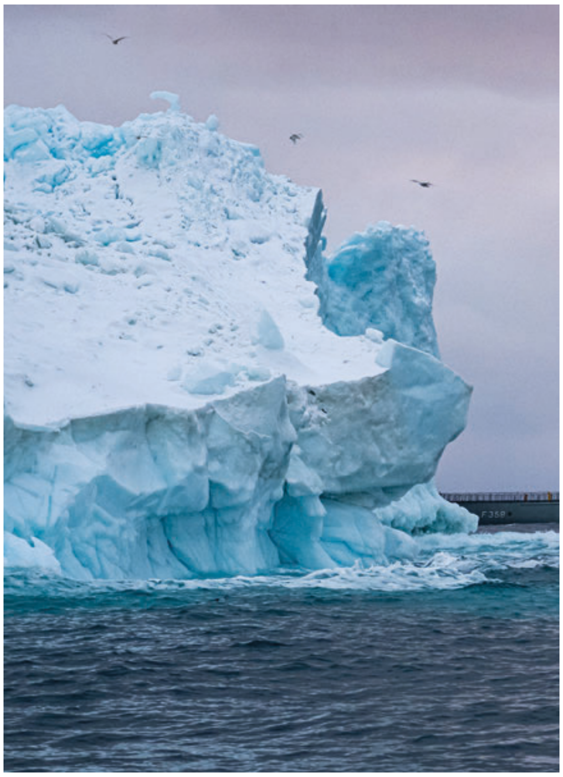
Easier access to the Arctic's natural resources, including sub-sea oil and gas reserves as well as fishing areas, may lead to increased economic activity in the region and may raise questions regarding ownership of resources. Thawing permafrost can damage the foundations of buildings and transport infrastructure, trigger landslides and destabilize industrial sites storing toxic waste.[51] It has also affected radar sites of the North American Aerospace Defence Command (NORAD) in Alaska and Canada, which are essential for Integrated Tactical Warning and Attack Assessment (ITWAA) of inter-continental ballistic missile and airborne threats.[52] Additionally, thawing permafrost threatens to release carbon emissions long stored away in the ice.[53]

Six out of eight members of the Arctic Council are NATO members – Canada, Denmark, Finland, Iceland, Norway and the United States. Finland's accession to NATO significantly enhanced the Alliance's posture in the High North by adding strong military capabilities particularly adapted to cold environments. Each of these Allies has developed an Arctic strategy to take account of the security dynamics in the region. A seventh member of the Arctic Council, Sweden, has been invited to join NATO. Activities in the Council had been suspended following the Russian invasion of Ukraine, but work on projects not involving Russia resumed in March 2023.

Adjusting its engagement in the High North as a result of climate change, Russia has significantly increased its military activity in the Arctic in recent years, perceiving this region as vital to its security and economic development. In addition to setting up a new Northern Joint Strategic Command, it has modernized and expanded its military capabilities in the Arctic, including bases capable of hosting nuclear weapons, as well as strengthened maritime capabilities.[54] Russia also invested in military capabilities that can endure extreme temperatures, such as specialized drones and patrol vehicles[55].

China, a self-declared "near-Arctic" state[56] and an observer in the Arctic Council, is also increasing its maritime activities in the region, due to the impacts of environmental change. One example is the "Polar Silk Road", linking China to Europe. China is strengthening its maritime capabilities in the region, including by building new icebreakers to service Arctic shipping routes.[57] China is also investing in energy exploration in the region.

Climate change is having a fundamental impact on the security of over 4 million people currently living in the circumpolar Arctic. Indigenous communities are disproportionately impacted, as their traditional means of subsistence and ways of living are under threat.[58]



The Way Ahead

In 2021, NATO leaders agreed an Action Plan meant to ensure that the Alliance's posture remains fit for purpose in a security environment that will increasingly be affected by the effects of climate change. It addresses a number of key components of NATO's deterrence and defence posture, including situational awareness, training, exercises and operations, infrastructure and installations, capability development and equipment, and resilience. Measures in the Action Plan include:

- Conducting an annual assessment to analyse the impact of climate change on NATO's strategic environment and NATO's assets, installations, missions and operations.
- Introducing climate change and security as a discipline into the curricula of civilian and military education institutions and doctrine.
- Integrating climate change considerations into capability development and procurement systems to ensure equipment capability maintains operational effectiveness in future operating environments.
- Reviewing and, if needed, developing standards for climate change and security, incorporating interoperability considerations.
- Upgrading existing and designing new fixed and deployed infrastructure based on climate resilient and eco-design principles.
- Preparing for changes in mission profiles, military tasking, and standard operating procedures.
- Taking into consideration the new scenarios that climate change will bring in planning, training and exercising.
- Incorporating the latest climate and environmental science in the sustainable management of land owned by the Armed Forces.
- Creating a compendium of best practice as a tool to share knowledge on adaptation and mitigation measures among Allies.
- Cooperating with Allied and partner governments, other international organizations, as appropriate, the business community and academia to strengthen existing and develop new partnerships, and promote R&D and business opportunities.

The findings of this Impact Assessment reinforce the importance of the measures included in the Action Plan. As Allies continue to implement these measures, several considerations should guide their work:

- Military effectiveness in carrying out NATO's core tasks remains the number one priority, even if this objective may sometimes clash with mitigation goals.
- The decisions taken in response to Russia's invasion of Ukraine to acquire new equipment offer an opportunity to build energy efficiency into capability design, reducing fuel and logistical requirements in future.
- The transition to "clean" technologies such as solar panels or fuel cells should take into account the importance of not creating new strategic dependencies, in particular on China, which currently dominates the control and processing of strategic minerals.
- Interoperability must remain a priority as Allies adopt new technologies as part of the transition towards a low-carbon energy system.
- NATO's adaptation measures could have benefits also in the civilian sector.
- A strong demand signal from Allied military establishments that they are determined to move towards new and cleaner technologies can stimulate industry to create the necessary materials, e.g., synthetic fuels.
- Finally, an "Energy Transition by Design" that seeks to balance enduring military requirements with evolving climate and energy concerns could benefit the Alliance across its adaptation and mitigation work, and reinforce NATO's credibility when it comes to tackling the challenge of climate change.

Annex

Methodology

NATO Staff have continued to review pre-existing work carried out by national authorities and other international organizations to (a) identify the efforts already undertaken that could inform the CCSIA process; (b) align the CCSIA with the timelines and deliverables of other work strands within the NATO Enterprise; and (c) detect potential shortfalls and challenges.

Given that projected warming patterns may prompt abrupt, discontinuous shifts in climate systems - rather than gradual, incremental changes - using an analytical framework based purely on probability would have reduced the accuracy of the impact assessment. Instead, for the first edition of the CCSIA, NATO conducted a 'screening assessment', based on a qualitative NATO-developed Climate Change Risk Tool (CCSRT) that groups hazards into six categories:

i. Heat & Cold (heat, frost, snow, glacier and ice sheet retreat, thawing permafrost);
ii. Wet & Dry (precipitation, river flooding, aridity, drought, fire weather);
iii. Wind (severe wind storms, tropical cyclones, hurricanes, sand and dust storms);
iv. Coastal (coastal flooding, sea level rise, coastal erosion);
v. Open Sea (changes in ocean chemistry, marine heatwaves); and
vi. Air & Radiation (pollution and radiation).

These hazards were modelled against two global average temperature increase pathways (2.0°C according to SSP2-4.5 and 2.5°C according to SSP5-8.5) at the year 2050 point and for four different geographic regions of particular relevance to the Alliance: the High North, Europe, Middle East and North Africa (MENA)/the Sahel, and North America. Further, the CCSRT takes into account that the overall vulnerability of a system to a given climate change hazard is a product of:

a) the probability of that hazard occurring;
b) the exposure of a given system to such hazard;
c) the anticipated impact of that hazard, i.e., risk without adaptation;
d) the anticipated impact of that hazard, i.e., risk with adaptation.

Through a consultative process, gathering input across the NATO Enterprise, a subjective rating - a risk criticality score - was assigned. This criticality score combines the Impact Score (1-5) with Probability (1-5) in the CCSRT. It presents a Red-Amber-Yellow-Green (RAYG) rating and gives an overview of where action should be prioritized.

The methodology underpinning the CCSIA is in line with internationally recognized approaches (see ISO standard 14090/14091(2021))[59] and designed to serve as a building block in assessing how given hazards generate direct and indirect impacts, which in turn propagate through a system at risk. The methodology is replicable across operating domains. Yet, certain limitations remain, particularly when it comes to assessing the adaptive capacity of systems at risk.

Revised Methodology

For the second edition, the methodology was supplemented by using relevant modelled climate change data in combination with NATO's qualitative security analysis to develop scenarios and draw risk-based conclusions. To develop this improved approach, NATO worked with the support of key partner organizations (including the World Bank Group and the World Meteorological Organization), to identify and apply the latest and most relevant climate change data and science[60].

To test the revised methodology, it was applied to three location-specific case studies: NATO Mission Iraq, Norfolk Naval Station as the location of ACT in the US, and the Naval Air Station hosted in Sigonella, Italy.

This resulted in a revised methodology, which comprised a mechanism to assess climate change risks by combining the qualitative approach developed in NATO's first version of the CCSIA with relevant quantitative data from the Coupled Model Intercomparison Project (CMIP). Part of the World Climate Research Programme[61], CMIP seeks to improve understanding of past, present and future climate change on a global scale[62], and is considered the gold standard for global climate change modelling. CMIP's associated data infrastructure has become essential to the Intergovernmental Panel on Climate Change and other international and national climate assessments[63].

The analysis used the CMIP6 data from the Shared Socioeconomic Pathways (SSPs) scenario SSP 5–8.5 equivalent to a 'worst-case scenario' warming of 2.5°C by 2050 and 4.4°C by, against baseline years of (1995-2014), and projections for the near term (2020-2039), medium term (2040-2059), and long term (2060-2079). These data were applied to the six environmental hazards categorized by the IPCC, (Heat and Cold, Wet and Dry, Wind, Coastal, Open Sea and Air & Radiation) and correlated with a series of climate indicators including, but not limited to: Projected Maximum Daily Temperatures, Days with Temperatures above 45°C, and Projected Number of Consecutive Dry Days.

It should be noted that the acquisition of the data differed slightly for each case study. For NMI and Naval Air Station Sigonella, the CMIP6 data were directly downloaded from the World Bank Group's Climate Knowledge Portal[64]. The data were obtained as Comma Separated Values (CSV)[65] and formatted. For Norfolk, the data were obtained from the National Oceanic and Atmospheric Administration (NOAA)[66]. Using NATO's in-house ArcGIS geospatial services, climate change data were used to create maps to visualize the scenarios for the case studies.

Building on this revised methodology, NATO is developing a Climate Change and Security Risk Management Framework (CCSRMF) that will combine the latest climate change modelling data with broader data including human security, and natural resource security, with wider geographic coverage. This will include incorporating a variety of relevant data sources to provide multi-layered analyses, for instance, data from the IPCC WGI Interactive Atlas: Regional Information (Advanced)[67]. The aim of the CCSRMF is to support more accurate short-term and longer-term planning assumptions and decisions, contribute to early-warning systems, and allow the Alliance, partners and the wider global community to respond and adapt proactively and effectively to the impacts of climate change on security.

Methodology Case Study: Naval Air Station Sigonella, Italy

The analysis used CMIP6 data processed for use by the World Bank Group. The data looked at near- (2020-2039), medium- (2040-2059), and long-term (2060-2079) projections compared to the historical reference period (1995-2014) under the IPCC Shared Socio-Economic Pathways SSP5-8.5 equivalent to a temperature rise of 2.5°C in the medium term and the 2022 CCSIA identified "worst case scenario". For replication purposes, the data were downloaded from the CMIP6 (mean projections collection), the calculation was set to climatology (mean value), the percentile was the Median 50th, using the multi-model ensemble.

The analysis focused on the following hazards; Heat and Dry and the climate indicators; Maximum of Max Daily Temperatures (°C), Days with Maximum Temperature above 35°C, Number of Hot Days (Tmax > 45°C) and Projected Number of Consecutive Dry Days, Number of Days with Temperatures above 25 (Tmax>25°C), Mean Annual Temperatures (tas), Average of annual maximum temperatures (tasmax), Precipitation (pr) and Max Number of Consecutive dry days (cdd).

Methodology Case Study: NATO Mission Iraq

The analysis used CMIP6 data processed for use by the World Bank Group. The data looked at near- (2020-2039), medium- (2040-2059), and long-term (2060-2079) projections compared to the historical reference period (1995-2014) under the IPCC Shared Socio-Economic Pathways SSP5-8.5 equivalent to a worst-case scenario temperature rise of 2.5°C around 2050. For replication purposes, the data were downloaded from the CMIP6 (mean projections collection), the calculation was set to climatology (mean), the percentile was the Median 50th, using the multi-model ensemble.

For Iraq, the analysis focused on the hazards; Heat and Dry and the climate indicators; Maximum of Max Daily Temperatures (°C), Days with Maximum Temperature above 35°C, Number of Hot Days (Tmax > 45°C).

For further information and to access the document online, please visit: **https://www.nato.int**

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NATO HQ
Boulevard Léopold III,
B-1110 Bruxelles, Belgique

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