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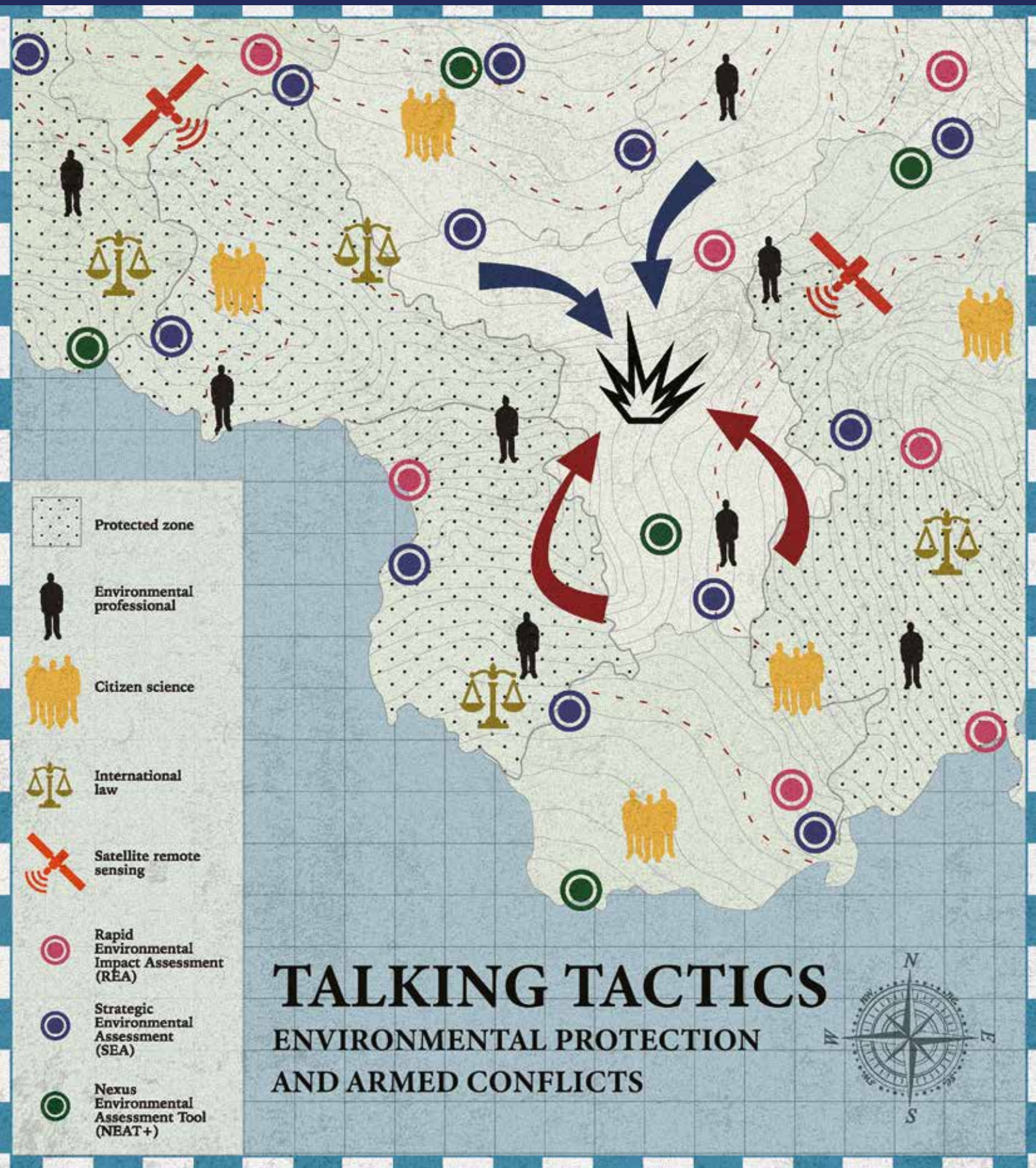

EDITORIAL

The science of destruction

In 1965, 29-year-old Dang Hong Nhut was visiting her husband in the Chu Chi region of Vietnam when the planes came. 'After they had gone, there was white dust everywhere', she recounted. 'I had very itchy skin, scabies and diarrhoea, but had no idea why.' Later, she had four miscarriages before she became pregnant again in 1977. 'I so hoped I would deliver a baby, but the baby was born early, at five months. When it was born, the doctor told me it was dead ... the baby was so deformed, they were afraid for my health if I saw it.'[1]

Dang, like millions of her compatriots, had been poisoned by one of a range of dioxin-laden herbicides, collectively known as Agent Orange, that the US military had sprayed over Vietnam, Cambodia and the Lao People's Democratic Republic to eliminate forest cover and destroy food crops for the North Vietnamese and Viet Cong troops. Alongside the 90 million litres of defoliants, the USA dropped 5 million tonnes of bombs – more than twice the total tonnage used by all sides during the Second World War. Fifty years on and still a million Vietnamese, 100,000 of whom are children, are disabled by the effects of Agent Orange.

"War," as former Canadian Prime Minister John Abbott acidly put it, "is the science of destruction." As long as wars have been fought, commanders have been tempted to use scorched-earth tactics for military advantage or retribution. And for just as long, peacebuilders have tried to constrain people's worst impulses and limit the collateral damage of war.

Environmental destruction exacerbates the human suffering of war. But the toxic legacy of conflict is not the only issue: since the Second World War as many as 60 per cent of all civil wars have had a strong link to natural resources. Environmental mismanagement can raise tensions. Fighters battle for control of valuable resources, such as diamonds and timber, that pay for weapons. Recovery after war is often complicated by the breakdown in environmental governance caused by fighting and the growth in illegal activities it permits.

Despite these challenges, we have seen progress. Slowly, the international community is moving the needle of what is acceptable conduct during conflict. The Chemical Weapons Convention of 1997 prohibits the use of most toxic chemicals in war (though the USA ensured a loophole for herbicides). The Mine Ban Treaty of 1999 forbids most anti-personnel mines. And the United Nations Security Council has started to consider how environmental change affects international security. In situations of war, where the facts may be an early victim of the violence, environmental scientists really are a critical part of modern peacebuilding.

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Cover design: Jessie Thavonekham is a designer based in London. Her work includes art direction, illustration and branding.

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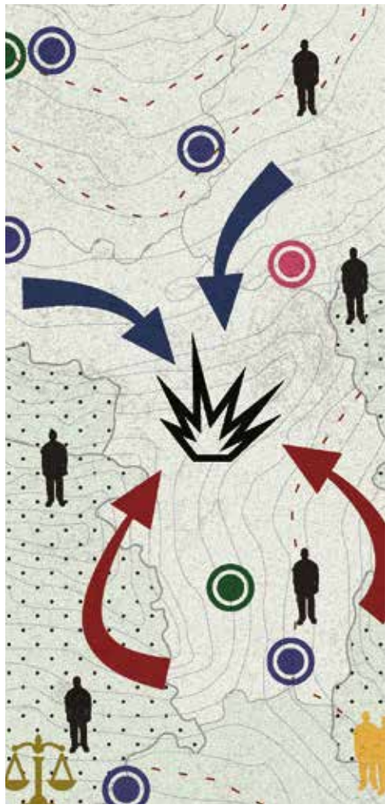

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Environmental damage from armed conflict

Linsey Cottrell calls for recognition of the importance of the environment and the need for its proper protection.

INTRODUCTION

The human cost of war is not disputed. Its impact on people's lives and the extent of human suffering is profound, and often widely reported during armed conflicts. However, war's environmental consequences receive far less attention, despite their potential for significant and long-term harm to human health and ecosystems. The link between the protection of the environment and the protection of human health is well established. Therefore, measures taken to protect civilians from the impacts of armed conflict must include environmental protection.

There have been more than 40 major conflicts around the world since 2000, yet the laws intended to protect the environment in relation to armed conflicts are underdeveloped. Routes to hold those responsible for environmental harm and its impact on human health are largely absent.

In many countries affected by armed conflict, addressing environmental protection may not be regarded as a priority, even though not doing so can impede sustainable recovery and undermine natural resources. More often than not, financial resources are limited and even the basic needs of the population and vulnerable communities cannot be met. The situation is often compounded by the collapse of systems of environmental governance during conflicts.

The authors in this issue address a broad range of topics that are often overlooked by many of us when thinking about the environment: how it can be affected by armed conflicts and military activities, and what can be done to increase its protection. To answer these questions, we need to consider the environmental conduct of armed forces and how they are constrained by the law. We also need to understand how environmental harm is assessed and by whom.

THE 'BOOTPRINT' OF MILITARY FORCES

Many armed forces, including those in NATO, already recognise the need to address the environmental impacts from their operations and have therefore developed environmental policy and management systems. To date, NATO has developed six Environmental Protection Standardization Agreements (STANAGs),[1] which focus on protecting the environment during NATO-led military operations. The STANAGs cover environmental planning and environmental risk management for military exercises in peacetime and during active missions but state that environmental damage may be an inevitable consequence

◀ **The disposal of munitions by open burning and open detonation can release dangerous contaminants to the environment, if not properly managed. (© Diego Cervo | Adobe Stock)**

INTRODUCTION

▲ **Oil drums litter the landscape surrounding an abandoned military base in Greenland.**

of operations. It is important that environmental protection is integrated into all military actions.

Many challenges remain, especially in countries where there is poor environmental governance or enforcement, a history of contamination from previous conflicts and differences in attitude towards environmental protection between NATO members. Environmental protection obligations around overseas military installations are typically established by bilateral agreements with the countries hosting them, but in many cases there is limited scope for enforcement.

NATO has been taking measures to reduce its environmental impact. For example, in 2016, a leak from the collapsible fabric fuel tanks (CFFT) at Kandahar Airfield, Afghanistan resulted in the contamination of more than 6,000 m^3 of underlying soil.[2] Remediation costing more than US$1 million was carried out, with the contaminated soil excavated and stored to enable the fuel to degrade and evaporate. However, a number of barriers have prevented remediation at other sites used by NATO in Afghanistan. These include a lack of funding and locally available qualified contractors. Overseas specialists are also often unwilling to deploy staff and equipment to the region. NATO policy is to 'respect' the environmental laws of a host nation or, where a NATO member's environmental standards are more stringent, these should be applied. NATO policy, however, does not require compliance with environmental laws if it is militarily necessary to not do so.

The UK Ministry of Defence's policies on environmental management and protection maintain that for operations overseas, they will 'apply UK standards where reasonably practicable and, in addition, respond to host nations' relevant environmental protection expectations'.[3] Within the UK, the Ministry of Defence no longer has immunity from prosecution regarding environmental law, except in circumstances where it is deemed vital to sustain 'operational capability'.

COSTS AND TIME

Globally, the cost of environmental liabilities linked with military activities remains very difficult to estimate given the scale, range and nature of contaminants, and inherent uncertainties. For the USA alone, environmental and disposal liabilities were estimated by the US Department of Defense (DoD) at US$76.1 billion in 2019,[4] an increase of US$5.7 billion on the previous year. This is based on estimates for remediation, cleanup and disposal costs from the use of DoD assets or operations but excludes costs associated with buried chemical munitions and agents, whose extent is unknown.

The legacy of conflict pollution can last decades. More than 40 years after the end of the USA–Vietnam war, a six-year remediation project was finally completed in 2018 at the former US airbase at Da Nang airport at the cost of US$110 million.[5] The airbase was used to store and handle herbicides used by the US military during the war. These included Agent Orange, which was contaminated with the highly toxic dioxin 2,3,7,8 TCDD. Work has now started at Bien Hoa airbase near Ho Chi Minh City, where the remediation of dioxin-impacted soils is expected to take around 10 years, with the first five years of expenditure estimated at US$183 million. The USA has not yet formally accepted liability for the contamination and is funding the work through development assistance.

In recent years, the United Nations has focused attention on environmental management within its peacekeeping operations. The deployment of peacekeeping forces into already fragile environments during or after conflicts has the potential to cause unintended environmental consequences if not planned and managed appropriately.

THE LEGAL FRAMEWORK

Strengthening the international legal framework, and ensuing that it is implemented by conflict parties, is critical for increasing environmental protection and accountability for damage. The UN Environment Programme (UNEP) reviewed the state of legal protection for the environment during armed conflicts in 2009. This concluded that work was needed to clarify and bridge the gaps in existing frameworks.[6]

A decade later, progress has been made but the work is ongoing and some weaknesses remain. In August 2019, the UN International Law Commission (ILC) adopted 28 draft legal principles on the protection of the environment in relation to armed conflicts (PERAC).[7] These are expected to be finalised and adopted by governments in 2021. In merging international humanitarian, environmental and

human rights law, they will represent the most significant shift in the legal framework since the 1970s. When adopted, the principles will cover periods before, during and after conflicts as well as situations of occupation.

ASSESSING THE ENVIRONMENTAL IMPACT

Environmental risks and damage can become highly politicised during conflicts, requiring independent scrutiny and assessment. Since 1999, UNEP has undertaken more than 20 post-conflict environmental assessments. While useful in highlighting key issues, comprehensive assessments based on data from the ground can only take place after the fighting has ended and can only identify the environmental conditions at the time of the assessment. Furthermore, states must grant field access to UNEP.

Once complete, governments are under no obligation to address the recommendations of assessments, but these assessments can be used to leverage financial assistance from the international community as part of wider post-conflict recovery programmes. Over the last two decades, post-conflict assessments have radically increased our understanding of the environmental dimensions of conflicts, which in turn has underpinned developments in law and policy intended to reduce harm.

THE ROLE OF ENVIRONMENTAL SPECIALISTS

Documenting and understanding how conflicts interact with the environment is complex, and at times can be counter-intuitive. For example, research has recently demonstrated how deforestation rates can increase rapidly in the wake of conflicts. Environmental specialists have a critical role to play in unravelling these relationships.

Security and logistical considerations often restrict access to conflict-affected areas. This has encouraged innovation in data-collection methodologies with international organisations and non-governmental organisations (NGOs) taking advantage of increased access to satellite imagery and remote sensing techniques. These can be used to track short-term environmental events and long-term trends, helping to identify areas of concern for later field studies. Remote sensing can also provide the information necessary for urgent responses and mitigation measures to minimise environmental harm.

Citizen-led approaches that rely on the participation of communities in conflict-affected areas to report and collect environmental data also hold promise. With the support of environmental specialists, local communities could be better protected and supported as they seek assistance with remedial measures to address wartime damage.

▲ **An old tank lies abandoned on a beach in Socotra, Yemen. (© Kairi Aun | Adobe Stock)**

With nearly 30 significant armed conflicts currently taking place, environmental protection in these contexts remains a huge challenge. This is also true for the environmental legacy of past conflicts, which includes land contamination, degraded resources and inadequate governance.

Several articles in this issue were written by colleagues at the Conflict and Environment Observatory (CEOBS). CEOBS is a UK charity working to raise awareness and to increase protection for people and ecosystems from the consequences of armed conflicts and military activities. Our Friends of CEOBS community aims to increase the technical resources available to us, so if you're an environmental specialist with expertise that could help support our work, please see the box above for our contact details and how to get involved. ES

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Closing the environmental monitoring gap in conflicts

Doug Weir examines how citizen science could help to protect both people and ecosystems in conflict zones.

Armed conflicts can create acute environmental risks and lead to degradation that impacts ecosystems, human health and livelihoods. However, poor security conditions in conflict-impacted areas have historically hampered on-the-ground investigations into the environmental legacy of conflicts. In turn this has encouraged the use of remote sensing and open-source intelligence (data and information that is available to the general public) for documenting environmental harm, although without data from the ground these approaches have their limitations. The peacetime use of low-cost participatory scientific research – citizen science – has grown rapidly in recent years, and researchers are now exploring its potential applications in areas affected by conflicts.[1]

▶ **Figure 1. A multi-sensing device for testing water sources enables communities in Colombia to determine if the water is safe for them to use, whilst also mapping the areas of water affected by illegal mining activity, an important factor in the ongoing insecurity in areas of the country.[10] (© Mirella Di Lorenzo)**

FEATURE

FEATURE

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ASSESSING WAR'S ENVIRONMENTAL LEGACY

Efforts to quantify the environmental consequences of armed conflicts date back to the Vietnam War.[2] Until the conflicts in the Former Yugoslavia, assessments had largely been undertaken by academia and civil society. The bombing of petrochemical sites and use of depleted uranium weapons in the conflicts in the Balkans changed this, and led to the emergence of a model of post-conflict environmental assessments from the United Nations Environment Programme (UNEP).[3] Over the last two decades, this model has been applied to numerous conflicts and to a wide range of environmental problems, from serious pollution incidents to damage to natural resources.

Although these assessments have vastly increased our understanding of the environmental consequences of conflicts, they have their limitations. By definition they are undertaken after conflicts, and typically when security conditions allow access for UN experts. They also tend to focus on the areas of highest concern, are often biased towards specific events rather than long-term changes, and any follow-up work on the problems they identify is left to the affected state, whose capacity and attention may be elsewhere.

It is no coincidence that growing interest in the environmental dimensions of armed conflicts – and their consequences for people – have developed alongside rapid increases in the availability of data on the environmental and societal conditions in conflict-affected areas. Coupling data derived from satellites and social media with online documentation from a diverse range of sources has allowed non-governmental organisations (NGOs) and others to document and draw attention to environmentally damaging incidents during conflicts, sometimes in near-real time.

This marks an astonishing change in the visibility of environmental harm during conflicts, and one that is already contributing to the development of law and policy intended to reduce harm.[4] However, remotely accessible datasets can be limited, especially where robust ground verification and supplementation are required to inform the scale of damage and risks to people or ecosystems. This ground perspective is also critical for targeting humanitarian and environmental assistance, and for informing remediation and post-conflict recovery. Moreover, it can hold open the prospect of ensuring accountability for harm – a goal that is poorly served by the existing legal frameworks protecting the environment in relation to armed conflicts.

THE CIVILIAN AS CITIZEN SCIENTIST

The idea that only professional researchers can collect environmental information is a fairly recent notion – members of the public and enthusiastic amateurs have actually been performing this function since at least the 18th century.[5] The term 'citizen science' was coined in 1995 and since then has come to describe a rapidly expanding field of activities, from large-scale information gathering to social justice activism, enabled by the internet and low-cost sensing technologies. As the field has grown and professionalised, its value has been accepted by governments and it has repeatedly played an important role in supporting, and at times challenging, the work of national regulatory authorities.

Underpinned by openness, sharing and the participation of communities across the entire scientific process, citizen science projects have the potential to inform, educate and empower participants. They can also benefit researchers. The local, situated knowledge of project participants can help refine methodologies and interpret results, and large projects, particularly those backed by mobile phone apps or websites, can provide far more observations than individual professional researchers can gather alone.[6]

On the face of it, these attributes hold promise for research projects that aim to plug the geographical and temporal gap inherent in the post-conflict assessments undertaken by the international community. They could also complement and reinforce data gathered by remote sensing and open-source methods. But is it feasible or realistic to expect civilians to be citizen scientists in participatory environmental research? Communities affected by conflict, whether *in situ* or


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following displacement, face priorities that may be far removed from environmental concerns, but that is not always the case.

A growing number of examples support the idea that participatory data collection can be undertaken in insecure contexts. In eastern Ukraine, the Redonbass platform, set up by the UN Development Programme (UNDP), collated geotagged photos of damage to buildings taken by residents in order to document the harm caused by explosive weapons and to expedite repairs.[7] In the rainforests of Cameroon, the Zoological Society of London (ZSL) has worked with the Baka people on the participatory mapping and reporting of illegal poaching.[8] World Cleanup Day's online platform allows app users to geotag the locations of solid waste for removal and has users in several conflict-affected and insecure areas.[9] Meanwhile, a project led by the University of Bath's Department of Chemical Engineering developed and deployed a low-cost, portable and user-friendly multi-sensing device for detecting heavy metals and measuring physicochemical parameters in water sources in Colombia (see **Figure 1**).[10] One of the motivations for the project was the high levels of mercury pollution in rivers from artisanal gold mining, which has played an important role in the ongoing insecurity in areas of the country.

JUST-GOOD-ENOUGH DATA THAT HAS AN IMPACT

A long-standing objection to the use of citizen science has been over the quality of data. It is inescapable that low-cost sensors will never be able to match the accuracy of contemporary research-grade instrumentation, although the gap may be shrinking thanks to super-materials and artificial intelligence. But this misses the point. Not only is the data itself just one component of projects – alongside community engagement and empowerment – but it is intended to complement, rather than replace, official monitoring. In earlier years the field viewed its goal as the collection of data that was just good enough: just good enough to highlight an issue, to trigger a response from the authorities or to stimulate more in-depth studies. In the case of the constraints found in post-conflict spaces, "just good enough" might mean drawing attention to a problem or providing stop-gap monitoring until the authorities can replace capacity lost due to conflict, or develop more long-term solutions.

Field access is another barrier for projects in insecure settings. Yet civil-society actors are often present in these spaces. Local NGOs, and international humanitarian or mine-action actors could provide the route into the field for equipment, provide capacity-building support for communities and help support projects aimed at improving environmental cooperation as a tool for peacebuilding.

The final challenge lies in how best to use the data; its ownership and decisions about how to use it must ultimately rest with the participating communities, who will have been involved in the study design from the outset. This will depend on the objective of particular studies. At its simplest, data could be used locally, for example in risk-awareness programmes in connection to pollution hazards, or for advocacy. The openness and transparency that is the hallmark of these kinds of studies could also help to counter growing trends in the weaponisation of environmental information during and after conflicts.[11]

Looking beyond the local, the data architecture necessary to ensure that results can reach those with the ability to act on it also exists. For example, the UN Office for the Coordination of Humanitarian Affairs' Humanitarian Data Exchange collects data from more than 1,000 organisations,[12] which is subsequently fed into the UN's humanitarian response system. In a sign of things to come, there is also growing international interest in developing a Digital Ecosystem for the Planet, a home for environmental data gathered by remote sensing and many other methods, including citizen science.[13]

Given the breadth of environmental harms associated with armed conflicts, and the paucity of field data on them, there is no shortage of potential applications for civilian science studies. Oil pollution is a common feature of many conflicts due to attacks on infrastructure, governance failures, or environmentally problematic civilian coping strategies.[14] Land degradation is also common, as is habitat and biodiversity loss, due to overharvesting, disruption to land management systems and the availability of firearms. The growth in warfare in urban areas has made damage to water and sanitation infrastructure commonplace, and this damage generates air quality issues linked to pulverised building materials and rubble – problems that are as yet uncharacterised in the literature. Participatory research could help to shed light on the human and environmental consequences of all these forms of harm and it is something that we are working on at the Conflict and Environment Observatory, together with colleagues from civil society and academia.

FUNDAMENTAL ENVIRONMENTAL HUMAN RIGHTS

Armed conflicts have been likened to sustainable development in reverse. While the specific environmental cost of each conflict varies depending on how and where it is fought, and on who is involved, in the majority of cases we see threats to public health and ecosystems, and damage that impedes recovery. In spite of this, the environment struggles for attention in these contexts, with obvious implications.

Addressing this requires creative thinking and approaches tailored for the specific needs of communities and the challenging circumstances they find themselves in. The rapid expansion of citizen science in peacetime, and its gradual progress into insecure or politicised settings, means that there is a wealth of experience and best practice to build on. Moreover, viewing the civilian as a citizen scientist in projects that help to protect and empower communities serves as a timely reminder that fundamental environmental human rights continue to apply during conflicts and in their wake. ES

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Post-conflict deforestation in Colombia

Joseph Martin outlines the reasons deforestation rates can soar after the fighting has stopped.

CASE STUDY

In 2018, the University of Waterloo in Canada published a research paper that looked at data on conflict zones around the world, with a specific focus on Côte d'Ivoire, Nepal, Peru and Sri Lanka. The study found that in the years after conflicts had ended in those countries, deforestation increased to roughly 68 per cent. In comparison, the world mean rate of deforestation is 7.2 per cent.[2]

The researchers concluded that in times of war, the forested habitats were used as cover for guerrilla fighting and isolated war camps, away from the grip of local military and police units. As a result, the forests became dangerous and few people disturbed them. However, when the conflicts ended, the rates of deforestation rapidly increased as people felled the trees to farm the land. Forest protection during a conflict followed by high rates of deforestation after the conflict has also been the case in Colombia (see **Figure 1**).

A POST-FARC COLOMBIA

When the government of Colombia and the left-wing guerrilla group, the Revolutionary Armed Forces of Colombia (FARC), signed a peace accord in 2016, there was hope that the occupied forests of the Amazon that had been used for basecamps would flourish under the new regime. The reality, however, has been unregulated deforestation.

FARC's withdrawal left local government officials unable or unwilling to enforce any type of regulation to protect the rich variety of tree species that exist in Colombia.

▼ **Figure 1. In the Colombian Amazon, there are huge areas where all the trees have been felled and the land has been burned. These are called *tumbas* – which also means 'tombs'.[1] (© Pixabay)**

After FARC moved out of the forests, industry moved in – including logging, goldmining and cattle grazing. A government analysis found that deforestation increased by 44 per cent in the year of the peace accord.[1] The report identified nine 'deforestation cores' spread across the country. Five of these were located in the Amazon Basin, where the dataset shows 70 per cent of Colombia's deforestation took place. According to the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), deforestation in Colombia resulted in 197,159 ha being lost in 2018 alone.[3] Some of the highest rates of deforestation are in Cartagena de Chairá and San Vicente del Caguán, where 10 per cent of the country's deforestation took place in 2018.[1]

The problem was and still is exacerbated by ex-FARC members potentially participating in extortion for agri-businesses and large landowners so that forested areas can be cleared by the FARC only (see **Figure 2**). Rules and fines are in place for significant damage to ecosystems as a result of deforestation, but conviction rates are very low.[1]

From 1967 to 2016, the FARC fighters' presence in forested areas resulted in many local farming families and smallholders fleeing to cities. Those who stayed behind grew coca trees, for which FARC paid them a regular income. These farming families and communities are now unsure of how to farm cattle and grow basic produce for markets. The landowners' dilemma is that their knowledge is tied in with coca plantation farming, not grazing animals in a traditional farming sense. In fact, many local landowners have now been forced to cut down large pockets of forests that they once protected in order to support themselves and their families.

Although IDEAM reported a reduction in overall deforestation between 2017 and 2018, satellite data from the University of Maryland indicate that the loss of primary forest rose in 2018, reaching the highest level since measurement began in 2001. While Brazil and Indonesia registered less deforestation than previous years, Colombia showed up as a dramatic case of accelerating tropical tree loss, with primary forest deforestation surging by 500 per cent in 2018 over the country's lowest level recorded in 2003.[3]

THE COST OF PEACE

The destruction of Colombia's biodiversity has also come from state-sponsored infrastructure (see **Figure 3**) schemes in recent years. The Marginal de la Selva is a multi-lane motorway project that is now largely complete within Colombia, but there is one sensitive stretch that has yet to be finished: the section that is planned to pass between two of the country's national parks.

The Corporation for Sustainable Development of the North-East Amazon (CDA) in Colombia was alerted to the deforestation being caused by the highway scheme by IDEAM's satellite imagery. Consequently, the scheme was immediately put on hold. The CDA director, César Meléndez, claims illegal armed groups are contributing to the increased deforestation across the region.[4] This is in stark contrast to the informal policies of FARC, which largely instilled fear and control over smaller factions. The results of FARC's demise and the rise of peacetime has seen unmitigated destruction of Colombia's prime forested areas.

FIRE AND ASH

The methods of deforestation have been varied but one, fire, has been observed extensively by satellite imagery. Scientists believe newcomers are now waiting to cash in on newly accessible land and that former combatants and others may be using fire to clear these forests (see **Figure 4**).

A Colombia University research paper published in 2018 focused on analysing images collected by NASA's Terra and Aqua satellites. The researchers noticed a spike in fire frequency during the summers of 2017 and 2018. Many of the fires occurred in the Amazonian Andes, in areas that used to be under strict FARC control. The researchers also detected a 69 per cent jump in deforestation within those areas – from about 7,500 ha in 2017 to some 13,000 ha in 2018 – following the fires. The trends could not be explained by weather patterns but were likely due to deliberate burning to clear the land once controlled by FARC rebels.[5]

HALTING THE DESTRUCTION

In order to fight to protect the areas most under threat, a government-led approach is required, with the buy-in of local communities; one of those programmes is Leveraging Agricultural Value Chains to Enhance Tropical Tree Cover and Slow Deforestation (LEAVES). This study, led by the World Bank Group and financed by the Program on Forests (PROFOR), has conducted agricultural commodity case studies involving beef, cocoa, coffee, oil palm, shea butter and soya beans to identify key recommendations and lessons that can help the World Bank Group and others realise the potential of reducing deforestation and enhancing tree cover in agricultural landscapes, including Colombia. The report states that 'A clear message is urgently needed that sustainability innovators will be recognized and rewarded…. Positive incentives must favour sustainable practices, forest maintenance, and enhanced tree cover'.[6]

The role of former FARC members could also become crucial. Several ideas that have received backing include former FARC members (many of whom are out of work and shunned by society) becoming stewards of the jungles they patrolled for years. Their knowledge and awareness of dense forestry tracts could yet prove invaluable in the fight to protect the forests of Colombia.

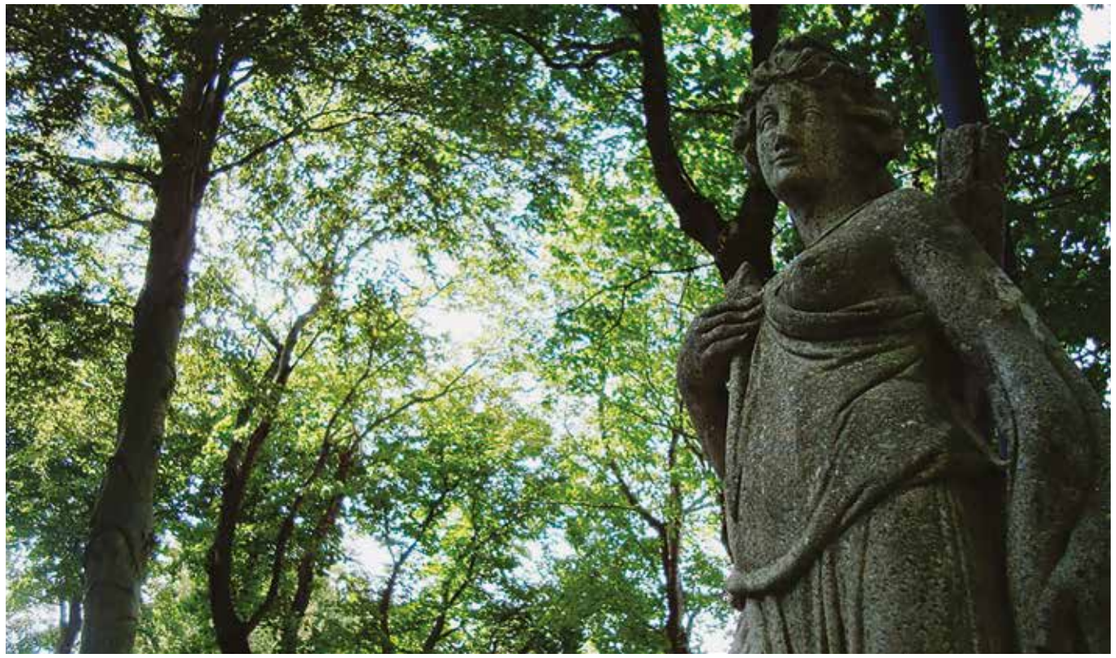
ARTEMISA

In Greek mythology, Artemis is guardian of wildlife and protector of forests (see **Figure 5**). On 28 April 2019, President Iván Duque named one of the largest military operations after the deity. Operation Artemisa is a frontline force operating on behalf of the government to combat and reduce deforestation in Colombia. It

▲ **Figure 2. FARC once dominated the Colombian landscape, but now their lack of control over it is being keenly felt. (© Unsplash)**

▲ **Figure 3. Major infrastructure in Colombia such as the Marginal de la Selva are increasing deforestation rates. (© Pexels)**

▲ **Figure 4. Uncontrolled forest fires are a major deforestation method in Colombia. (© Pixabay)**



▲ **Figure 5. Statue of Artemisa, guardian of wildlife. (© Pixabay)**

involves 'a specialized brigade to combat illegal mining, four anti-drug battalions, six jungle battalions, six jungle infantry battalions, 10 high mountain battalions and 19 special road battalions'.[7]

Artemisa is part military strategy, part education campaign, and involves rural communities whose active participation is seen as crucial in limiting deforestation in the most vulnerable areas. As Artemisa is state sponsored, it has more authority and is held in higher esteem by local communities. Once Artemisa progresses, the recovery process of large swathes of land formally falls under intergovernmental agencies coordinated by the Ministry of Environment and Sustainable Development, the Ministry of National Defense and the Office of the Attorney General. The question is how these agencies combine and work together to produce consistent results in the fight to protect Colombia's most precious natural resource.

The government's stringent Artemisa approach has received praise from urban-based environmental sectors, but has generated pushback from local cattle ranchers and human rights activists. They feel action must come from local communities, which should not have inflexible and unrealistic protocols forced on them and their way of life. Some of the ideas that have been suggested include local communities controlling their own domestic timber market. Perhaps the most innovative idea is to enrol locals in government-sponsored schemes designed to teach farmers how to use the land in a more sustainable manner. The possibility of the retention of land rights and indigenous communities retaining their own culture and societal customs is also of the utmost importance. Grant-led woodland schemes would follow, promoting the virtues of farming methods that are sympathetic to the continued use of forested areas in Colombia.

THE TROPICAL FOREST ALLIANCE IN COLOMBIA

In 2020 Colombia pioneered an innovative new approach that is beginning to make a lasting difference. The Tropical Forest Alliance (TFA) Colombia Alliance aims to help businesses shift to deforestation-free supply chains by sharing best practices, monitoring forest clearance and training small farmers in sustainable agricultural methods.[8] It also aims to promote the development of certified sustainable products, from beef to palm oil, for consumers to buy in local supermarkets. Norway is one of four main donor countries, along with the United Kingdom, Germany and the Netherlands, backing the TFA 2020, an initiative hosted by the World Economic Forum.

THE WAY FORWARD

There is no single approach in Colombia that will allow local communities and the government to halt the destructive practices that have decimated Colombia's most valuable rainforests. FARC played a significant part in limiting deforestation rates, but this has risen alarmingly in the last few years. Since 2019, however, the TFA Columbia Alliance and Operation Artemisa have proved effective and this shows that the government is making a concerted effort to limit deforestation.

The most successful approach, however, is one in which each local community is actively involved in the protection of forests while being supported by the government, an approach that recognises that agriculture and forests in Colombia coexist in a mutual relationship that cannot be separated. ES

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Eyes in the sky

Eoghan Darbyshire explains how Earth observations are used to monitor the environmental dimensions of conflict.

Regions of active conflict are typically data poor, access for environmental measurements is limited and many contemporary conflicts show no sign of conclusion. Earth observation (EO) via satellite remote sensing can fill these data gaps and provide a wealth of information ranging from short-term environmental risks to long-term changes. All this information can help target locations for humanitarian response, remediation or *in-situ* data collection via citizen science or post-conflict environmental assessments. Observations can help form the basis of environmental peacebuilding or could even help hold those responsible for environmental crimes to account.

WHAT CAN WE MEASURE FROM SPACE AND HOW?

Most sensors are passive, meaning that they rely on the Sun's energy to illuminate the Earth and the atmosphere and then measure the return signal. This energy could be directly reflected at visible wavelengths, or absorbed and re-emitted at infrared, ultraviolet and microwave wavelengths. Different surface objects and atmospheric compounds re-emit this energy at different wavelengths, so each one has its own spectral 'fingerprint'. Sensors aim to capture this information by measuring multiple or very specific wavelengths.

Landsat, Sentinel-2 and MODIS are among the key passive sensors providing myriad imagery and data on, amongst others, land and sea surface temperature, surface water, vegetation health, fire activity, deforestation, desertification and pollution. Of the atmospheric constituents of interest, only those with the strongest signals can be retrieved; key sensors include TROPOMI (carbon monoxide, formaldehyde, methane, nitrogen dioxide, ozone, sulphur dioxide), GOSAT (carbon dioxide, halocarbons, methane, nitrous oxide) and MODIS (aerosol type and optical depth).

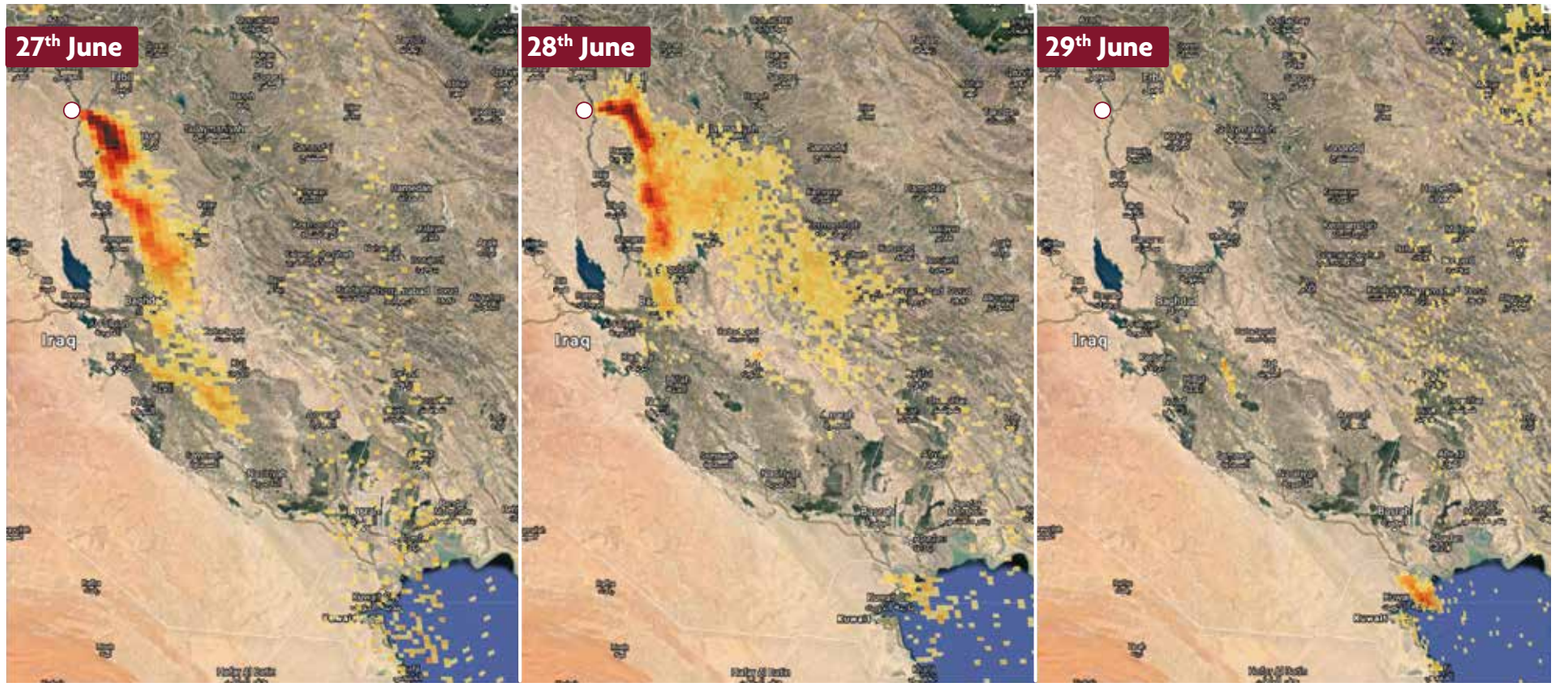
With the exception of anthropogenic night-time lights, passive sensors cannot provide data when it is dark or cloudy. At these times, active sensors – radar and lidar – are invaluable as they do not rely on the Sun, instead transmitting their own narrow band of energy towards the Earth. Radar sensors can measure surface topography via altimetry (height above sea level; e.g. Sentinel-3); precipitation structure via Ka-band radar (e.g. GPM); and trees, leaves and surface elevation via synthetic aperture radar (SAR) at L-band (PALSAR), C-band (Sentinel-1) and X-band (TanDEM-X) respectively. Interferometric-SAR (InSAR) is the practice of combining SAR data to monitor ground movements. Lidar sensors help us understand canopy structure (GEDI) and the vertical distribution of atmospheric winds (AEOLUS) and aerosols (e.g. CATS).

Most EO satellites fly in a low (700 km) Sun-synchronous orbit, i.e. they observe the same scene at the same angle and illumination. The size of the scene, called the 'swath', ranges from metres to hundreds of kilometres and determines the time between revisits to the same surface location. To complete a full Earth survey may take days to months with smaller swaths and hence, unless fortunate, they are of limited use for incident monitoring. The compromise for sensors with a larger swath is a reduction in spatial resolution. At the extreme, sensors in geostationary orbit, i.e. moving in sync with the Earth's rotation to look at one area, can provide rapid data (e.g. every 15 minutes with SEVIRI) but at low spatial resolutions as they have to fly at high altitude (36,000 km).

USING EO DATA IN CONFLICT SETTINGS

As the environmental consequences of conflict can be wide ranging and pervasive, the majority of EO satellites are useful. The difficulty is in knowing which are available, can be easily accessed, quickly processed and trusted to draw robust conclusions from. EO sensors can also help us understand environmental changes that may contribute to conflicts – be they natural or anthropogenic – and that may be useful for environmental peacebuilding post conflict or for improving predictions of potential conflict hotspots.

▶ Figure 1. Red Sea oil spill following an attack on the *Sabiti* tanker. As seen from space using SAR from the Sentinel-1 sensor on 22 October 2019. Contains modified Copernicus Sentinel data 2020.



▲ **Figure 2. Sulphur dioxide plume from a fire at the Mishraq Sulphur State Company, as measured by the TROPOMI sensor. The black and darkest red indicate the highest intensity of sulphur dioxide. Google Earth Engine, Map data 2020 Imagery. Contains modified Copernicus Sentinel data 2020. (© TerraMetrics)**

Most EO data are open source and freely available. It is easy to forget how incredible this democratisation of data is, and without it, the world and our understanding of it would be much poorer. Increasingly, commercial satellite providers provide free high-resolution imagery for disaster monitoring. Derived products integrate multiple satellite and/or model data streams to provide more detailed and systemic information.

The best understanding arises when these satellite data are integrated with open-source intelligence (OSINT), a catch-all term that includes humanitarian data, social media, traditional media, georeferencing of event images and videos, and forensic architecture. Together these datasets let us identify the link between conflict and the environment, rather than just environmental change in a conflict zone. Sometimes this is clear and obvious but often it requires careful untangling, as is now explored through examples of recent work at the Conflict and Environment Observatory.

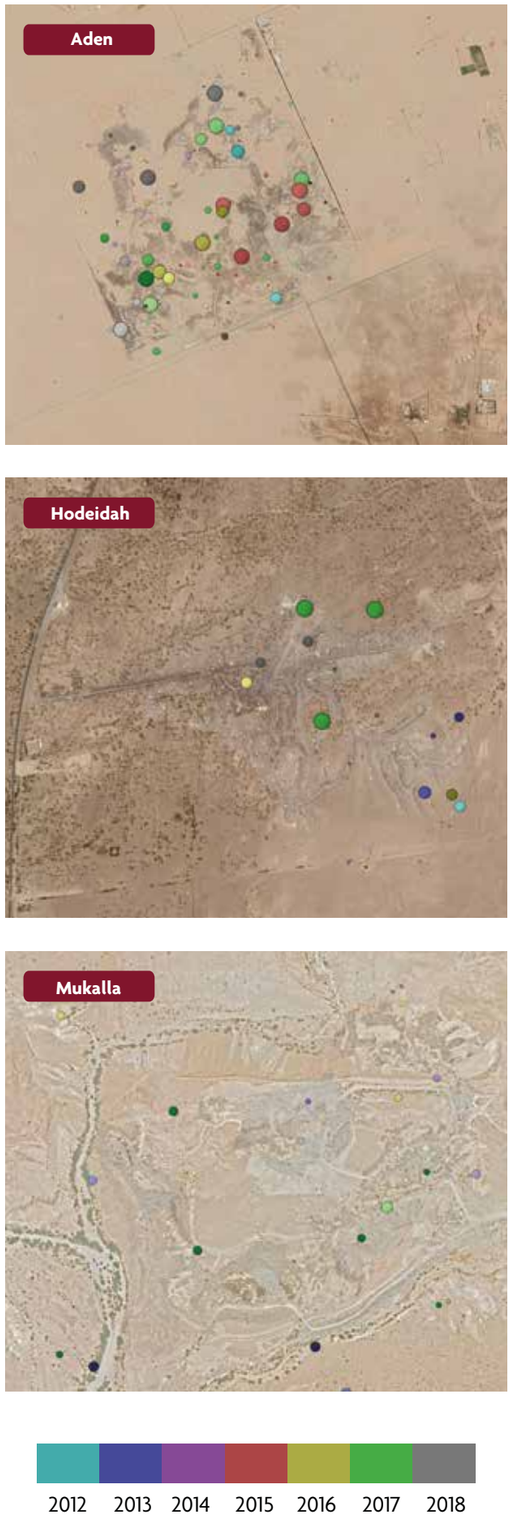
FAST RESPONSE INCIDENT MONITORING

A significant part of our work is searching social and traditional media to find reports and locations of potential incidents. The aim is to quickly assess the veracity of these claims – environmental disinformation is rising in this fake news era – and characterise the scale and risk of the incident.

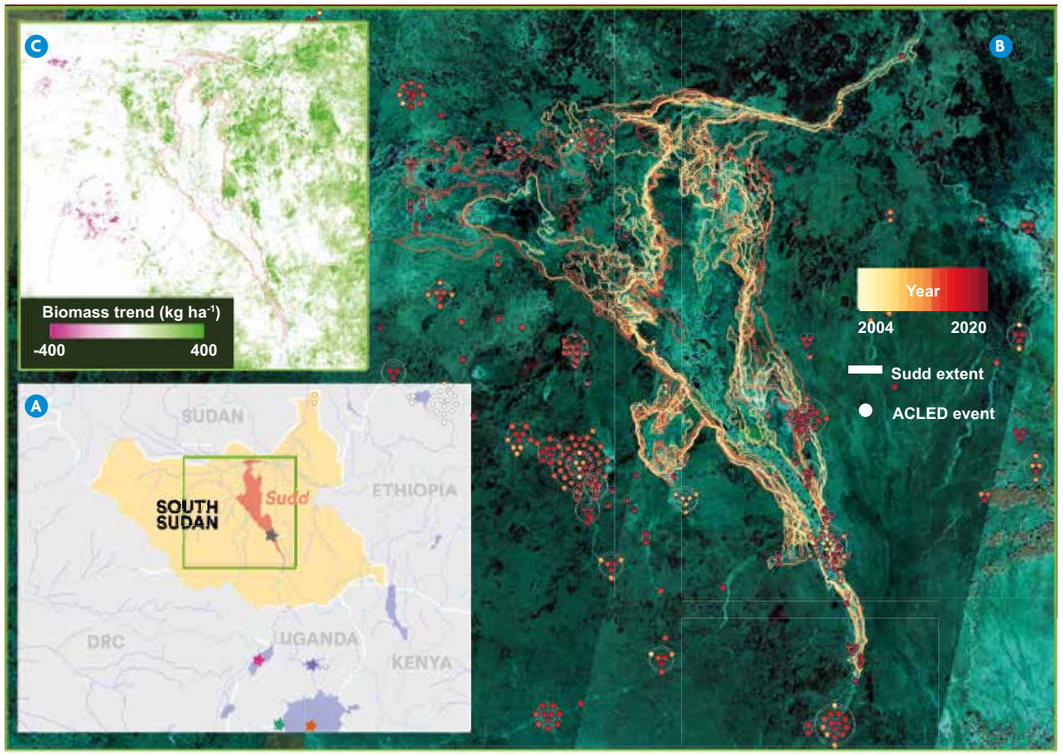
For example, on the evening of 26 June 2019, reports emerged that belligerents had set alight stockpiles of purified sulphur at the Mishraq Sulphur State Company in northern Iraq, resulting in the release of a significant near-surface plume of sulphur dioxide. Concern was significant, given that two previous fires, burning for 18 days in 2003 and seven days in 2016, had resulted in deaths and hundreds of hospital admissions in nearby Mosul, Erbil and Kirkuk. The latter looked vulnerable, based on quick online dispersion forecasts using the HYSPLIT model. Furthermore, if the entire sulphur stockpile[1] were to burn, the amount of sulphur dioxide released would be on the scale of the 1991 Mount Pinatubo volcanic eruption – with a similar reduction in the quality and quantity of sunlight, affecting the global surface temperature alongside agricultural and economic productivity. The risk was heightened given the record number of crop fires in the region, linked to various belligerents but mainly Islamic State, and limited firefighting capacity.

Active fire data allowed confirmation of fires in the facility's immediate vicinity on the same day. The next day, the Aura sensor provided the first data verifying a significant sulphur dioxide release, via the NASA Worldview platform, just hours after its overpass at 13:30 local time. The higher-resolution TROPOMI sensor allowed a more detailed insight into the plume structure when the data were released approximately a day later and processed via Google Earth Engine (a cloud computing service free to researchers). Fortunately, especially as concentrations were akin to the previous burns, the plume centreline missed urban areas and was fully extinguished within three days (see **Figure 2**).

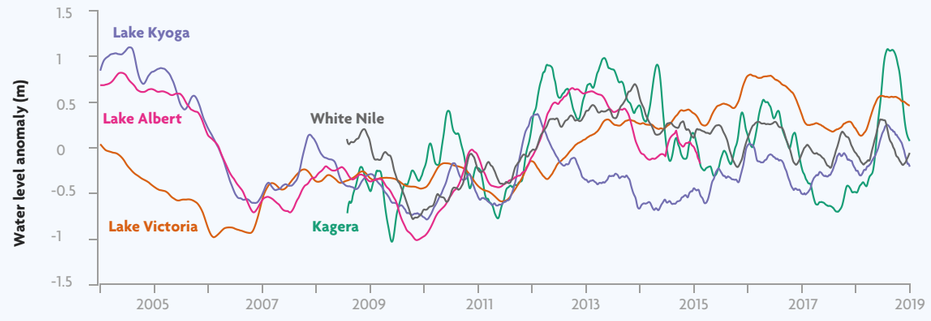
Given the cloudless skies, the scale of the incident and lack of other local sources, this incident was relatively easy to track. Oftentimes data are less accessible and the story more difficult to interpret. Several months after the incident there are additional and more robust data available to use in an ongoing project to forensically assess the incident: the how/why/where/who of the fire, the sulphur emitted and



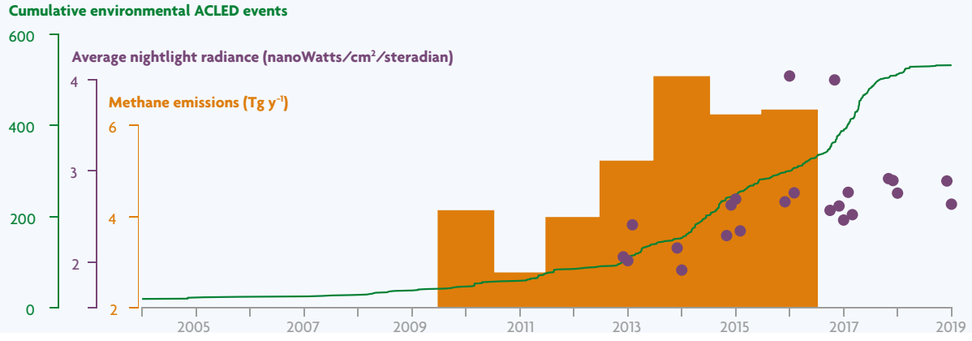
▶ **Figure 3. Informal dump sites in Yemen, near the cities of Aden, Hodeidah and Mukalla, identified using data from the VIIRS satellite sensor that show the location, time (marker colour) and intensity (marker size). Underlying imagery is from Google Earth Pro. (© 2020 Maxar Technologies)**



D **Monitoring river and lake levels from space in different parts of the Nile basin helps in understanding the hydrology of the wetlands**



E **A variety of socio-economic and scientific datasets are required to understand the whole wetland system**



the agricultural and hydrological impacts of this plume, in addition to those from previous fires at the site. Given the regional security situation, new and more significant fires are possible, so we remain attentive.

MONITORING LONG-TERM CHANGES

Environmental issues can drive and sustain conflicts, be they small or large, direct or indirect. Alternatively, or additionally, cumulative environmental degradation during a conflict can lead to conditions that prevent a sustainable peace. In all cases, it is imperative to properly characterise environmental changes.

The consequences of conflict in Yemen have been severe for the environment: falling groundwater levels, farm abandonment, direct attacks on infrastructure and workers, collapse of wastewater management, deforestation and the introduction of alien species to the Socotra archipelago. **Figure 3** shows informal waste dumps, identified from satellite using fire hotspot data from VIIRS. Landfills are a source of highly flammable methane, the presence of which can result in spontaneous accidental fires; methane can also sustain fires that are intentionally started to reduce waste volumes. Informal landfills have proliferated during the conflict as governance has collapsed, yet how waste is managed has implications for the protection of civilian health, their livelihoods and the environment.

EO is essential for monitoring and, when integrated with other datasets, can yield a fuller understanding of stories across active conflicts. While the higher-specification sensors launched in the past few years are powerful, it is often the sensors that have been in place for two decades or more that are the most useful, providing the longer time series essential for these analyses. For example, **Figure 4** shows some of the long-term datasets we are currently using in our ongoing research into South Sudan at the Conflict and Environment Observatory.

◀ **Figure 4. Snapshot of EO data used as part of ongoing research into the Sudd wetlands A. in South Sudan. Contains modified Copernicus Sentinel data 2020. B. Lines show the wetland extent as identified from diurnal land surface temperature gradients, measured by the MODIS sensor, and markers show the time and locations of environment-associated conflict incidents, from the ACLED Project; background imagery from late December 2019 as measured by the Sentinel-2 satellite and presented as a false-colour composite to show water courses. C. Statistically significant linear trends in total biomass produced per year, based on multiple satellite measurements acquired via the WaPOR platform.[7] D. Water height anomaly from the JASON satellite altimetry sensor acquired from the Hydroweb platform.[8] E. Cumulative ACLED events in South Sudan, the intensity of night-time lights and the estimated methane emissions.[6]**

Here we focus on the Sudd wetlands (see **Figure 4A**), which provide the only palatable grasslands in the dry season for the cattle of pastoralist tribes. As the area of the wetlands changes, so too does the available grazing area, which can lead to tensions between tribes and with agriculturalists. This is in addition to the state violence and country-wide conflicts.

To untangle these complex interactions, the first step is to understand environmental changes, as these are little studied:

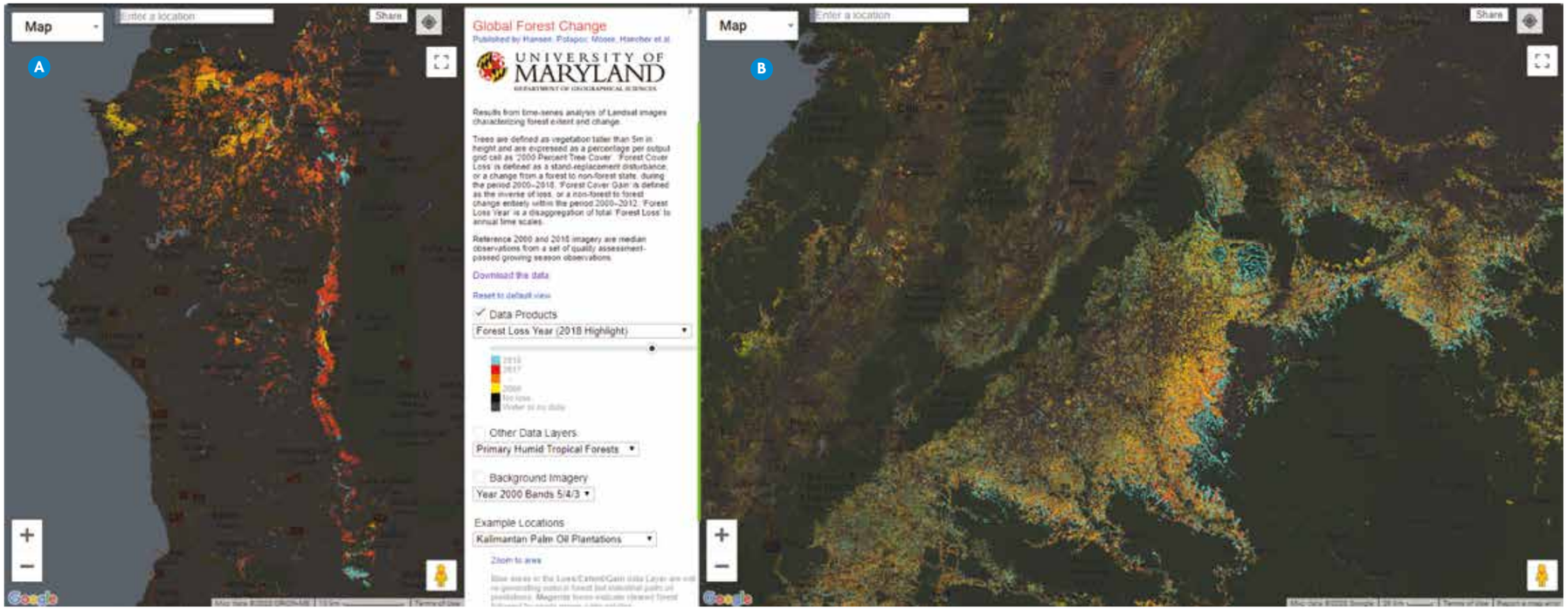
- Determination of the wetland extent using diurnal land surface temperature gradients (via MODIS emissivity retrievals, see **Figure 4B**);
- Understanding the hydrology upstream using precipitation data (via GPM precipitation radar) and lake/river levels (via JASON satellite altimetry, see **Figure 4D**), coupled to watersheds identified from digital elevation models (via SRTM) and knowledge of dam operations;
- Identifying vegetation changes (via **Figure 4C**) and attributing them to natural or human causes – be these direct (land-use changes) or indirect (e.g. via climate change); and
- The global importance of the Sudd to climate change – a recent analysis found the wetlands to be an unexpectedly large source of methane, likely from microbial activity.[6]

Once the environmental factors are understood, we then proceed to untangle how they have or have not played a role in the conflict. This can be done by integrating a conflict dataset into the analyses, such as text mining the Armed Conflict Location & Event Data Project (ACLED) for events associated with the environment, as shown in **Figure 4B** and **4E**. Further insight can be gained from ancillary EO datasets – for example VIIRS night-time light data (see **Figure 4E**) can be linked to population density or fuel availability.

TRY IT YOURSELF

Although many technical barriers still exist to processing and analysing EO data, one positive change in recent years has been the proliferation of interactive online platforms that are easily accessible and understandable for the layperson.

A number of portals illustrate data on a phenomenon with a complex relationship to conflicts: deforestation. Syria has lost a quarter of its forested area since 2010 and, as the Global Forest Change visualisation in **Figure 5A** shows, in particular during the last four years. These losses are coupled to the conflict: collapse in governance and declining fuel access have allowed belligerents to open new and unregulated markets in fuel wood, charcoal and commercial logging. Meanwhile in Iraq, fighting and border-management burns also contribute



▲ **Figure 5. Overview of the Global Forest Change portal for (A) western Syria and (B) the Amazon/Andes barrier in southern Colombia.**

to deforestation. The Middle East is at the forefront of climate change and cannot afford to lose already minimal tree cover, given the significant consequences for biodiversity, farming, floods, soil erosion, dust storms and desertification.

The conflict–deforestation relationship is less clear in Colombia (see **Figure 5B**). Although the conflict did exert an overall negative impact, the area of forest disturbance accelerated by 50 per cent in 2017 and 2018, *following* the peace agreement.[2,3] 'Gunpoint conservation' by the FARC rebel group had ended, thus allowing drug cartels, large landowners and dissidents to exploit weak policy and start large-scale coca and cattle ranching farms, including in protected areas.

The apps.sentinel-hub.com EO browser is a powerful portal that allows users to choose from a host of sensor imagery collections, specify a region of interest, collate imagery from selected cloud-free dates and choose how it is presented. Most usefully, users can easily select band combinations to generate false-colour imagery, or write short snippets of code to manipulate the data or imagery.

Data come online approximately two days after the overpass, making the platform useful for near-real-time incident monitoring. The EO browser was helpful in quickly identifying and monitoring oil spilling into the Red Sea from the *Sabiti* tanker on 22 October 2019, following an attack on the vessel by unknown belligerents 11 days previously. Sentinel-1 SAR was processed using code available in the custom scripts repository[4] to display water surface roughness (see **Figure 1**). The spill was significant in extent, yet there was no cleanup operation. The environmental damage is unknown, but the spill was close to endangered corals.

ONGOING CHALLENGES AND FUTURE DIRECTIONS

As there is no commercial incentive and a misconception of unimportance, the field of observing the environmental dimensions of conflict with EO is small – it consists of a handful of non-governmental organisations (NGOs) and academics. Despite recent growth, which has helped to influence important progress in the legal, peacebuilding and policy spheres, there is still a need for sustained funding for environmental monitoring in regions at risk or affected by armed conflicts.

Assuming continued funding, the discipline ought to grow in step with the space sector, ensuring the application of frontier technology from new missions including BIOMASS, FLEX, NISAR, Landsat-9 and GeoCARB. Plans are in place to build the discipline, using the Group on Earth Observations framework to form a new working group and entrain experts from other relevant fields along with practitioners from conflict-affected countries. One objective would be to work with relevant legal actors to understand, and later implement, the minimum data standard and presentation style for admissible evidence in a court of law.

Given the huge scope of work, especially in the face of today's diverse, intractable and dynamic conflicts, there needs to be a move towards automation and cloud computing. For incident monitoring, this could involve an algorithm that (1) trawls social media looking for events, (2) pulls out the relevant data and then (3) generates plots and statistics. Continuing assembly of a spectral and SAR fingerprint library will help identify surface pollutants and features with greater speed and accuracy. For long-term monitoring, automation will be through increased use of machine learning and artificial intelligence – these can also be trained to find emerging trends. Dealing with such vast volumes of data has logistical and ethical considerations and is all part of a wider discussion on building a digital ecosystem for the planet.[5] ES

Dr Eoghan Darbyshire uses open source data at the Conflict and Environment Observatory (CEOBS) to robustly characterise, communicate and advocate further study of the environmental dimensions of conflict. He formerly worked at the University of Manchester, taking *in-situ* measurements across the globe to probe atmospheric aerosol composition.

BOX 1: GLOSSARY OF ACRONYMS

AEOLUS: Atmospheric Dynamics Mission Aeolus; **CATS:** Cloud-Aerosol Transport System; **FLEX:** FLuorescence EXplorer; **GEDI:** Global Ecosystem Dynamics Investigation; **GeoCARB:** Geostationary Carbon Cycle Observatory; **GOSAT:** Greenhouse Gases Observing Satellite; **GPM:** Global Precipitation Measurement; **HYSPLIT:** Hybrid Single Particle Lagrangian Integrated Trajectory; **JASON:** Joint Altimetry Satellite Oceanography Network; **MODIS:** Moderate Resolution Imaging Spectroradiometer; **NISAR:** NASA-Indian Space Research Organisation Synthetic Aperture Radar; **PALSAR:** Phased Array type L-band Synthetic Aperture Radar; **SAR:** synthetic aperture radar; **SEVIRI:** Spinning Enhanced Visible and Infrared Imager; **SRTM:** Shuttle Radar Topography Mission; **TanDEM-X:** TerraSAR-X Add-On for Digital Elevation Measurement; **TROPOMI:** TROPOspheric Monitoring Instrument; **VIIRS:** Visible Infrared Imaging Radiometer Suite; **WaPOR:** Water Productivity Open-access portal

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ANALYSIS

Intertwined but apart: natural heritage in cultural property protection

Emma Cunliffe explores the issues surrounding the protection of natural heritage in times of conflict.

International attention has focused on the widespread damage to cultural heritage in recent armed conflicts, with conspicuous international effects. International aid to affected sites has increased: for example, the British government created the £30 million Cultural Protection Fund, and multiple countries and private funders contributed to the International Alliance for the protection of heritage in conflict areas (ALIPH) Fund, which contains US$77.5 million. Ratifications of the international cultural property protection laws have also increased, alongside a successful prosecution of cultural destruction at the International Criminal Court (ICC), with another case pending. Yet the destruction of natural heritage has received virtually no attention, even though the humanitarian impact of wartime environmental damage is enormous[1] and the ICC Office of the Prosecutor 'will give particular consideration to prosecuting Rome Statute crimes that are committed by means of, or that result in […] the destruction of the environment'.[2]

Through a comparison to cultural property, this article examines the protection that international law could provide for natural areas during conflict, focusing on areas dedicated to conservation rather than civilian environmental infrastructure, such as irrigation works. There are both overlaps and major differences in law and current practice, and the comparison suggests new avenues for natural protection.

THE ROLE OF INTERNATIONAL LAW

Customary international law consists of rules of war that come from general state practice and are internationally accepted as law. These laws are binding on all parties in all conflicts at all times and do not require a signature. They offer protection to cultural property[3] as a civilian object and in its own right in, for example, the 1977 Additional Protocols I and II to the 1949 Geneva Conventions. Additional Protocol I, article 53, protects 'historic monuments, works of art, and places of worship which constitute the cultural or spiritual heritage of peoples' against military use or attack. (There

◀ **Figure 1. Agent Orange, a herbicide, being sprayed on farmland during the Vietnam War. It caused widespread, long-term, severe damage. (© Brian K. Grigsby)**

ANALYSIS

▲ **Figure 2. MONUSCO troops operating in the jungle of Virunga National Park, a World Heritage site. (© MONUSCO Nord Kivu brigade/Major Lakshay)**

is no damage threshold: any attack is a crime.) If severe enough, attacks may be prosecuted under the 1998 Rome Statute at the ICC as war crimes.

However, specific legislation relating to the management and protection of cultural property during conflict was introduced in 1954, in the Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict (signed today by 133 states), followed by two Protocols (1954 and 1999). Its provisions include a definition of cultural property (in article 1): 'movable or immovable property *of great importance* to the cultural heritage of every people' (my emphasis). Cultural property meeting the definition is granted a level of protection and immunity from use or attack during conflict that may only be waived in cases of imperative military necessity. What meets that definition has been subject to much debate; ultimately, it is up to the state to decide.[4] States may also identify locations of 'very great importance' and 'of the greatest importance for humanity' to be granted special and enhanced protection respectively. Operating in or against those areas requires higher military authorisation, potentially even from the force commander. These distinctions of importance and the significance of the command authority are critical to the protection of cultural property. Unfortunately, international law has nothing similar to the 1954 Hague Convention for natural heritage.

Few international laws specifically address environmental protection; in most cases, the environment is better protected indirectly as a civilian object or by the customary international laws that regulate the means and methods of warfare.[5,6] Additional Protocol I (1977) requires the protection of the natural environment 'against widespread, long-term *and* severe damage' (article 55) (see **Figure 1**) and is now considered to form part of customary law. However, this so-called 'triple threshold', where all three (only vaguely defined) criteria must be met for a crime to have been committed, is extremely hard to meet evidentially, rendering prosecution – as a punishment or a deterrent – very difficult.

EVOLUTIONS IN UNDERSTANDING AND LAW

Yet, as our understanding of culture has developed, the international community has recognised that 'the existing legal concept of "property" does not … cover all that evidence of human life that we are trying to preserve: those things and traditions which express the way of life and thought of a particular society; which are evidence of its intellectual and spiritual achievements'.[7] Strong arguments were put forward by both the Special Rapporteur for the protection of the environment in relation to armed conflicts[6] and the Special Rapporteur in the field of cultural rights[8] that the destruction or damage of any natural area with significant cultural links to a living population is also violation of their human rights, particularly with regards to indigenous people.

The World Heritage Convention, created in 1972, recognised both cultural and natural heritage of 'outstanding universal value' and that the two were frequently interlinked. This is embodied in the 39 cultural landscapes on the World Heritage List – 'combined works of nature and humankind, they express a long and intimate relationship between peoples and their natural environment'.[9] The Convention is generally accepted[5] to operate during armed conflict: it contains measures that the World Heritage Committee must fulfil in the event of 'the outbreak or the threat of an armed conflict' (article 11.4), and obliges states not to deliberately damage sites on other states' territory (article 6.3). Today, it is

▲ **Figure 3. The Long Walk at Windsor Great Park, England, a Grade 1 listed historic garden, protected today under the 1954 Hague Convention. (© Solobratscher)**

the most widely signed international treaty in existence. The United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO) Peacekeeping Mandate included 'providing assistance to disarm and evacuate armed rebel groups from the World Heritage sites' (see **Figure 2**). MONUSCO peacekeepers cooperated with paramilitary rangers hired by the Institut Congolais pour la Conservation de la Nature (ICCN) in the Virunga National Park World Heritage site to protect the park against armed groups. The environmental protection unit of MONUSCO also monitored the return of endangered species and provided transport to veterinary surgeons.[10]

Yet, when a Second Protocol to the 1954 Hague Convention was first envisioned in the 1990s to deal with apparent deficiencies in the Convention, there was discussion about whether natural heritage should be included. Those revising the Convention decided that 'the question of granting special protection to natural sites, such as those included in the World Heritage List, would not be an appropriate matter for the 1954 Convention, but could form the subject of a separate Convention'.[11] Despite this, the United Nations Environment Programme (UNEP)[5] suggests that 'protection for environmental resources may be provided, under certain circumstances, by the 1954 Hague Convention […], to the extent that such resources fall within the definition of cultural property under article 1 of the Hague Convention'. Nor do all countries exclude it in practice, underlining the intertwined relationship. For example, the UK defined its protected cultural property under the 1954 Hague Convention in 2017: natural World Heritage sites were excluded, but all Grade I listed historic parks and gardens were included (see **Figure 3**).[12] Another environmental contender could be UNESCO Biosphere Reserves, which recognise the important links between biological and cultural diversity. A key characteristic of their inscription is that they 'integrat[e] cultural and biological diversity, especially the role of traditional knowledge in ecosystem management'.[13]

Yet, in general, there are few overlaps in international protection laws, and the protection provided to natural heritage in conflict is extremely limited. Most natural areas are considered worthy of protection not because of their cultural elements, but because of their natural significance, limiting the legal protection offered by cultural property protection laws. There are practical lessons to be learned from the Hague Convention.

LESSONS FOR PROTECTION: DESIGNATION

The first lesson is the value of defining specific areas, prioritised by importance. Although cultural property is protected under the Geneva Conventions' Additional Protocols (and as civilian property), some specific cultural property is designated for greater protection, realised in two ways. The first is through the legal requirement for higher command authorisation and responsibility in decision-making: the more important the area, the greater the command authorisation required, forcing recognition of its protected status (see **Figure 4**). The second is practical – the higher the intensity of the combat, and the greater the pressure on personnel and resources, the more difficult it will become to protect multiple locations. In such circumstances, it may only be possible to protect the most important places, requiring their identification and prioritisation, which is not currently done for natural sites.

There is no definitive list of what constitutes a protected natural area. According to the International Union for Conservation of Nature (IUCN), the primary objective of all protected areas is to conserve nature, but there is significant variety within this and the areas do not map directly onto the definitions in the legal protective frameworks, leaving gaps in protection.

On the whole, protected areas do not have any legal status in armed conflict above and beyond the general environment.[5] There may be some exceptions, of which the two most widely ratified laws are the 1971 Convention on Wetlands of International Importance especially as Waterfowl Habitat (also called the Ramsar Convention) and the Convention for Biological Diversity (1992), both of which designate protected areas and (debatably) continue to operate during armed conflict.[5,6] There are also several applicable regional treaties designating protected areas, but these are binding only on signatory states (usually those with coastlines), and are not recognised globally (so a hostile force operating in another country may not recognise an area as protected). Several non-binding United Nations General Assembly Resolutions, including the World Charter for Nature (1982) also support protected areas in conflict.

Even without a legal obligation, however, designating and prioritising specific natural areas for protection could improve their management, fulfilling the same practical role in combat as the cultural property system. I attend NATO training exercises as a subject matter expert to support NATO in realising cultural property protection. In one recent exercise, the protected site list (for a fictional location) included Ramsar sites, demonstrating NATO's awareness of the need to protect natural heritage, and willingness to do so. Prioritisation of areas can also improve the potential for prosecution and therefore act as a deterrent. In order to constitute a war crime, destruction must be a 'grave breach' of law; for example, parts of Mali's World Heritage site destruction were prosecuted at the ICC. Specifying important areas may contribute to the threshold required for a war crime prosecution.

LESSON FOR PROTECTION: SAFEGUARDING

The second lesson to take from the 1954 Hague Convention is the importance of the required safeguarding measures (article 3), which must be completed during peacetime, in addition to the military measures during conflict.

▲ **Figure 4. Historical monument in Mtskheta, Georgia. Its enhanced protection status makes it one of the most protected sites in the world. (© Paul Fox/Blue Shield International)**

The Second Protocol (article 5) details the safeguarding measures, recommending inventories – a list of what must be protected. NATO called such data 'a critical decision support tool and precondition for engaging […] on a strategic and tactical level'.[14] The simple provision of a list (including boundaries) of what areas must be protected could significantly increase their recognition. Other measures include developing proactive measures 'against the foreseeable effects of an armed conflict' – understanding how conflict impacts natural sites is key to mitigating it. The Convention also specifies the need to establish competent authorities to manage safeguarding; given the diverse bodies with responsibility for protected natural areas, the creation of a single point of contact is important for coordination with military authorities (national and foreign), much as state heritage bodies are responsible for cultural property during conflict.

THE FUTURE

The measures suggested only apply to protected natural areas; they will not provide protection to farmland, water reserves or other widespread and important environmental infrastructure areas essential to sustaining civilian populations. However, these areas are also protected under Additional Protocol I, so the development of a system pertaining exclusively to natural protected areas has many benefits.

Although there is only a limited legal case for the protection of natural areas over and above general environmental protection, it remains of practical benefit to armed forces. Today, there is pressure on armed forces to sustain a good reputation and positive relations with local communities, recognising that negatively perceived actions can affect mission success. Even though it is legally unclear whether NATO *needed* to protect a Ramsar site in the exercise, they proactively identified the relevant sites. Similarly, Rush[15] reported cases in Afghanistan where US soldiers protected vineyards and rose gardens that were locally culturally significant. It is perhaps at this intersection of law and practice that natural heritage protection can best be encouraged, resulting in improved reputation for armed forces operating in good faith and greater protection for protected natural areas of significance. **ES**

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Jack Hague

Winner

IES photography competition: nature during lockdown

With many of us spending more time at home over the last few months, we have been reminded of the importance of our green spaces and engaging more with the local wildlife we find around us, strengthening our connection with the natural environment. We asked you to submit your best photographs of nature during this time; taken in your garden, local green space, or even from your window. The winning photograph, along with a selection of the highest-scoring runners-up, are displayed on the following pages.

We received over 100 entries from across the world, with an exceptionally high standard of images submitted. To determine the winning entry, the judges were asked to rank their favourite five photographs from first, worth five points, to fifth, worth one point. The winner, with almost double the final score of any other entry, was Jack Hague's magnificent image of a bank vole. Describing capturing the winning photograph, Jack said "I sat on the floor of the woodland for around 45 minutes following this little mammal scurrying around the leaf litter foraging for seeds, berries and insects."

Peter Crome

Jamie Wood


Phil Underwood


Emma Crosby


Sarah Freeman


Jimi Irwin


Jimi Irwin


Sara Gowers


Hugo Siedlecki


Sara Gowers


Emma Crosby


Douglas Tillbury


Douglas Tillbury


Jack Hague

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Charlotte Bithell – Environmental Consultant
Sarah Booley – Environmental Consultant
Emma Boucher – Climate Change Consultant
John Brooks – Environmental Officer
James Browne – Senior Air Quality Consultant
George Byrne – Environmental Consultant
Jo Campion – Senior Project Engineer
Rachael Chambers – Environment Interfaces Manager
Angie Chan – Air Quality Consultant
Ricky Chui – Assistant Consultant
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Neil Cooper – Principal Consultant
John Cullen – Environmental Consultant
Sarah Davies – Senior Geo-environmental Consultant
David Denham – Senior Acoustic Consultant
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Sophie Doyle – Senior Environmental Consultant
Uduakobong Edet – Tutor
Andrew Edwards – Director
Filipa Fonte – Social Value & Sustainability Manager
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Emma Geering – Environmental Chemist
Claire Giribaldi – Consultant
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Alistair Halcrow – Environmental Advisor
Colin Harbinson – Director
Jacob Hepworth-Bell – Associate Director
John Hills – Geo-environmental Engineer
Steven Holdsworth – Regional Head Forester
Nicole Holland – Air Quality Scientist
Kevin Holmes – Senior Geo-environmental Consultant
Hannah Jackson – Senior Marine Environmental Consultant
James Jervis – Associate Environmental Consultant
Lewis Jones – Principal Environmental Consultant
Jeremy Kalkowski – Chief Forester
Georgina King – Senior Environmental Manager
Florence Kirk-Lloyd – Principal Air Quality Scientist
James Learmonth – Principal Consultant
Matthew Lennard – Senior Geo-environmental Engineer
See-Yan Lin – Executive Chairman & CEP
Daniel Loup – Assistant Engineer
Hannah Lyon – Environment Manager
Josh McLaren – Senior Air Quality Consultant
Anita Metelko – Senior Land Quality Officer
Kirsten Mills – Senior Geo-environmental Consultant
Laura Mitchell – Senior Development Manager
Colin Morton – Senior Geo-environmental Consultant
Thomas Mynott – Environmental Consultant
Max Nancarrow – Senior Air Quality Consultant
Michael Neep – Senior Ecologist
Amy Newman – Principal Engineer & Team Leader
Marta O'Brien – Teaching & Research Senior Technician
Noelle O'Leary – Environmental Scientist
Reinier Oosten – Consultant
Hana Pearce – Graduate Air Quality Consultant
George Peet – Head Forester
Martin Peirce – Principal Consultant
Elizabeth Philp – Technical Director
Lucy Quick – Principal Geoenvironmental Engineer
James Regan – Associate Director (Technical)
Nisha Rehm – Senior EIA Consultant
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Betsabe Sanchez – Associate Director
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Andrew Surdevan – Principal Consultant
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George Teesdale – Environmental Consultant
Jayne Trevelyan – Principal
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Roy Walker – Senior Geo-environmental Consultant
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Jolly Wasambo – Programme Coordinator
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Jonathan White – Associate Environmental Consultant
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Morag Wilson – Lead Environmental Specialist
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Ryan Miles – Graduate Air Quality Consultant
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Frazer Nisbet – Graduate Environmental Consultant
Nnamdi Obasi – Material Technician
Aisling O'Neill – Project Environmental Scientist
Rohan Patel – Graduate Consultant
Viral Patel – Environmental Consultant
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Harry Porter – Graduate Air Quality Consultant
Emily Portergill – Graduate Environmental Consultant
Farhad Qayum – Geo-environmental Engineer
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Jade Roche – Graduate Consultant
Claire Rogers – Environmental Health Officer
Emma Ryder – Graduate Environmental Consultant
Sophie Sibley – Environment and Energy Data Analyst
Christopher Skinner – Graduate
Andrew Smith – Graduate Air Quality Consultant
Phoebe Stockton – Graduate Air Quality Consultant
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The promise and perils of protected zones

Stavros-Evdokimos Pantazopoulos provides an overview of area-based environmental protection in relation to armed conflict.

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ANALYSIS

The relationship between war and biodiversity loss is now well established.[1] Armed conflicts have been found to lead to both species and habitat loss, and accelerate the depletion of forest cover.[2] In addition, conflicts are linked to the illegal exploitation of natural resources, and help to facilitate poaching and the illegal wildlife trade due to the presence of so many weapons. The collapse of biodiversity research and management in areas affected by armed conflicts only serves to aggravate these conditions, further complicating conservation efforts.

Unfortunately, biodiversity hotspots do not have special legal protection beyond that accorded to civilian objects during armed conflicts. Even worse, parts of the environment can be directly targeted on the basis of their location or use. So place-based protection (designated protected zones that benefit from increased protection, if not immunity, from targeting) could be an important tool to protect important ecosystems from the harmful effects of armed conflict.

THE EARLY ATTEMPTS

The idea of establishing demarcated, place-based zones to protect ecosystems in times of armed conflict is not entirely new. During the Diplomatic Conference of Geneva of 1974–77 that led to the adoption of Additional Protocols I and II,[3] it was proposed that nature reserves would be protected and respected. In 1995, a Draft Convention on the Prohibition of Hostile Military Activities in Protected Areas was drafted by the International Council of Environmental Law (ICEL) and the Commission on Environmental Law of the International Union for the Conservation of Nature (IUCN). Unfortunately, both of these failed to be approved.

Turning to pertinent, non-binding legal instruments, it is worth noting that the notion of protected zones found its way into two influential documents. First, the San Remo Manual on naval warfare states that 'the parties to the conflict are encouraged to agree that no hostile actions will be conducted in marine areas containing: (a) rare or fragile ecosystems; or (b) the habitat of depleted, threatened or endangered species or other forms of marine life'.[4] On a similar note, the Draft International Covenant on Environment and Development refers extensively to the designation of natural and cultural sites for enhanced protection:

> "Parties shall take the necessary measures to protect natural and cultural sites and objects of special interest, in particular sites designated for protection under applicable national laws and international treaties, as well as potentially dangerous installations, from being subject to attack as a result of armed

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> conflict, insurgency, terrorism, or sabotage. Military personnel shall be instructed as to the existence and location of such sites and installations."[5]

Interestingly, the commentary to this article refers back to Additional Protocol I's 'demilitarized zones and non-defended localities'[6] as having the potential to furnish protection to natural and cultural sites.[5] A demilitarized zone is defined as an area, agreed upon between the parties to the conflict, which cannot be occupied or used for military purposes, while a non-defended locality is any inhabited place near or in a zone where armed forces are in contact that can be occupied by an adverse party. Neither of these types of area-based protection has yet been operationalised to give environmental protection.

MULTILATERAL (ENVIRONMENTAL) AGREEMENTS

The concept of *in-situ* protection is already found in the 1992 Convention on Biological Diversity (CBD).[7] However, whether multilateral environmental agreements continue to apply in times of armed conflict is a controversial issue. For our purposes it is enough to mention that 'area-based' protection regimes, as established in the CBD, the 1972 UNESCO World Heritage Convention[8] and other related treaties, require the 'continuation in conflict of a "protected area" regime … alongside IHL rules'[6] and the potential 'acceptance of a new IHL provision on this issue'. International Humanitarian Law (IHL), also called 'the law of armed conflict' or 'the laws of war', is the legal framework for situations of armed conflict and occupation.

The CBD and the World Heritage Convention hint at a prohibition on the use of specifically designated ecologically sensitive areas to further the military effort and, importantly, to the emergence of a prohibition on undertaking hostile acts against such areas.[6] Assuming that the World Heritage Convention continues to apply during armed conflicts, it could be used to set up systems of international cooperation and assistance to protect natural heritage areas, because of their importance for the international community as a whole.

DRAFT PRINCIPLES ON PROTECTED ZONES

Quite recently, the UN International Law Commission (ILC) adopted, on first reading, two draft principles (DPs) on protected zones.[9] They read as follows:

> "Draft principle 4: Designation of protected zones: States should designate, by agreement or otherwise, areas of major environmental and cultural importance as protected zones."
>
> "Draft principle 17: Protected zones: An area of major environmental and cultural importance designated by agreement as a protected zone shall be protected against any attack, as long as it does not contain a military objective."

Given the prevalence of non-international armed conflicts in contemporary times, it is worth noting that both are intended to apply to either an international or a non-international armed conflict. DP 4 is also applicable after armed conflicts, and thus could form the legal basis of contemporary best-practice tools, such as the creation of peace parks. These are 'transboundary protected areas that are formally dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and to the promotion of peace and co-operation'.[10]

Another element that stands out is the explicit linkage between areas of environmental importance and areas of cultural importance, which illustrates their significance for indigenous peoples and enables a stronger case to be made for the cultural value of biodiversity. In this regard, the ILC commentary explains that such protected zones 'would nevertheless include … ancestral lands of indigenous peoples, who depend on the environment for their sustenance and livelihood'.[9] Along the same lines, the very first paragraph of the CBD foregrounds the cultural value of biodiversity by acknowledging 'the intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values

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of biological diversity and its components'. In addition, DP 8 on 'human displacement', which concerns the 'environmental degradation in areas where persons displaced by armed conflict are located', showcases how conflicts can indirectly harm the environment, even in areas removed from the fighting. Displaced populations may inadvertently harm sensitive areas through coping strategies, such as the overharvesting of firewood.

All in all, DPs 4 and 17 provide for area-defined protection and could be interpreted to afford special environmental protection to ecologically sensitive areas. Notwithstanding the fact that the potential that this specific type of protection holds has not yet been explored in practice, it could be considered the way forward for biodiversity protection in relation to armed conflicts. DP 25, which applies post-conflict, could complement in biodiversity conservation, as it encourages 'relevant actors, including international organizations, to cooperate in conducting post-armed conflict environmental assessments and adopting remedial measures'.

THE MISUSE OF ENVIRONMENTAL PROTECTION

However, those advocating for area-based protection in areas affected by armed conflicts should be aware of its potential dark sides. To begin with, there could be increasingly forceful responses that deploy militarised techniques to ensure that protected areas and their resources are not used to further the military effort. This militarisation may, in turn, compound the uncontrolled circulation of arms in areas that are sensitive, both from a conservationist and a security perspective. The recently reported incident of armed eco-guards, tasked with protecting wildlife in the Democratic Republic of the Congo, beating up and intimidating hundreds of Baka people living deep in the rainforest attests to the dangers of increased militarisation.[11]

The final outcome might be a model of militarised conservation, which has been characterised as fundamentally unjust because it covers specifically chosen areas and/or species and is not at all concerned with addressing the root causes of poaching and trafficking.[12] In other words, it treats area-based protection and conservation as the panacea that tackles the symptoms, namely poaching and trafficking, but fails to engage with the 'much deeper and complex structural contexts' underlying these practices.[12]

This model of conservation has been highlighted as leaning towards 'war by conservation', a move away from the previous model of war for conservation,[13] which approach was driven by the idea that wildlife is under threat and therefore using force was justified. In contrast, in the current war by conservation model, environmental protection and conservation objectives become increasingly securitised, as they intermingle with global security concerns[13] to such an extent that it becomes increasingly difficult to distinguish between them.

Moreover, the designation of protected sites, zones or 'areas of major environmental importance' (the term used by the ILC in its DPs) can also be abused when used to exclude the local community, especially following a 'fortress conservation' model of exclusion, as has been recently reported with respect to Israel's announcement of seven nature reserves in the West Bank.[14] Given that more than a third of the proposed location of these nature reserves reportedly lies on private land owned by Palestinians, the proposed designations may restrict Palestinians' access to their own property.

PROCEEDING WITH CAUTION

Area-defined environmental protection carries great potential. Even though the ILC DPs do not form part of existing international law at the moment – they will be finalised in the summer of 2021 – emerging trends are pointing to the recognition of an IHL rule affording special protection to 'areas of major environmental importance'. In any event, place-based environmental protection could already be undertaken using multilateral (environmental) agreements, on the understanding that their applicability does not cease during armed conflicts. Nevertheless, the promise of protected zones carries with it some perils, namely the establishment of fortress conservation and increased militarisation. For all these reasons, the international community should proceed with caution in this domain. ES

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Conceptual site models to support environmental management of training areas

Ole Feurer, Tracey Temple and **Melissa Ladyman** describe how this form of mapping supports the prevention, mitigation and remediation of ammunition-related contamination on military ranges.

The contamination of land and water by energetic materials (explosive fillers and propellants) has become a considerable environmental problem worldwide.[1,2] For example, 70 years after the Second World War, Germany has approximately 750 former explosive and ammunition factory sites that cover a total area of 10,000 km^3 and are registered as contaminated land.[3] Other sources estimate that up to 3,200 sites in Germany require remediation.[4] The main issue with explosive facilities and military training areas is the possible contamination of natural resources, which may in turn lead to uncontrolled operational and reputational risks for ammunition producers and military users alike.[5,6]

FEATURE

Unfortunately, the financial costs of the remediation of areas polluted by unexploded ordnance and ammunition-related waste are high. It is estimated that the clearance of unexploded ordnance at 1,976 closed military sites in the USA, for example, may cost US$15–140 billion, not including the subsequent remediation of the environmental contamination.[7] Increasingly stringent legal obligations can also make the prevention of environmental pollution by materials and substances associated with military firepower very expensive.[6,8,9,10]

SOURCES, PATHWAYS AND RECEPTORS

For an environmental impact to occur, an entity of monetary, cultural, ecological or health-related value must be negatively affected by a pollutant released to the environment.[1] A pollutant will only reach a receptor if it is transported through a pathway (e.g., water, soil or air). This is referred to as the 'pollutant linkage' or 'source–pathway–receptor' (SPR) model[11,12] (see **Figure 1**). By understanding the pollutant linkages in the area of interest, effective mitigation and remediation can be implemented.

To manage the environmental impact of explosive use at military ranges, it is necessary to identify the source

▲ **Figure 1. A generic pollutant linkage model showing the way that sources, pathways and receptors are linked.**

and quantity of contamination and how it affects the environment. A simple approach is to construct a conceptual site map to capture the likely pollutant linkages, containing, for example: details of the contamination source, vulnerable receptors and the pathway mechanisms.

SOURCES AND TYPES OF CONTAMINATION

Military training ranges are essential for armed forces to conduct live-firing training, which produces contamination by explosives from weapon systems ranging from small arms and hand grenades to artillery, rocket and missile launchers, and tank cannons.[13] Other impacts include cratering and the degradation of the terrain by heavy vehicles, leakage of fuel and lubricants, and buried or abandoned waste and equipment associated with the accommodation of troops.[2,8]

Most chemical contamination is found at the firing positions and the impact areas, while the entire range and surrounding areas may be impacted by other types of pollution, such as noise and ground vibration.[9] At the firing positions, contamination from propulsion systems includes heavy metals, deposition of propellant due to incomplete combustion, and burnt additives. At impact areas, there are generally two contamination processes. The first is when munitions function as designed, with the high-order detonation of warheads (the desired outcome) leaving only minimal explosive residue on the soil surface along with structural material such as metal fragments.[11,13] The second type of contamination is from unexploded ordnance, when high-explosive and pyrotechnic warheads fail to function as designed and remain either intact or damaged in the target area. Different types of ammunition that entirely fail to function (duds) degrade over time and gradually leak energetic materials into the surrounding environment. Explosive warheads that do not fully detonate (low-order detonation) crack and spread the explosive fill over a wider area, leading to environmental impact and contamination.[14]

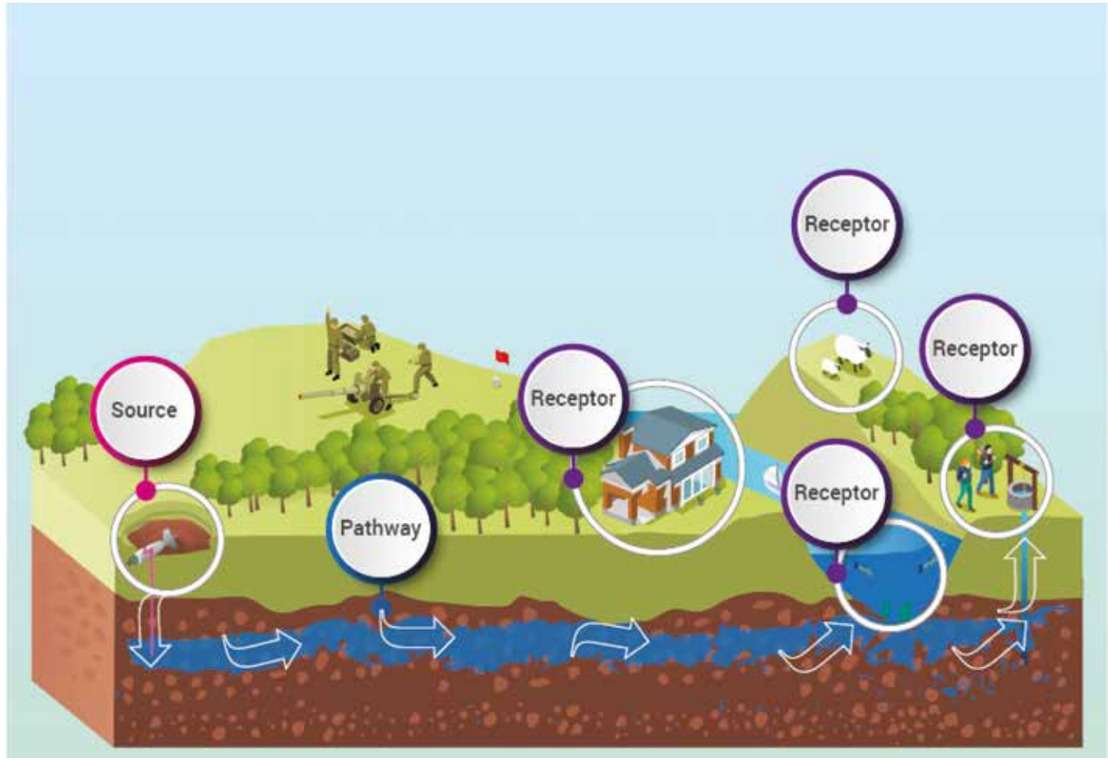
TYPES OF IMPACT

Some impacts on a receptor, such as the poisoning of cattle due to eating contaminated grass, may be obvious, while others show their causality only after detailed investigation. For example, macroinvertebrates dying from water contamination may have a mortality effect on the bird population due to a shortage of insects to feed on; the carbon soot of a propellant burn site may incrementally stain the walls of a centuries-old church; the discolouration of a watercourse exiting a training range may lead to a reputational damage irrespective of its toxicity.

The adverse effect on a receptor by a contaminant is dependent on a variety of additional factors such as:

- Mobility in the environment (solubility, adsorption to soil particles);
- Toxicity to the receptor of interest;
- Persistence of the contaminant and its fate in the environment (bioconcentration);
- Accumulation along the food chain (biomagnification); and
- Metabolisation and degradation (biotransformation).[5,6]

The concept of environmental impact is limited to where there is a known linkage between a pollutant and a receptor, and hence is limited to the knowledge and experience of the model developer and the current state of the art. Nevertheless, the pollutant linkage model has a strong and legitimate role in the understanding of environmental pollution and is the only effective and applicable model available.



▲ **Figure 2. Conceptual site map showing the source–pathway–receptor from unexploded ordnance to various receptors.[6] (© IOP Publishing Ltd 2020)**

CREATING A CONCEPTUAL SITE MAP

Information relevant to the circumstances can be added to pollutant linkages to create conceptual site maps. In order to undertake preventive or curative management decisions, the physicochemical interactions of contaminants with the local environment must be fully understood. The established standard requires that all the source–pathway–receptor linkages that exist or may arise within the site of interest are mapped and investigated. The result is a conceptual site model, based on historical data, maps, pictures, interviews, existing range reports and site observations. It will establish factors such as:

- Geology and hydrogeology of the site, including surface water bodies and subsurface aquifers;
- Topsoil characteristics, including vegetation cover and organic biomass;
- Meteorological parameters, including prevailing wind and annual precipitation;
- Identification of all contamination sources and their nature, location and extent;
- Identification of all possible pathways linking source and receptors; and
- Identification of all possible receptors within *and* around the site, including flora and fauna, protected species and habitats, sites of specific scientific interest, human health and safety, and cultural heritage.

These maps need to be developed before undertaking any practical identification work (e.g. air, land and water sampling on the site) to ensure a thorough understanding of the environment, or to highlight missing information about the site, such as the activities taking place. When undertaking an evaluation, the source is usually evident as it is directly related to activities on the range. Receptors can be identified through observation of the site, particularly where there have been historic contamination incidents. However, understanding the pathways is more complex, as they depend on how the contaminants enter the environment and the physical and chemical interactions between the contaminants and the air, land or water. Understanding these pathways often requires a combination of on-site sampling, simulated experiments and predictive modelling. **Figure 2** is an example of a conceptual site model, showing an unexploded munition as the source of contamination and clear pathways of groundwater transport with a variety of environmental receptors that could be affected.

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ENVIRONMENTAL MANAGEMENT OPTIONS

The first and most cost-effective option is to prevent any pollution from occurring, irrespective of its perceived impact potential (prevention) – a requirement that is difficult to meet given the continued need for live-firing training with energetic materials and weaponry. The second option is to reduce the environmental impact by weakening the pollutant linkage, either by making the receptor more resilient (by, for example, improving communication of live-fire activities taking place) or by reducing the amount of contamination input into the system through the use of training rounds with reduced quantities of energetic material (mitigation). The third option is to locate and remove the contaminant from the environment and restore it to its original state as far as possible (remediation).

Where applicable and possible, computational models can be used to predict and quantify the severity of the interactions identified. For instance, the program GSSHA allows the prediction of the watershed of a perimeter[15] and computational modelling allows the estimation of the retention of specific explosives in different soils. Based on the conceptual site map, an evidence-based decision framework will lead to a formal environmental risk assessment.[16] Technical investigations such as sampling and analysis of groundwater, soil and biota or recording of noise levels are used to support or reject established contamination hypotheses. A structured risk assessment matrix allows decision-makers to identify and prioritise both apparent and ambiguous business risks that may jeopardise the continuity of operations.

Environmental concerns constitute only one of many requirements involved in running a military training range. Historically, operational needs dictated the layout and usage pattern of training ranges. In most cases, the environmental rehabilitation of government land will be a reactive action that is triggered either by a change in land use or when a pollutant linkage has led to an unacceptable environmental impact on receptors of concern. However, by integrating environmental management as early as possible into land-use planning, the overall life cycle becomes more cost effective and better adaptable to changing needs and legislative constraints.

Live-firing training is an essential requirement for defence forces, which inevitably leads to environmental contamination. However, if there is a good understanding of these areas from an environmental perspective, it is possible to undertake these military activities with suitable mitigation and management in place.

Augmenting a conceptual site map with details of relevant pollutant linkages and the key environmental features of the training area enables suitable and effective management and mitigation. These approaches should be developed as early as possible with cost-effective options and opportunities for through-life review. ES

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ANALYSIS

Post-conflict and post-disaster waste management

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Thorsten Kallnischkies discusses the challenges of dealing with the aftermath of destructive events.

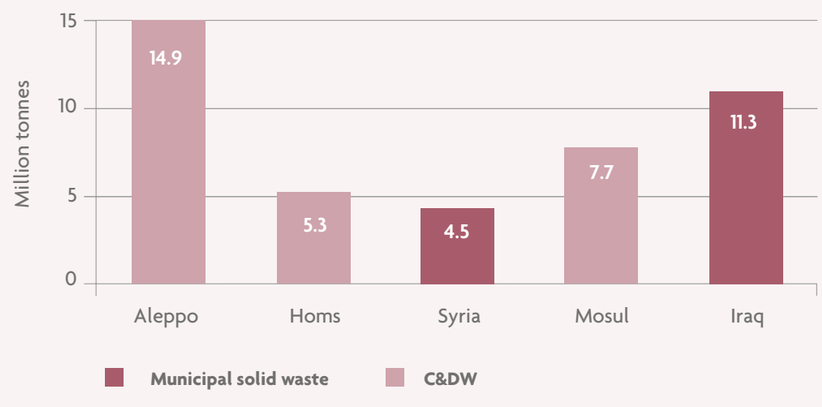
Waste management after disasters and conflicts is usually outside the focus of public attention, and often a blind spot in post-conflict/post-disaster (PC/PD) early recovery and reconstruction. Critical infrastructure and means of transport are often destroyed or heavily damaged in a conflict or disaster, so in the first few days, the initial cleanup work often consists of armed forces or civil protection agencies trying to make critical infrastructure accessible and functional using heavy equipment. These early responders dominate the news during these first days, but although the attention of the news media dwindles, the cleanup work continues for months and years afterwards.

Disasters usually take minutes, hours or just a few days to produce a huge amount of waste; conflicts can continue to do so for months and years. Both post-conflict and post-disaster waste tends to overwhelm city administrations and municipalities by its sheer quantity. Estimated post-conflict waste amounts in Aleppo, Syria are three times the weight of the annual municipal solid waste production in Syria (see **Figure 1**).

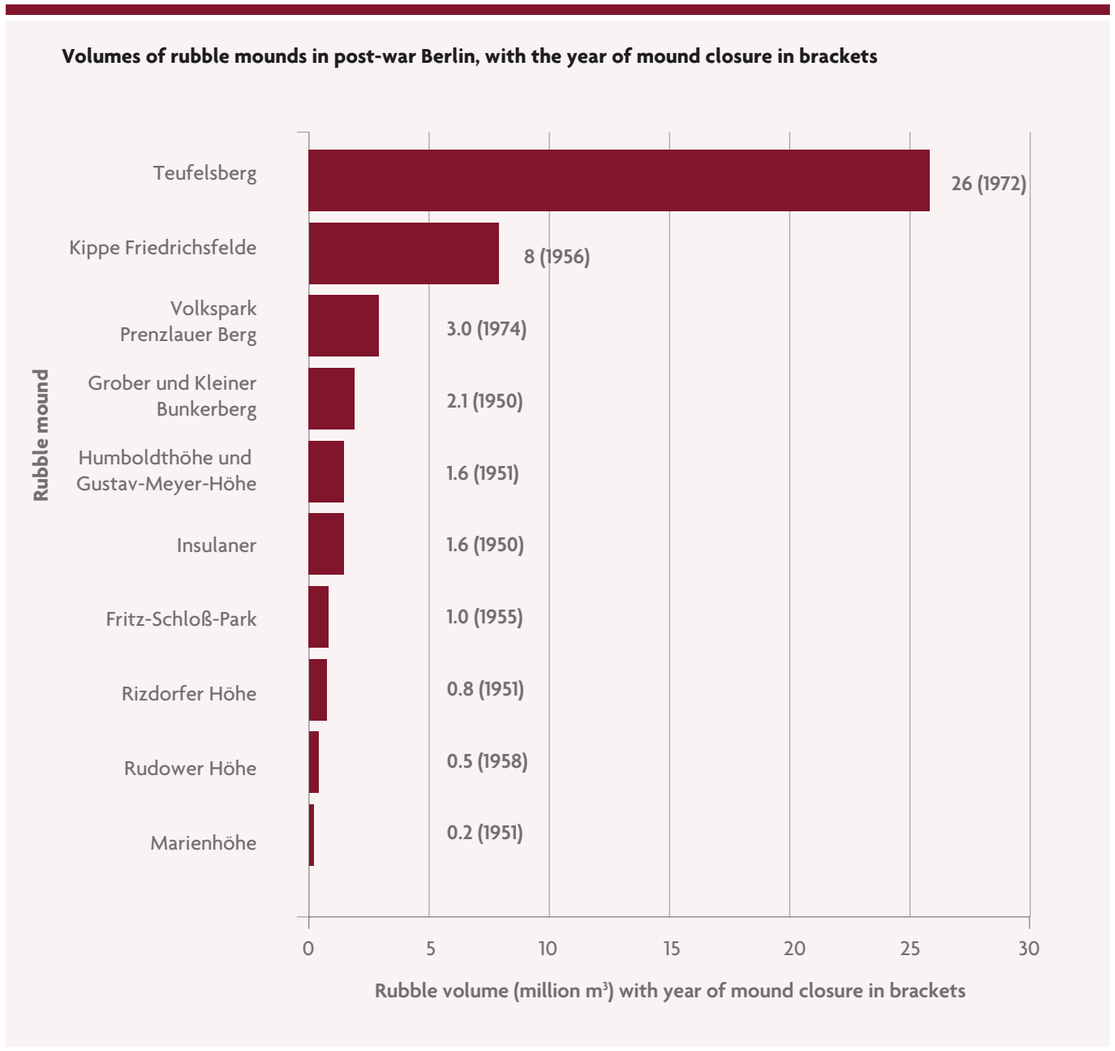
DEFINING PC/PD WASTE

Technical jargon in waste management is often complex, which probably is one of the major communication obstacles for PC/PD waste management. Many first response, early recovery and development actors use the term 'debris' indiscriminately to cover a wide variety of wastes, which frequently leads to confusion and misunderstandings. Since the term 'debris' is ambiguous, its use should be avoided or at least restricted to the material that is initially cleared away by armed forces, civil protection, fire brigades, etc to provide access to critical infrastructure.

Comparison of amounts of post-conflict construction and demolition waste (C&DW) in Aleppo, Homs and Mosul compared to annual amounts of municipal solid waste generated in Syria and Iraq



▲ **Figure 1. Amounts of C&DW generated during recent conflicts in Aleppo, Homs and Mosul are greater than or similar to annual amounts of municipal solid waste generated in Syria and Iraq.[1,2,3,4,5] (© Thorsten Kallnischkies)**



▲ **Figure 2. Volumes of rubble mounds in post-war Berlin.[8] (© Thorsten Kallnischkies)**

'Disaster waste' is an established technical term in post-disaster recovery. It can consist of a wide range of materials, from sediments after floods to rock and mud after landslides, and wood and organic material. Medical waste, human body parts, dead animals, damaged medicines and food items can also be present, as can hazardous substances, hazardous waste (including asbestos), and construction and demolition waste (C&DW). 'Post-conflict waste' follows the general definition of disaster waste, but as it is mostly caused by the bombing and shelling of buildings, the major component is usually C&DW, and there is a significant likelihood of unexploded ordinance (UXO) being present in ruins.

The composition of the waste generated during conflicts and disasters closely matches the definitions in the EU List of Wastes,[6] which is very useful as a tool in PC/PD waste management. In addition, in terms of quantity, most of the 'debris' generated during a conflict would fall under the EU List of Wastes' definition of construction and demolition waste.

LESSONS FROM RECENT HISTORY

Despite seven decades of experience in modern PC/PD management, methods have changed little since the Second World War, even though technology has improved, and removing PC/PD waste has always been

▲ **Figure 3. Rubble classifier in Hamburg (1948), which processed 200 t/h. (© SZ Photo/Süddeutsche Zeitung Photo)**

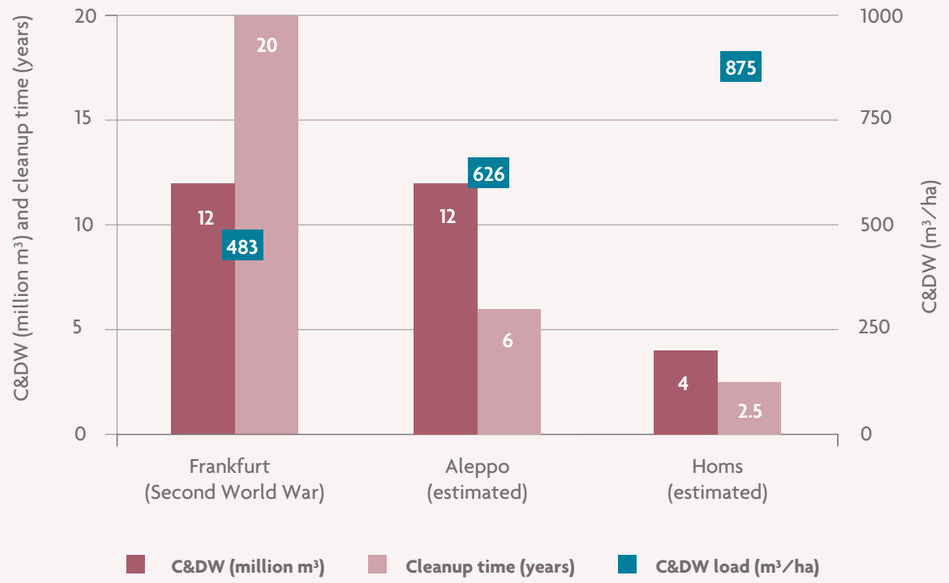
a tedious process that can take many years. Post-war Germany is an example: the total volume of C&DW in Germany at the end of the Second World War amounted to more than 200 million m³, and its capital Berlin had to cope with 70 million m³ alone.[7] In post-war Berlin, approximately 45 million m³ (more than 60 per cent) of C&DW was deposited in 14 rubble mounds. The last rubble mound in Berlin was cleared in 1974, completing C&DW operations 29 years after the end of the Second World War (see **Figure 2**).

Immediately after the end of the Second World War, street cleanups and materials recovery was mainly done manually due to the lack of heavy equipment. The cleanups resembled the modern-day practice of emergency employment (Cash for Work). German legend has it that the bulk of the 200 million m³ of post-war C&DW was removed by the *Trümmerfrauen* ('ruin or rubble women') although historic documentation suggests that more than 90 per cent was removed by companies using heavy equipment and plant (see **Figure 3**).

In Frankfurt, immediately after the Second World War, the Trümmerverwertungsgesellschaft (TVG, the Rubble Recycling Association) was founded as a non-profit public–private partnership between the city, two major construction companies and a major process technology company. They constructed a large rubble processing plant, and between 1945 and 1964, TVG removed and processed approximately 2,000 m³ of C&DW per day and recovered a total of 29,000 t. Each year they produced an average of 200,000 m³ brick aggregate concrete, 23 million bricks, 6.6 million hollow stone blocks and 0.3 million m² of roofing tiles.[9]

Anecdotal reports indicate that similar operations have been carried out successfully in Iraq, although figures were not available at the time of writing. Comparing post-conflict C&DW data and activities from post-war Germany with Syria and Iraq gives an estimate of likely clean-up time frames. In recent disasters and conflicts, the time frames for cleanup and reconstruction appear overly optimistic. While the total cleanup time was 29 years for Berlin and 20 years for Frankfurt, cleanup times for Aleppo, Syria have been estimated as six years, even though the quantity of C&DW is similar to Frankfurt's. The cleanup time frames for Aleppo and Homs appear to be ambitious, taking into account the limited logistic resources, much higher area load of C&DW (see **Figure 4**), and the need for additional resources to manage hazardous waste.

Comparison of construction and demolition waste (C&DW) quantities, loads and cleanup times for post-war Frankfurt with estimated data for Aleppo and Homs



▲ **Figure 4. Comparison of C&DW quantities (million m³), loads (m³/ha) and cleanup times.[17] Despite the similar quantities of C&DW in Aleppo and post-war Frankfurt, cleanup time for Aleppo has been estimated at an ambitious six years. (© Thorsten Kallnischkies)**

UNINTENDED CONSEQUENCES

When estimating reconstruction time frames, governments, donors and the aid community should take into account that their activities may have negative economic side effects. This can become significant with shorter estimated time frames for reconstruction, since short-term demand can drive up the prices of construction materials and transport. After a conflict or disaster, local economies are fragile, and the consequences of PC/PD actions are not always visible.

For example, after super-typhoon Hayian in the Philippines in 2013, donor organisations hired a huge amount of transport capacity. This increased transport costs drastically, causing economic difficulties for the many local families that specialised in cardboard and paper recycling in the affected areas. In the same way, importing construction materials for reconstruction purposes can cause local production or recycling markets to collapse, and can leave potential resources unused (such as recycled aggregate and C&DW).

DANGEROUS SUBSTANCES

Along with the households that usually store small quantities of household chemicals and occasionally domestic heating oils, businesses and industries typically handle and store large quantities of hazardous and potentially hazardous substances (fuels, organic solvents, inorganic salts, agrochemicals, etc). Normally they do not constitute any significant risk, provided they are stored, handled and used properly. However, where infrastructure and industry are destroyed during a disaster, or targeted or unintentionally attacked during conflicts (see **Figure 5**), the uncontrolled release and leakage of hazardous substances is likely, with the potential for generating hazardous waste, large-scale environmental contamination and health hazards to neighbourhoods or the cleanup workers.

Asbestos is frequently found as a construction material, commonly in corrugated asbestos cement roofing sheets. While it is intact, this material does not constitute any significant risk since the fibres are firmly bound inside the cement. However, health risks arise if the material starts to crumble, typically when it is not properly dismantled and disposed of. Common malpractices causing the release of asbestos fibres and health risks are: breaking up asbestos cement sheets during demolition, using asbestos-contaminated rubble for filling potholes and as general infill, and even attempting to burn it in open fires.

Although inherently difficult for regions affected by conflicts or disasters, the preferred method should be manual removal of asbestos from buildings (deconstruction) by trained workers under certified supervisors. Removal and handling of asbestos by untrained workers and volunteers has frequently been observed, without proper personal protective equipment (PPE) and respiratory protective equipment (RPE), with activities often carried out by small non-governmental organisations (NGOs). So both supervisors and workers need to be trained to build in-country capacity, and NGOs active in PC/PD reconstruction need to be encouraged to build asbestos awareness and capacities in supervising staff, to minimise the risk of exposure to people and the risk of later legal claims against the employing organisations.

After super-typhoon Hayian in the Philippines in 2013, some NGOs employed international volunteers alongside local workers to demolish private houses. Due to lack of knowledge about the destroyed asbestos cement roofing sheets in the ruins, no proper PPE or RPE was used, putting workers and volunteers at risk. The United Nations Development Programme (UNDP) provided asbestos awareness trainings to NGOs shortly after this fact was discovered.

"Why do we have to buy expensive protective boots for the workers? Medical attention for workers is free!"

Representative of an aid agency to the author

After conflicts and disasters, emergency employment (Cash for Work, Food for Work) is a way of providing the affected population with income or food. In these cases, workers need to be equipped with appropriate PPE and RPE under appropriate working practices. However, in low-income countries in particular, PPE costs per worker can be higher than the workers' daily wages. Costs for PPE depend on quality, availability of items and duration of terms per worker.

In most industrialised countries, deconstruction (the selective removal of hazardous construction materials; see **Figure 6**) is carried out before demolition takes place. Dust suppression on demolition sites may reduce the public health risk if applied properly. For many PC/PD

▲ **Figure 5. Bomb damage to a glass factory in Lebanon in 2006, which exposed several dozen tonnes of soda ash. This constituted a hazard to cleanup workers and the neighbourhood. (© Thorsten Kallnischkies)**

▲ **Figure 6. Selective deconstruction (windows, asbestos, etc) of a school prior to demolition. (© Thorsten Kallnischkies)**

"Despite everyone saying debris is a priority, nobody wants to pay. Everyone wants to reconstruct. The World Bank and IDB [International Development Bank] want to build. The EU wants to build. But before building we have to clean up. But no one wants to pay for that."[10]

Gabriel Verret, Executive Director of the Interim Haiti Recovery Commission (IHRC) (2013)

situations, demolishing buildings by implosion, i.e. using explosives, has become common. This method can cause huge clouds of dust that may include asbestos and other hazardous materials. The use of high-reach demolition excavators with targeted dust suppression is often the safer alternative, even if the process takes longer. Public health and safety concerns should usually outweigh strict time plans.

Although explosive remnants of war (ERW) are usually not considered to be PC/PD waste, their potential presence after conflicts requires explosive ordnance disposal (EOD) experts to clear PC/PD waste and clarify potential risks from toxic explosive residues. Specialised machinery (explosion protection) with trained operators is also required, and all of this can increase costs significantly.

"Over two years since retaking most of Anbar's shattered cities [...], rubble continues to be a major obstacle for tens of thousands of displaced persons to regain their homes, and restart their lives and businesses."[11]

Mustapha Arsan, Deputy Governor of Anbar Governorate, Iraq (2018)

THE CHALLENGE OF FUNDING

The lack of funding for demolition, C&DW and PC/PD waste management after disasters and conflicts is generally a severe obstacle to reconstruction. A pattern seems to emerge in reconstruction projects: donors are willing to fund the reconstruction of schools and kindergartens, hospitals and administrative buildings, but have little awareness of the importance of clearing away rubble and hazardous materials before construction can start. Even though this statement may be supported anecdotally rather than by robust statistics, the term 'debris removal' has not raised much donor interest in the past, as some quotes scattered over this page from the humanitarian community show.

In urban brownfield redevelopment projects in industrialised countries, the demolition of derelict buildings is an important element of cost calculations. Brownfield redevelopment includes the need for pre-construction assessments (geotechnical and land contamination investigations), demolition, land remediation and land levies, and these should be given with the same importance as construction costs. Experience in brownfield redevelopment projects on former Russian forces' military facilities in Germany shows that demolition and decontamination costs can be more than 20 per cent of the total redevelopment costs in brownfield redevelopment projects.

"We need to replace the destroyed cities with better things, to redesign the German cities as a whole. [...] There is an opportunity to eradicate past mistakes, to create better human living and working conditions for the future."[14]

Dr Kurt Blaum, former mayor of Frankfurt, 1945

So why does C&DW management in PC/PD situations appear to be unattractive to donors? Some of the possible reasons may be lack of donor awareness about the links between demolition, C&DW management and post-conflict and post-disaster reconstruction; the fact that C&DW management does not promote donor visibility; or the assumption that is has been taken care of by other actors.

The application of the Build Back Better principle in reconstruction must include the removal of C&DW and the demolition of ruins, because poor and unplanned disposal can cause environmental damage – from habitat loss to contamination of drinking water and agricultural land. Uncoordinated dumping of post-conflict C&DW into dry river beds, as documented in and around Mosul, Iraq[12] and Khiyam, Lebanon,[13] can cause increased flood risks upstream and environmental pollution downstream. Well-separated C&DW is a valuable resource for secondary construction materials (concrete and brick aggregate), recycling (metals), etc.

CONCLUSIONS

'Debris' is an umbrella term for the different waste types that accrue during and after conflicts and disasters. 'Debris management' is often excluded in donor funding for reconstruction for a number of possible reasons, but keeping the responsibility for and funding of 'debris' clearance and demolition separate can inhibit PC/PD reconstruction activities.

PC/PD waste management, demolition and reconstruction should be viewed holistically as parts of reconstruction. Brownfield redevelopment in industrialised countries serves as an example of how reconstruction after conflicts and disasters could be streamlined. Donors funding PC/PD reconstruction should consider including 10–20 per cent of their reconstruction budget for demolition and management of C&DW, as has been standard in brownfield redevelopment projects internationally for decades. If in PC/PD reconstruction the demolition and site clearance requirements and costs are not met, there is the risk of delay in reconstruction and long-term environmental harm due to the mismanagement of waste.

No actor should neglect the responsibility of protecting the environment. Even in a PC/PD situation, actors from industrialised countries in particular should aim to operate to the best regulations possible. Most donors and governments expect to have highest international standards (gold standards) applied to activities they are funding. The EU Construction & Demolition Waste Management Protocol[15] and the EU List of Wastes provide excellent guidance for coping with PC/PD waste, and especially with C&DW. ES

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TECHNICAL

Rapid environmental assessments in conflict and post-conflict areas

C. Kelly explains the techniques used to maximise data gathering to integrate the environment into post-conflict recovery.

Understanding the nature of the damage to an environment that may have occurred during a conflict, and the environment-related challenges arising after a conflict, is critical to the successful recovery from a conflict. This article looks at approaches that can be used to quickly assess environmental impacts during and after conflict. Assessment results can be used, among other things, to:

- Document possible crimes, including those related to the way fighting took place or to concurrent resource extraction;
- Identify sites with hazardous materials, such as unexploded ordnance;
- Quantify losses in ecosystem services;
- Define environmentally sustainable rebuilding options and opportunities;
- Quantify the direct, indirect and cumulative impacts of the conflict and rebuilding process; and
- Identify where and how conflict recovery efforts can improve or reinforce environmental conditions and services.

ASSESSING ENVIRONMENTAL IMPACTS

Normal environmental impact assessments involve a deliberative, highly structured, detailed, transparent,

exhaustive, comprehensive and consultative process of defining the nature and extent of positive and negative impacts. The gold standards for normal impact assessments are based on whether the:

- Impact assessment process stands up to a legal challenge; and
- Results framing positive and negative impacts are acceptable to at least a large part of the potentially affected population.

These criteria can be hard to achieve during or after conflicts. The simple task of assessing water quality, for example, can be complicated if all records have been destroyed during fighting, leaving no baseline, and water sources are in the middle of active fighting.

Public consultations can be difficult. There are significant personal risks to bring people together into a specific place in a combat zone for consultations during a conflict (see **Figure 1**). After the conflict, when populations are moving back to their homes or to new locations, it can be hard to organise meetings or assure meetings are representative of the impacted populations.

Further, normal environmental impact assessments are based on reviewing the impact of a project on the environment and vice versa.[1] During a conflict, there may be no formal project on which to base the assessment. Warring parties are unlikely to disclose short- and long-term plans in support of an assessment process. Post-conflict projects are often development quickly, with details not well defined until implementation has started.[2]

It is possible to use a scenario-based approach to impact assessments: it involves developing several scenarios of the progress and outcome of the conflict, with each scenario treated as a separate project. The contrasting impacts are enumerated and assessed.

Apart from the time and effort needed to develop detailed, project-like scenarios, this approach does carry the risk of prolonging a conflict by defining advantages to one side of the conflict or the other. It can also be seen as aligning an assessment with one party or the other to the conflict, a hazardous outcome for the assessors.

CONFLICT-RELATED ASSESSMENTS

Viable and useful assessments can be completed during or after a conflict, but the approach and expected outcomes need to change from those of a normal environmental impact assessment in four ways. First, the assessment process should not focus on the conclusive results seen with a normal environmental impact assessment. The focus should be on results that are good enough[3] for the issues that need to be addressed.

▲ **Figure 1. Public consultations can be difficult during a conflict as bringing together large groups of people in one place can make them a target for attack. (© REA Project)**

Good enough does not mean poor or sloppy. The intent of good enough is to provide results that are (1) as good as can be achieved under the conditions where the assessment takes place and (2) relevant to the programmatic or operational decisions to be taken at the time the assessment is completed. This implies a tight link between operational needs and the work of an assessment as well as a need for updating assessments as operational requirements change.

Second, the assessment should focus on documenting what is known using available information while accepting that historical data or baselines may not be available. At the same time, the lack of data or baselines should be flagged as a critical issue going forward.

Third, the assessment should recognise and incorporate a necessary trade-off between accuracy, timeliness and utility into the data collection and analysis. A highly accurate report may not be completed in time to be useful. A report that is completed too quickly may be so inaccurate as to lead to bad, and life-threatening, decisions.

The balance between accuracy, timeliness and utility is very context specific, so it has to be based on what is good enough for decisions to be made at the time of the assessment. Possible inaccuracies incorporated into an assessment need to be flagged so that the limitations of the assessment process and results are clear and can be considered in using the results.

Fourth, consultations with affected populations, and their neighbours, should take place if at all possible. The humanitarian sector has developed a range of approaches to make consultations happen, such as those compiled by the Active Learning Network for Accountability and Performance (ALNAP). These should be exploited as conditions permit.

PRIORITISING ISSUES

Realistically, the possibilities for consultations may be limited or non-existent during conflict. Considering this challenge, a surrogate prioritisation process that assumes specific concerns in the affected populations can be used. This process is based on ranking the issues identified in an assessment by whether there is:

- An immediate threat to the lives of the affected populations;
- A threat to the health, welfare and livelihoods of the affected populations that is not immediately life threatening; and
- A threat to the environment but no immediate threat to life, or to health, welfare or livelihoods.[4]

This hierarchy presumes that if actual consultations were to take place with affected populations:

- Saving lives would be the top priority;
- Preserving health, welfare and livelihoods the second priority; and
- Addressing and reducing threats to the larger environment the third priority.

The hierarchy is intentionally simplistic, to aid in speeding up an assessment. But it is also realistic in the way that affected populations make decisions about where to focus their time, resources and efforts during and following a conflict.

CONFLICT-FOCUSED ASSESSMENT

As noted, formal environmental impact assessment procedures are difficult or impossible to follow during or following a conflict. However, three methods adapted to the conflict context can be used to assess environmental impacts with varying levels of specificity, as summarised below.

A strategic environmental assessment (SEA) can consider the broad, thematic and programmatic impacts of a conflict or post-conflict recovery planning.[7] An SEA considers the possible major environmental impacts of broad programmatic approaches, planned sector interventions or, in the case of conflict, military activities, to identify how they may affect natural resources and the environment.

For instance, an SEA would consider the amount of water and sand needed to rebuild a war-damaged city and how these requirements would be met from available resources. An SEA generally results in a broad, strategic overview of possible negative environmental impacts and opportunities to frame more detailed planning and implementation. An SEA can be desk based, thus reducing the risks faced by the assessors, but with the trade-off of a lack of contact with the affected populations.

A rapid environmental impact assessment (REA)[4] provides, as the name implies, a rapid method to

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assess overall environmental issues arising from a conflict or post conflict that could affect planning and operations. The REA uses three modules to (1) consider the perspectives of external assistance providers, (2) consider the perspectives of the affected populations and (3) develop a synthesis and prioritisation of results. This last module uses the threat to life, threat to welfare, threat to the environment prioritisation mechanism described above.

The REA can also be desk based and focus only on the perspectives of external assistance providers.[8] But an REA provides the best results when the perspectives of the affected population are collected and analysed.

The Nexus Environmental Assessment Tool (NEAT+)[9] provides a project or activity-level screening of possible environmental issues by focusing on key sectors such as water, sanitation, shelter and food security. NEAT+ covers some of the same areas as an REA but is more specific to a location or project site. NEAT+ is commonly done in the field but can be done off site if sufficient information from the field is available.

Unlike an REA, NEAT+ does not have an element specifically for input from affected populations. However, when done in the field, NEAT+ can be completed from the perspective of the affected populations or with their input. NEAT+ uses KoBoToolbox, a free, open-source tool for mobile data collection, and the resulting data can be analysed quickly using an automated process in Excel.

Ideally, the SEA, REA and NEAT+ would be used in sequence, with:

- The SEA defining major environmental issues and opportunities;
- The REA identifying and ranking the importance of a wide range of immediate and near-term environmental challenges; and
- NEAT+ providing hands-on guidance at project sites.

However, each assessment method is valuable in itself. Any opportunity to use one or more of the methods should be pursued.

THE ISSUE OF FIELDWORK

Normal environmental impact assessments involve a considerable amount of time spent on fieldwork. The reasons for this range from collecting data on environmental conditions to multi-layered consultations with affected populations.

Activities related to field-level impact assessment are limited or impossible during a conflict. Conditions for fieldwork immediately post conflict may be only slightly better than during a conflict (e.g. due to mined roads). The rapid pace of post-conflict recovery activities may create very fluid working conditions (e.g. challenges in community consultations where a community is on the move).

Addressing the challenges of getting to, and effectively operating in, the field need to be developed for each assessment. In this process, three key points should be considered.

First, a detailed data-collection and analysis plan is critical, even when there is limited time for pre-assessment planning. As with other types of crisis, conflicts and post conflicts have an overabundance of data and information in some areas and substantial gaps in others. The collection and analysis plans should indicate data needs as defined by the assessment process, not by the data available. The plan should include how data is to be collected and analysed. This planning is also useful in defining the limits of the assessment.

Second, the availability of a tool or specific opportunity should not drive the data collection. For instance, using mobile phone polling to collect information from the conflict affected can be very attractive from the perspectives of cost and ease of use. However, because of the potential biases that may come from using this tool (e.g. mobile phone use only being possible in parts of the conflict-affected area), it is also necessary to identify and use other ways to collect information from those affected by the conflict. Always questioning how a tool will be used and what data it will generate is important to avoid significant inaccuracies in the assessment.

Third, it is vital to triangulate and confirm data, information and analysis. PAX and partners have been very successful in using remotely sensed data, official reports and information collected from conflict-affected locations to identify and validate data, information and analysis. A report by PAX on civilian oil refining in Syria is a good example of using a combination of data-collection tools and triangulating and confirming analysis.[10] The triangulation and confirmation process is also important in improving the chances that the results circulated are as accurate as possible and are not seen as supporting one particular party in the conflict.

Finally, the personnel doing an impact assessment during or after a conflict should not be put at unnecessary risk. All fieldwork, whether or not in a conflict, has risks that should be minimised to the extent possible, particularly through the use of guidance on safe operations in conflict zones[5] and institutional safety and security procedures and advice.[6]

Environmental impact assessments in conflict-affected locations can be difficult but are by no means impossible. Assessments based on the guidance in this article can successfully provide the information and analysis to support decisions that will reduce negative environmental impacts and support sustainable post-conflict recovery. Key to these results is using the assessment process to provide results that are good enough for the planning and operations critical to assisting the affected populations and environments.

ES

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Landmines and the environment – can we do better?

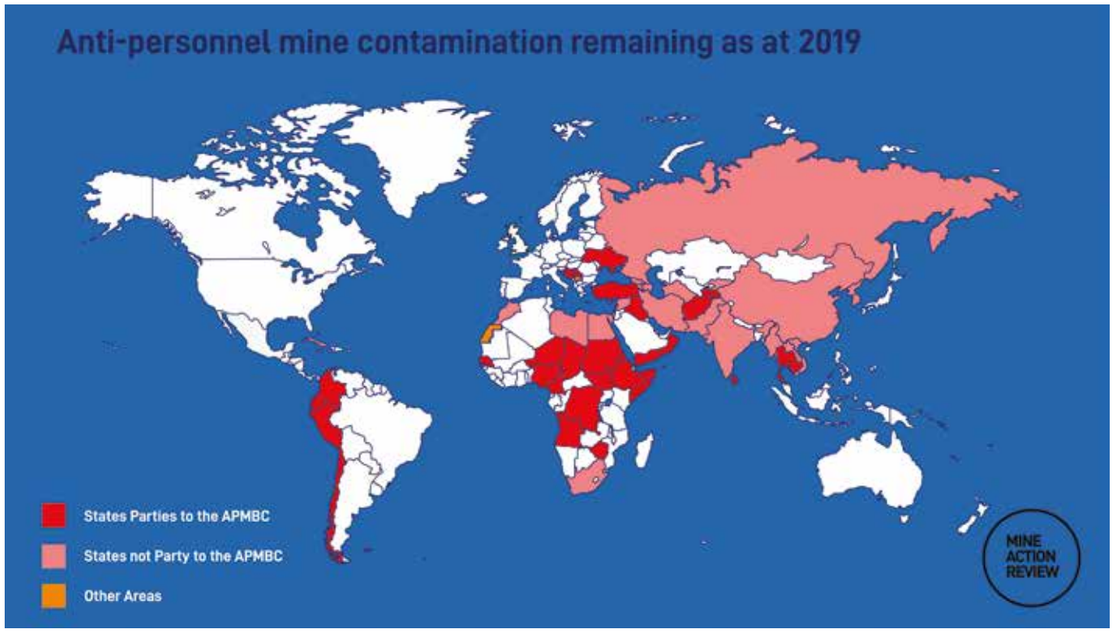
Linsey Cottrell and **Kendra Dupuy**

review the ways in which we can improve the environmental outcomes of mine clearance operations.

The late Princess Diana's involvement with the work of The HALO Trust did much to highlight the issue of anti-personnel landmines. The Anti-Personnel Mine Ban Convention is a disarmament treaty that was adopted after Princess Diana's death in 1997 and came into force in 1999.[1] The treaty includes a commitment for state parties to not develop, produce, acquire, stockpile or use anti-personnel mines and to ensure that mined areas within their territory are cleared. The treaty has been signed by more than 80 per cent of the world's countries (see **Figure 1**), but China, Russia and the USA are among those countries that have not signed.[2]

With more than 60 million people estimated to be living in areas affected by landmines,[3] and the increased use of improvised explosive devices (IEDs) in recent conflicts, the risks facing communities 20 years after the Treaty was signed are still prevalent. Explosive remnants of war (ERW) include landmines and cluster munitions (which are dropped by aircraft or fired from ground level and open mid-air to release multiple submunitions). They can remain in the ground for decades and prevent a community's safe access to land and therefore local resources (see **Figure 2**). Humanitarian demining operators remove ERW to make the area safe for people to use and include organisations such as Norwegian People's Aid (NPA), the Mines Advisory Group (MAG) and The HALO Trust. They all operate globally and have been implementing mine clearance programmes for more than 25 years.

ANALYSIS



▲ **Figure 1. Countries across the globe that are contaminated with anti-personnel mines and are party or not party to the Anti-Personnel Mine Ban Convention (APMBC). (© Mine Action Review)**

CONSEQUENCES FOR THE ENVIRONMENT

Humanitarian demining is not without risk of environmental harm, and this is acknowledged by work carried out by the United Nations Mine Action Service (UNMAS), the Geneva International Centre for Humanitarian Demining (GICHD) and mine action operators such as NPA on the development of international mine action standards. However, the current International Mine Action Standards (IMAS), developed as a framework to guide national authorities and operators alike, do not incorporate specific practical measures to minimise potential environmental impacts.

Many national authorities in countries dealing with the legacy of landmines and ERW have not yet introduced a national standard to incorporate environmental management, and many of these countries also do not always have strong environmental legislation or governance in place.

Mine clearance activities may involve the clearance of vegetation, the use and deployment of heavy machinery, the detonation or disposal of large quantities of explosives and the generation of hazardous and non-hazardous waste – all of which has the potential to result in adverse environmental effects if not properly managed. This is also true of how land is used following the clearance of landmines. Where there is a severe threat to people, from injury or death from unexploded ordnance, it can be more difficult to relay the importance and relevance of the potential environmental effects of landmine clearance, even though these may have long-term significance.

PRIORITISING THE ENVIRONMENT

In light of budgetary, logistical and sometimes ongoing security constraints, environmental management and mitigation has not always been a priority. Moves to improve this are gaining momentum within humanitarian demining work, as well as action across other the wider humanitarian aid sector. At this year's annual National Mine Action Director's meeting at the UN,[4] the environment was highlighted and there were positive discussions about what is already being done and what more can be done to improve environmental performance across the sector.

For the wider humanitarian sector, the UN established the Environment and Humanitarian Action (EHA) network in 2014,[5] with the aim of promoting environmentally responsible humanitarian programmes. Organisations such as the International Committee of the Red Cross have been working to embed environmental practices in their operations and have already launched a Green Response initiative.[6] However, research in 2019–20 by students from the London School of Economics suggests that many humanitarian organisations have yet to develop and implement environmental policies for their humanitarian aid and field work.[7] Factors limiting progress include the availability of resources, expertise and funding.

Worst-hit countries for landmines[13]

Afghanistan | Bosnia and Herzegovina | Cambodia | Iraq | Yemen

4,600,000

Number of anti-personnel landmines cleared 1998–2018[12]

At least **6,897**

people killed or injured by anti-personnel mines in 2018 alone[14]

Worst-hit countries for cluster munitions[13]

Lao People's Democratic Republic | Vietnam | Cambodia | Iraq | Lebanon

2,800 km²

Area of land cleared 1998–2018[12]

▲ **Figure 2. Key facts and figures for landmine contamination across the globe.**

REGIONAL CHALLENGES

The potential environmental impacts relating to demining activities, and their significance, varies with the region affected and the specific legacy of ERW involved. In Libya, for example, the long history of armed conflict has left numerous large ammunition stockpiles, landmines and unexploded ordnance. Missiles procured by the former Libyan regime also used highly hazardous liquid propellent fuels (such as unsymmetrical dimethylhydrazine) and chemical oxidisers (such as red fuming nitric acid), which pose significant safety and environmental risks. Appropriate handling and disposal of these hazardous liquids during mine action, in an environmentally acceptable manner, is critical to ensure protection for the demining teams, local populations and the wider environment, especially given Libya's high reliance on groundwater resources.

Cambodia is regarded as one of the countries most heavily contaminated by cluster munitions (see **Figures 3** and **4**), the result of heavy bombing by the USA during the USA–Vietnam War and its targeting of the Viet Cong's supply lines. The UN Development Programme (UNDP) completed an environmental and social impact assessment in 2016,[8] which highlighted the important role of the clearance in supporting economic growth for the country. However, Cambodia has also experienced high rates of deforestation, with an estimated 27 per cent decline in tree cover since 2000.[9]

One of the areas in Cambodia most heavily contaminated by landmines is the K5 mine belt, located in the north-west along the Cambodian–Thai border. The K5 belt was laid with mines in the mid-1980s as part of a Cambodian defence plan to prevent the Khmer Rouge militia returning to Cambodia from Thailand. Creating the K5 belt required the clearing of tropical forest to create an open space approximately 500 m wide and 700 km in length. After almost 40 years, the tropical undergrowth has re-established, so areas like the K5 mine belt are regarded as 'crucial to maintaining biological corridors between transboundary protected areas and remain some of the last forested tracts in areas of high agricultural encroachment and rapid deforestation'.[8]

Internal migration, increased settlement and greater demand for agricultural land have already accelerated rates of deforestation close to the Cambodian–Thai border and K5 mine belt. People in low-income communities often have little choice other than to risk their lives to earn a living from land known or suspected to be contaminated by landmines. With people prepared to take such risks by either cultivating or foraging within mine-contaminated land or forest, demining operations are critical to protect local people. The clearance of mines and release of land could, however, lead to other unintended environmental consequences by improving access to forests and potentially increasing deforestation rates.

Countries such as Angola, Colombia, Myanmar and Vietnam, where humanitarian demining is taking place, have also experienced high rates of deforestation in recent years. Long-term planning is required to ensure that demining operations do not attract people and economic development into areas that were previously sparsely populated, as this would potentially increase deforestation and vegetation clearance and adversely affect local biodiversity in post-clearance areas.

Humanitarian demining in Colombia is often cited as an example of good environmental practice, with the Colombian Mine Action Authority (Oficina del Alto Comisionado para la Paz – Descontamina Colombia [OACP-DC]) and the Swiss Foundation for Mine Action (FSD) working together to develop tools and specific environmental advice. This is especially important for a country that is so rich in biodiversity but suffers from the threats of deforestation and illegal logging. The Colombian government stipulates a requirement for compensatory planting in areas where vegetation clearance cannot be avoided, reduced or mitigated during demining work but, to date, there is no guidance on what is meant by compensatory planting or how it should be done.

Tree and other compensatory planting are not normal day-to-day activities for demining operators or their area of expertise. Where planting is needed or

▲ **Figure 3. Warnings signs as manual clearance takes place of US cluster mines from a cashew nut plantation in Ratanakiri province, Cambodia. (© Linsey Cottrell)**

▲ **Figure 4. The remnants of a cluster munition, marked by the red circle. Many land without exploding, with failure rates estimated at 10–20 per cent. (© Linsey Cottrell)**

recommended to offset negative effects from demining activities or to enhance the environment, guidance from and partnerships with local organisations active in reforestation or planting initiatives are needed. This would ensure an approach based on the right plants in the right place, with informed species selection, community consultation and management planning. Compensatory planting could then establish properly and contribute positively to the environment.

OPEN BURNING AND OPEN DETONATION

Despite obvious costs and logistical constraints, the humanitarian mine action sector must also seek to ensure that all practical and responsible efforts are in place to minimise the environmental impact from the disposal and destruction of munitions. The residual soil and water contamination at military ranges caused by the firing, detonation and disposal of munitions by open burning and open detonation (OBOD) is well documented, and there has been increased attention on finding more environmentally acceptable options.

Within the military sector, OBOD has come under increased scrutiny due to environmental concerns, with a view to further reducing and eliminating its use. Although OBOD of waste explosives is banned in countries such as Canada, Germany and the Netherlands (unless there is no other means) and discouraged in others, it remains in use in many regions since it is cost effective and does not require sophisticated infrastructure and equipment (see **Figure 5**). This is particularly the case in developing and conflict-affected states, or where expedient destruction is needed for the disposal of unsafe items; often no other practical option is available.

For the humanitarian sector, disposal options must remain cost effective and practical. Alternatives to OBOD, such as explosives harvesting or chemical treatment/neutralisation, may be viable but we need to understand their feasibility and how they may need to be adapted to meet needs within the humanitarian sector. Techniques developed include the conversion of explosives into non-energetic by-products, such as fertilisers, which could be sold to generate revenue. This would be subject to the quality assurance of any products (e.g. checking residual heavy metal content).

As well as good environmental performance, munition disposal options must be economically viable and consider a range of factors, such as the state and

▲ **Figure 5. Dealing with a US incendiary munition containing white phosphorus at a central disposal site in Hue province, Vietnam, a remnant from the USA–Vietnam War. (Low-resolution screenshot of video footage; © Linsey Cottrell)**

type of munition, the amount to be disposed of, local staff training and competencies, consistency with international agreements and alignment with any applicable national safety, security and environmental regulations. The United States Environmental Protection Agency recently undertook a review[10] of the alternatives to OBOD, and further research into viable alternatives to OBOD and mitigation practices for the humanitarian sector is required.

CLIMATE CHANGE AND MINE ACTION

To date, the IMAS do not yet provide guidance on how climate change may affect mine action, or the potential need for climate change adaptation planning. Climate change may potentially impact local humanitarian mine action activities in a number of ways.

Back in 2014, for example, heavy rain and flooding across parts of Bosnia and Herzegovina resulted in more than 3,000 landslides. These made the records of the location of minefields unreliable, requiring reassessment. Other countries where flooding or landslides have been reported to have affected mine clearance activities include Angola, Iraq, the Lao People's Democratic Republic (PDR), Sudan and Zimbabwe. For Lao PDR, which remains the world's most heavily contaminated country by cluster munitions, news reports[11] cited the risk that severe tropical storms and flooding in 2018 had caused explosive items to move. In the future, areas previously considered as a low priority for survey and clearance may now need to be re-prioritised or targeted if they are more vulnerable to climate change. This includes coastal locations, river banks or areas with steep slopes, all of which may become more technically challenging and costly to clear.

Intense rainfall can also halt or hinder clearance programmes, due to restricting access or by limiting the use of machinery or mine-detection dogs, which are unable to work in wet conditions. In the long term, the impact from future population movements and climate refugees may also require consideration in mine clearance because of increasing pressures on land use.

Higher summer temperatures could also adversely affect the management of munition stockpiles. Munitions are designed to withstand intense heat in the short term, but prolonged high temperatures and humidity can destabilise them, weaken their structural integrity, damage seals and increase the risk of explosion. Tidal surges and warmer sea temperatures due to climate change may also increase risks from the legacy of marine-dumped ordnance, and will require consideration by specialist underwater clearance teams.

SECTOR-WIDE CHALLENGES

Even though the sector is highly specialised and usually operates in very difficult environments, many of the challenges ahead are not unique to humanitarian demining, so lessons can be learned from elsewhere. Similarly, humanitarian demining organisations already have a strong track record in training and building up local workforce capacity. This is something that will be important in developing stronger environmental practices and working partnerships with local environmental non-governmental organisations (NGOs) and communities.

It is important that resourcing is available to support environmental planning and implementation within the sector, with mandatory environmental training, awareness raising and the implementation of data-collection systems for environmental management. Unless there is monitoring, as with any management system, measures to control and manage environmental impacts cannot be properly assessed. These can then be used to develop long-term indicators to monitor performance improvements and register the benefits achieved.

The humanitarian demining sector reports a current funding shortfall of approximately US$1 billion – only 0.4 per cent of overseas aid is allocated to mine action. Another priority and challenge will be to address preconceptions that meeting higher environmental performance will lead to higher costs. Some donors already require environmental impact assessments to be carried out, or at least evidence that environmental commitments are in place. But donors should also accept that resources should be made available to achieve these.

In countries where there is already a struggle to meet even the most basic needs of the population, the management of the environment will often be regarded as a lower priority. However, the two aspects must not be viewed as either/or: done well, environmentally sensitive demining can further benefit the health, livelihoods and climate resilience of communities, as well as protecting ecosystems. ES

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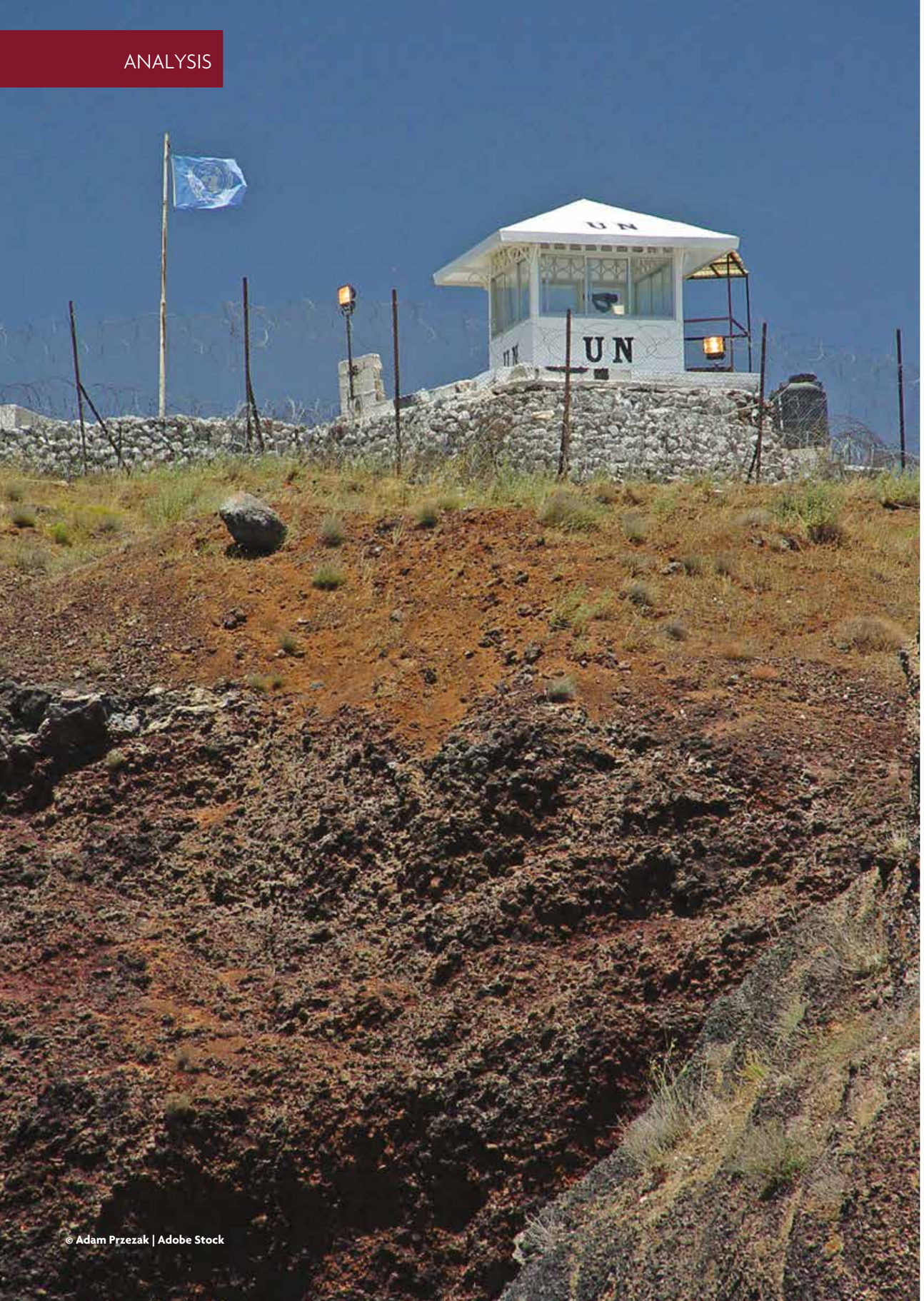

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ANALYSIS

Environmental considerations in peace operations

Annica Waleij asks what we have learned and what needs to be done.

Peace operations, which include peace support, peace enforcement, peacekeeping and peacebuilding, are some of the tools the international community can use to help conflict-ridden nations towards peace. Since 1948, the United Nations (UN) has launched 71 peace operations, and the number of peace operations launched by non-UN actors including the North Atlantic Treaty Organization (NATO), the European Union (EU) and the African Union has increased. Although UN Peacekeeping was created to address inter-state conflict, contemporary peace operations are increasingly used in intra-state conflicts and civil wars to reflect the fact that the nature of conflicts has also changed. So the mandates and range of duties of today's peace operations are broader than ever: they maintain security, help with the disarmament of combatants and promote the return of the rule of law.

One area that has come under increasing focus is environmental stewardship – the management and protection of the environment – because it is crucial that operations do not exacerbate environmental problems in an area. However, peace operations have historically left an undesired environmental legacy in often fragile and resource-scarce areas after the deployment of military and civilian personnel and major logistics operations.[1,2,3] One striking example of an unintended consequence is the 2010 cholera outbreak in Haiti, which later was deemed to have been caused by the UN Peacekeeping force by its lax wastewater management.[4]

PEACE OPERATIONS AND THE ENVIRONMENT

With time, however, a more holistic understanding of the relationship between peace operations and the environment has emerged, so that operational military necessity is balanced with environmental impact. An environmental guidebook for military operations, with a supplementary training toolbox, has been developed in a trilateral collaboration between the governments of Finland, Sweden and the USA. It is an example of practical guidance on how to proactively address environmental issues in operations.[5]

There are four principal ways that peace operations and the environment are connected:[6]

- Ensuring that troops and civilians are not at risk from environmental hazards;
- Minimising the environmental impact – the 'bootprint' – of the operation itself;
- Avoiding competition with local communities for scarce natural resources; and
- Assisting with capacity building in the management of the environment. (Although the military may engage in capacity building, this is not its primary role – other actors in the peace operation are often more suited to such activities.)

Peace operations may harm the environment, so considering the environment in military operations is not as far-fetched as it may seem. The environment

BOX 1: SUSTAINABLE BUILDINGS

In July 2012, the UNDFS introduced eco-friendly building components into the systems contract for prefabricated buildings that also provide improved insulation for energy saving and noise attenuation. In the United Nations Mission in South Sudan (UNMISS), the FOI and the engineering section of UNMISS ran a project called Juba III/UN House Pilot Project. This pilot proof of concept incorporated renewable energy, water conservation and waste management measures into houses, and the result was reduced energy and water consumption and decreased waste production.

▲ **Top: the pilot containers had solar panels and insulation added for use as living/office space or for ablutions. The picture shows (left to right): a control unit (with no solar panels or insulation), an ablution container and a living container (that could also be used as an office).**
Bottom: brick house made with sustainable bricks produced with equipment that uses high pressure, no fuel wood and almost no water.
(© Swedish Defence Research Agency)

influences military operations in many ways. For instance, to reduce an operation's dependence on the environment and infrastructure of the receiving nation, supply chains delivering commodities such as water, fuel and construction materials to a theatre of operation are needed. There are also financial incentives: an operation that causes unintended environmental impacts, such as land pollution, can result in financial liability.

This article focuses on the military component of UN Peacekeeping, their environmental footprint and the strategies they use to achieve sustainable operations. Sustainability in this context refers to the capacity and capability of sustaining a mission, as well as environmental, social and economic sustainability. The environmental performance of a mission depends on its environmental management, which can be divided into four areas:

- Environmental policy and doctrine that is constantly updated to reflect best practice and lessons learned from operations;
- Mission-specific tools, environmental best practice and sustainable technologies;
- Environmental awareness training to familiarise personnel with the tools and practices of environmental stewardship and to instil environmental ethics at all levels in the chain of command; and
- Systematic collection and evaluation of environmental intelligence.

POLICY AND DOCTRINE

Environmental policies and doctrines are the starting point for addressing environmental considerations. Previously, environmental issues (e.g. the handling of waste and hazardous substances) were dealt with on an *ad hoc* basis by individual missions. Although personnel were often aware of the need to address environmental issues, the lack of standing operating procedures made it difficult for them to take coherent environmental action.

In 2009, the first Environmental Policy for UN field missions was launched.[7] At the highest level of the UN's peacekeeping doctrine, the environment is also mentioned, although indirectly: 'lax waste management practices are just some of the negative impacts that may seriously undermine the perceived legitimacy and credibility of a mission, and erode its popular support'.[8]

▲ **Figure 1. Fictional scenario work in the classroom. (© Swedish Defence Research Agency)**

▲ **Figure 2. Oil spill from a generator farm at the base camp. (© Swedish Defence Research Agency)**

▲ **Figure 3. Remediation of an oil spill using easily available local materials. (© Swedish Defence Research Agency)**

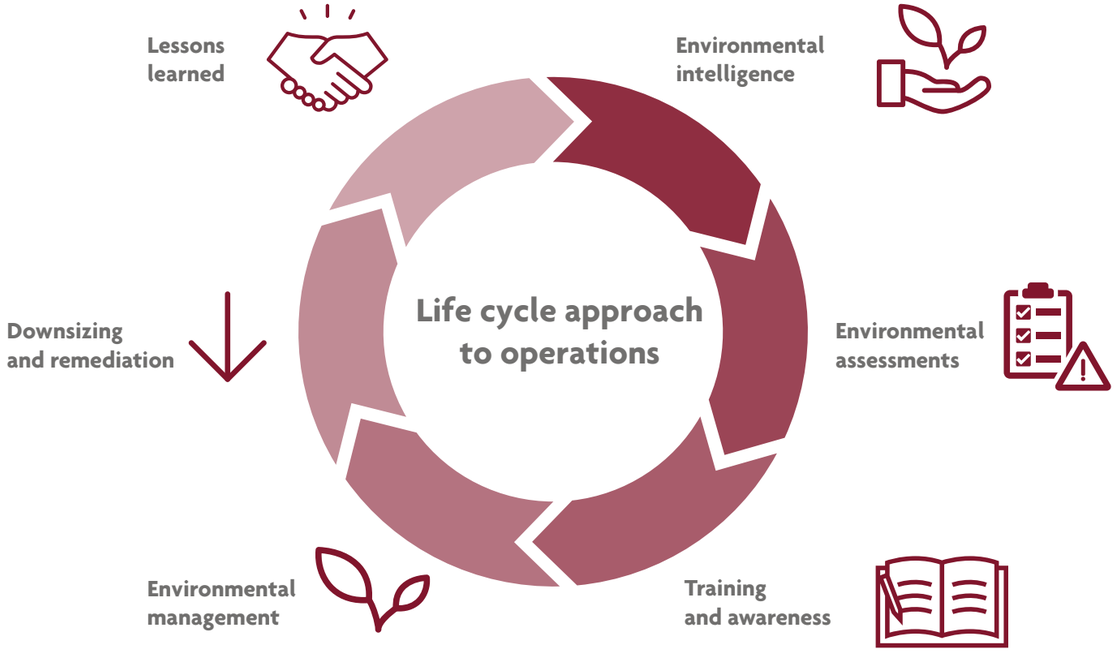
In 2012, the flagship policy report, *Greening the Blue Helmets*, was published to support the implementation of the Environmental Policy.[9] Together with work carried out by, for example, the UN Department for Field Support (UNDFS) and the Acting Secretary General for the Environment, Franz Bauman, it paved the way for a comprehensive environmental programme, the UN Peace Operations Rapid Environment and Climate Technical Assistance Facility (REACT). Environmental considerations may also be part of a UN mission's mandate. Since the 2013 UN Multidimensional Integrated Stabilization Mission in Mali (MINUSMA), the UN Security Council has mandated four additional missions to consider the environmental impacts of its operations.[10]

MISSION-SPECIFIC TOOLS

Environmental policies and doctrines need to be complemented by additional tools, such as an environmental management system (EMS), that help an organisation achieve its environmental goals through consistent review, evaluation and improvement of the organisation's environmental performance. Still, there are no silver bullets, so each tool must be assessed on its own merits, as well as the context it is intended for.[11]

Assessment tools. The deployment of peace operation personnel cannot easily be addressed by a traditional environmental impact assessment (EIA). There are many challenges, which may include time constraints and lack of environmental governance in the host nation. Based on various environmental assessment methodologies (e.g. EIA, strategic environmental assessment [SEA], vulnerability assessment [VA] and environmental baseline study [EBS]), the Swedish Defence Research Agency (FOI) assisted the UN with developing environmental assessment methodologies for UN Peacekeeping operations.[5,12]

A field-level EIA pilot study was conducted in 2010 at a planned UN Support Office for the African Union Mission in Somalia (AMISOM) base in Mombasa, Kenya, while a remote EIA, using geographic information systems (GIS) and remotely sensed data, was conducted for an African Union base in Mogadishu, Somalia, because it was deemed too dangerous to travel to Mogadishu as the budget did not allow for a security detail for the team. Alongside the Mombasa EIA, two EBSs were carried out to inform the selection of possible sites for the new logistic base and ensure that pre-existing environmental conditions were documented. This due diligence practice



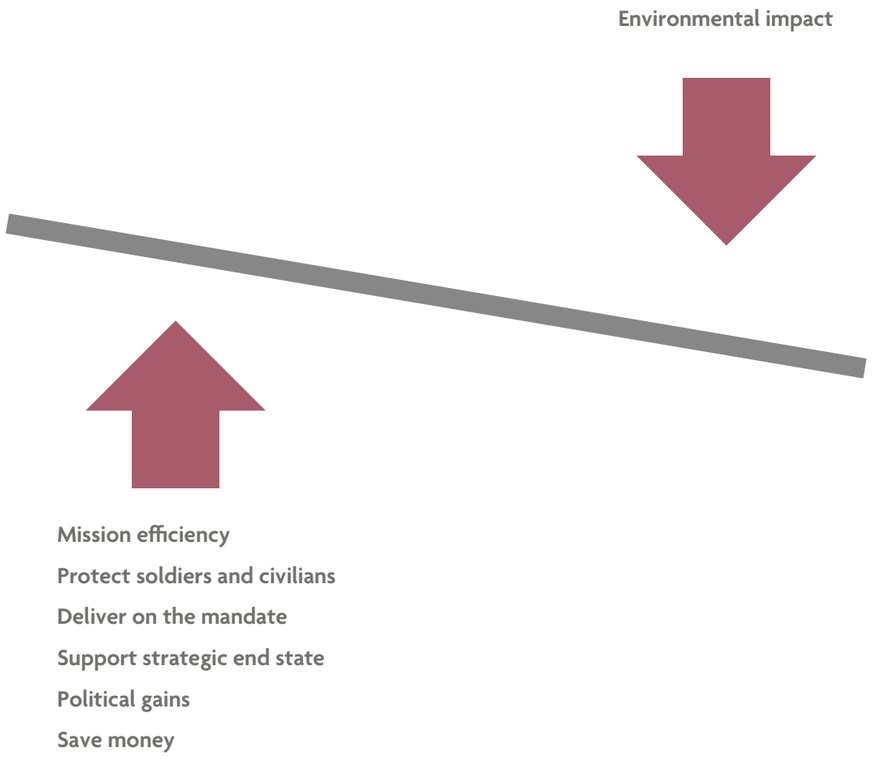
▲ **Figure 4. A life cycle approach to operations using various environmental considerations and tools. (© Swedish Defence Research Agency)**

can limit the UN's liability for pre-existing environmental damage and allow a mission to monitor its environmental performance as required by the UN Environmental Policy.[13,14,15]

Sustainable technologies. Technology can enhance the safety and security of personnel serving in difficult, remote and dangerous environments. The use of modern technology can help to preserve and sustain life in the field and reduce a mission's environmental footprint. Such technologies can be a combination of high tech, low tech and retrofitting. For instance, ground-penetrating radar and advanced geospatial imaging can help to improve the odds of successful drilling for water, and simple techniques such as rainwater harvesting can decrease the need to use potable water for non-sensitive uses.[16] Additive manufacturing (3D printers) can print spare parts in remote locations while creating little waste.[17] Solar panels, energy-saving light fixtures and energy conservation can reduce diesel consumption (see **Box 1**). It is important to think outside the box and prove what works, while at the same time avoiding negative effects and using a systems-of-systems approach (where the different functions are regarded as being interdependent rather than separate).[18]

ENVIRONMENTAL AWARENESS TRAINING

Environmental awareness sets the conditions for sound environmental management. In this, leadership is paramount. In 2006, environmental awareness training was initiated for UN peacekeepers. Although the Environmental Policy was then in draft format, UN field officers deployed on field missions were trained at the UN logistics base in Brindisi, Italy. As well as lectures and a demonstration of some off-the-shelf equipment for the environmental screening and monitoring of environmental contaminants, a practical session of exercises with recent mission experience in a fictive



▲ **Figure 5. A desired win–win situation, where operational requirements contribute to reduced environmental impact. (Adapted from a drawing by Lieutenant Colonel Lloyd Chubbs, Canadian Forces)**

mission ('Anyland') was conducted. Participants were invited to share the environmental challenges they had encountered at their respective peacekeeping operations. The outcome was a list of suggested actions that in the participants' opinions would be valuable for short- and long-term best practice for environmental protection in UN field missions.[19]

In 2008, two more pilot training sessions were held in Juba, Sudan (see **Figure 1**), for countries that had contributed troops to UNMIS. One session focused particularly on petroleum, oil and lubrication (POL) handling, spill prevention and waste management (see **Figure 2**). Because the Juba base camp was in an area where the groundwater level is normally high, hazardous materials – for example, from oil spills – can easily percolate down to the groundwater and pollute the aquifer. As a complement to the lectures, participants engaged in a remediation exercise to demonstrate the biodegradation of a small oil spill from a generator farm at the base camp. The exercise was carried out with existing equipment, such as shovels and barrels (an excavator would have been needed for larger oil spills), and with material – such as cow manure, sawdust and hay – that could easily be acquired (see **Figure 3**). The goal of the exercise was to demonstrate to participants that a great deal can be accomplished using local and readily available resources, and to reinforce the notion that every individual can and should be an environmental steward.

With growing pressures on the environment and its resources, sustainability will increasingly become key to overall mission success.

Since then, additional pilot trainings have been carried out during missions and at peacekeeping training centres, an e-learning module has been developed and an environment and natural resources module is included in the core pre-deployment training module on the UN Peacekeeping resource hub.[20,21]

ENVIRONMENTAL INTELLIGENCE

Environmental intelligence is an emerging concept that does not yet have a consistent definition. Within the context of the Swedish Armed Forces, environmental intelligence is conducted within the framework of medical intelligence, which involves the collection, analysis, interpretation and dissemination of information related to animal and human health (the latter includes environmental health).

Complex environmental questions may arise during a peace operation. Since relations between security and the environment, for example, are very intricate, they require careful and considered management.[22] Some of these issues may be identified in the planning stage, whereas others are discovered on site. Mission planning should be informed by environmental intelligence for three reasons:

- To avoid damage to the environment and natural resources of the receiving nation;
- To ensure adequate resources, including funding for environmental stewardship and appropriate technologies; and
- To understand if environmental issues or natural resources are potential drivers of the conflict.

To facilitate analysis, information sharing and integration with GIS, environmental intelligence should be linked to geo-coordinates when possible. Although environmental intelligence could potentially be used to establish early-warning systems for environmental and natural resource conflicts, and as a source of information for civilian organisations, security restrictions may limit opportunities to share environmental data. For actual information sharing to take place, trust is needed.[23,24]

WHAT LIES AHEAD?

Policies, environmental awareness, technical tools and environmental intelligence are all important, but the ultimate goal is to take what has been learned from previous operations, use it as the basis to develop best practice, and apply this to future operations (see **Figure 4**). With growing pressures on the environment and its resources, sustainability will increasingly become key to overall mission success. Lessons must be documented and transformed into true lessons learned; it is also crucial to learn from the failures.

Environment, security and health issues are fundamentally interconnected and require an integrated approach. Recognising the multiple interdependencies and assessing them based on these offers a number of benefits. Several policies and operative tools exist that, apart from providing decision-makers with information, can also inform security and conflict analysis (see **Figure 5**).

MAINSTREAMING THE ENVIRONMENT

At the operational and tactical levels, environmental considerations are usually an engineering responsibility. However, it is important to focus not only on issues that can be 'engineered away', but also on more strategic issues. Indeed, environmental protection also plays an important part in human health protection, and the recognition that environment and health represent two sides of the same coin signal the need for close interaction between, for example, the engineering, environmental, medical and social aspects.

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Clearly, no single organisation can carry out all of the multifaceted tasks required to support and consolidate the processes leading to a sustainable peace; partnerships between military and civilian actors are indispensable for achieving global stability.[25,26,27] We must do a better job of mainstreaming environmental considerations into foreign policy and the operations of all stakeholders in post-conflict settings, with the understanding that the fallout from a fragile environment is not restricted by organisational boundaries. If armed forces continue to contribute to climate change and other forms of environmental degradation, they will be partially to blame when they are called in to defuse or clean up future conflicts over scarce, degraded or rapidly changing resources. By striving to limit additional harm to the environment and make a positive contribution, peace operations can help shape the overall post-conflict situation and determine how future peace operations will be perceived.

The views expressed in this article are those of the author and do not necessarily reflect the views of the Swedish government, the United Nations or other organisations. ES

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