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Early Warning, Emerging Issues and Futures

The role of remote sensing and social research in monitoring the environmental impact of refugee/Internally Displaced Persons camps

Background

The Foresight Briefs are published by the United Nations Environment Programme to highlight a hotspot of environmental change, feature an emerging science topic, or discuss a contemporary environmental issue. The public is provided with the opportunity to find out what is happening to their changing environment and the consequences of everyday choices, and to think about future directions for policy. The 32nd edition of UNEP's Foresight Brief explores the use of remote sensing as an environmental monitoring tool in areas where camps have been set up to house displaced people.

Summary

Across the world, men, women and children are being displaced by conflict, economic conditions and climate change. Camps are set up to house displaced people as a short-term solution, but in many cases the displaced are unable to return and camps endure for decades. There are increasing numbers of displaced people (globally) and in many situations camps have grown. The existence of camps has an impact on the environment over time, particularly affecting water quality, deforestation and soil degradation which exacerbates existing environmental challenges with women having to encounter unique challenges related to environmental degradation and gender roles. Remote sensing, and in particular satellite images of high and very high spatial resolution supported by social research, can serve as a monitoring tool. For example, they can help determine the actual population and the dynamics of its changes, but also identify the type and location of environmental transformations occurring within the camp as well as in the surrounding areas.

Introduction

In recent decades, the trend of mass displacement of people due to both natural and humanitarian disasters has persevered. According to the United Nations High Commissioner of Refugees (UNHCR), at the end of 2022 approximately 108.4 million people were living in situations of forced displacement. This includes 62.5 million internally displaced persons (IDP), 35.3 million refugees, and 5.4 million asylum seekers (UNHCR 2023). Compiling the numbers in terms of world regions, the regions most affected are Europe (36%), followed by Asia and the Pacific (20%), the Americas (17%) and East and Horn of Africa and the Great Lakes region (13%) (UNHCR 2023). [**Figure 1**]

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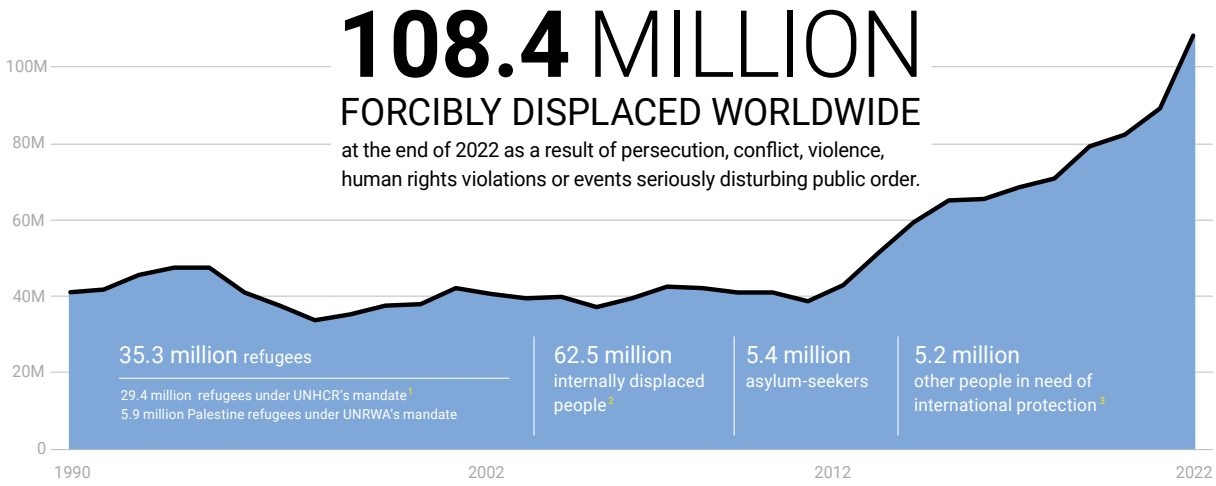


Figure 1: Source: Global Trends report (Internal Displacement Monitoring Centre), UNHCR 2023

Displacement causes immense suffering for affected communities and has immense detrimental impacts with these women and men disproportionately affected and being exposed to new differential vulnerabilities such as safety and security, health, psychological and emotional impact deepening pre-existing gender divides. The continuous displacement growth, in both size and complexity, is of great concern to stakeholders and decision-makers in the field of emergency response (i.e. European Union, the United Nations or non-governmental aid organizations) and the scientific community supporting the policy-making of the above-mentioned authorities, and is increasingly being seen as a security issue and is driving some of the international discourse around climate change and the resulting insecurity.

Nevertheless, challenges remain in dealing with the dynamically changing situation in refugee/IDP camp areas and their surrounding. Diverse housing conditions, uncontrolled growth due to the constant influx of new migrants, water and cooking fuel and energy supply issues, sanitation, hygiene and security are just some of the challenges the refugee/IDP camps inhabitants face. Large-scale settlements often lead to environmental pollution and land degradation, where severe deforestation and surface water pollution are just pieces of a larger picture. Common management mechanisms implemented for IDP/refugees camps do not sufficiently respond to different environmental, cultural, social and economic backgrounds of both settlements and host communities, pushing both of those groups towards maladaptive strategies.

Undoubtedly, in such complex areas as refugee/IDP camps, the situational monitoring and management require the joint efforts of humanitarian aid agencies and local authorities as well as interdisciplinary research support. The joint implementation of satellite imagery, remote sensing techniques, geo-information tools and social research, the role of which will be presented in more detail later in the Foresight Brief, should be a promising approach to support these efforts.

Why is this important?

Challenges in the IDPs/refugees settlements management

The humanitarian response system was created as a reaction to crises with the principal assumption that the actions being taken, including camp establishment, are short term and with time should lead to closure of the camp and integration of forcibly displaced people into the host community. The Manual Guide with Minimum Standards for Camp Management created by the International Organization for Migration (IOM) established minimum standards to support meaningful engagement within a site as well as planning and coordination between sectors and agencies. The standards cover different sectors such as, education, emergency telecommunication, food security, health, logistics, nutrition, protection, shelter and WASH (Water, Sanitation and Hygiene) or early recovery. Although host communities are partly included in some of those sectors, the natural environment is not. Such a gap in camp management often leads to degradation of the environment with serious consequences for all residents of the region. Inclusion of the natural environment as one of the sectors and monitoring of the influence of camp management on the environment is therefore crucial to preventing detrimental long-lasting consequences of camp management.

The significance of Satellite analysis

Remote sensing, and in particular satellite images of high and very high spatial resolution [**Figure 2**], can serve as a monitoring tool adapted to specific user needs (Kemper *et al*. 2011; Jenerowicz *et al*. 2019). They can help determine the actual population and the dynamics of its changes, but also identify the type and the direction of environmental transformations occurring in the camps as well as in the surrounding areas.

Satellite images taken six years apart (2014 and 2020) show the land cover changes in the area of Khanke IDP (internally displaced people) camp in Iraq.

Source: multispectral pansharpened images, 0.5m spatial resolution, false color composition (NIR, R, G), where red color indicates healthy vegetation (DigitalGlobe)

In addition, recent advances in combining Earth Observation (EO) with socio-economic and demographic data are enabling an in-depth understanding of human-environmental interactions. Such integrated datasets are increasingly used to determine trends of land use/cover changes and thus predict what the analyzed area will look like in the near future. It is possible to upload such datasets into an online solution like geoportal for better accessibility to a wider audience. Such a solution can support a more comprehensive understanding of the collected data by visualizing it in a user-friendly form. Not only is this helpful for the dissemination of information on the topic in question, but it can also be a practical tool to support decision-makers. Nevertheless, there is still a gap between the development of research techniques themselves and the dissemination and use of the resulting data, especially in the context of political or humanitarian actions.

Case studies background

Two examples highlight the influence of the location of huge numbers of people in one place and camp management on the natural environment: Mtendeli Refugee Camp in United Republic of Tanzania and Kutupalong Refugee Camp in Bangladesh.

United Republic of Tanzania - Mtendeli Refugee Camp
For over 30 years, United Republic of Tanzania has hosted displaced persons from nearly a dozen countries (Chaulia 2003; Da Costa 2017). It started feeling the pressure of being a host for a continually growing number of refugees in the 1990s. By 31 December 2000, it hosted more refugees than any other country on the African continent, a total of 543,000, one-sixth of all African refugees and one twenty-sixth of the world's refugees (Chaulia 2003, 147-148; USCR 2001). Most of them were settled in the country's northwestern region of Kigoma – the poorest area in the country with a large percentage of forest and game reserve. This led to significant changes in natural resources in the camps' surroundings, followed by a change in state policy towards refugees significantly reducing their rights.

Banana trees next to the destroyed inhabitants huts (Kibondo)
Photo credit: J.Haarpaintner (NORCE)/ARICA

There are currently more than 246,000 refugees and asylum-seekers in United Republic of Tanzania, mainly from Burundi and the Democratic Republic of the Congo. More than 80% of them live in two camps in the Kigoma region (Nduta and Nyarugusu). Ongoing climate change in the region has resulted in reduced water availability during plant growing seasons, increased temperatures and a greater risk of flooding. This affects crop production, increases soil erosion, and ultimately makes it more difficult for local ecosystems to sustain populations. Until December 2021, Mtendeli Refugee Camp also functioned in this area under such conditions. As the camp has been closed and its residents relocated to Nduta it makes an interesting case for analyzing environmental changes and attempts of restoration with the use of remote sensing, and in particular satellite images of high and very high spatial resolution.

Mtendeli Refugee Camp was first opened in 1996, closed in 2010 and reopened a few kilometers away in 2016 (ACT Alliance 2016). The camp covered 1,500 hectares (UNHCR 2018) and was home to 26,597 Burundian refugees at the time of its closure (UNHCR 2021). The campsite was located about 30 km from the Burundian border and less than 5 km from the host community village Kasanda. In its proximity, there was the Buyungu Forestry Reserve (Kweka 2007). The Eastern side of the camp practically bordered the Moyowosi Game Reserve, which was not in line with UNHCR guidelines stating that the distance between the camp and ecologically fragile areas should be between 12 and 15 km. The camp was located in the catchment area of the Nyabiyoka stream, which was the main source of water for both the local communities and the Mtendeli refugee camp (Gwamagobe 2015, 47).

Bangladesh - Kutupalong-Balukhali Refugee Camp
Bangladesh is neither a party to the 1951 Refugee Convention, nor the 1967 Protocol, nor the 1954 and 1961 Statelessness Conventions. Nonetheless, it became home for a significant number of Rohingya people escaping persecution, and a place where the largest refugee camp in the world is located.

Kutupalong-Balukhali Refugee Camp
Photo credit: J.Haarpaintner (NORCE)/ARICA

This dominantly Muslim minority, living in Myanmar's Rakhine state (formerly known as Arakan) on the border with Bangladesh, witnessed a range of state-sponsored humiliations, law depravations and discrimination as early as 1948 when Myanmar (then Burma) became an independent state. First significant persecution started just after the national census from 1977 when approximately 200,000 Rohingyas fled to Bangladesh. At that time Rohingya refugees were living among Bangladeshi citizens. However, another significant flow of Rohingyas in the 1990s led to the establishment of the first refugee camps in Cox's Bazar District in 1991 (Ullah 2011), which, despite repatriation of some of Rohingyas to Myanmar continue to operate until today (Islam and Hossain 2019).

The last but also the biggest influx of Rohingyas into Bangladesh was between August and October 2017 when over 600,000 Rohingyas joined more than 200,000 already settled in Cox's Bazar District (Holloway and Fan 2018; Kudrat-E-Khuda 2020). In a very short time, the population of Rohingya refugees increased fivefold in early 2018 (Braun *et al*. 2019). As for early 2022 the mass influx increased the total Rohingya population in Cox's Bazar District to over 950 000 (Gob and UNHCR 2021b). The refugees' settlement areas expanded from 36 hectares in early 2016 to 146 hectares in December 2016, then to 1365 hectares in December 2017 and to 1850 hectares at the beginning of 2019 (Braun *et al*. 2019; Hassan *et al*. 2018). Similar to the United Republic of Tanzanian situation, this camp was established in the environmentally sensitive area of the Teknaf Wildlife Sanctuary, a habitat for many species of plants and animals, including elephants.

Consequences for the environment

United Republic of Tanzania – Mtendeli Refugee Camp
Areas in which the refugee camps were set up in United Republic of Tanzania had previously been miombo forestlands. The appearance of a large number of people in a short period strongly impacted on the environment, leading to the extinction of various species of flora and fauna important for local communities, such as medical plants, edible insects and fruits.

Water quality and quantity: Representatives of the host community pointed out that before the refugees came, nearly all the rivers were year-round sources of water. They also maintained that water quality was high and potable (Gwamagobe 2015). Mtendeli refugees were only allowed to draw water from public taps in the camp but due to the limited access to this critical resource, they also collected water from the river outside Mtendeli. Both water irrigation systems in the region as well as these illegal practices have significantly affected rivers and streams. Certain rivers became seasonal, others dried up. Water also became a means of carrying disease. While Mtendeli was supplied with treated water, the local community had no access to such conveniences. Water pollution caused by refugee camps upstream was suffered by locals downstream.

Deforestation: Before the refugees came in 1991, the woodland cover in Mtendeli was at 71%, (Gwamagobe 2015). In 2009, when the camp was being prepared for closure for the first time, the forest cover was at only 17.7%. Deforestation occurred in two ways. On the one hand, trees were felled to build camp infrastructures such as roads or public buildings. Such activity accounted for 30% of all deforestation causes. On the other hand, deforestation had an informal course – up to 67.7% of all deforestation causes were variants of illegal farming (Gwamagobe 2015).

The local community did not know that fire could be used to clear trees. When the refugees arrived and the land was turned into fields, a new method was introduced, namely that of drying trees. It consists in debarking them, and only then cutting them down. The spread of this technique significantly increased the destruction of forest cover (interviews with refugees).

Bush fire
Photo credit: S. Aleksandrowicz (CBK PAN)/ARICA

Both the refugees living in Mtendeli and the inhabitants of surrounding villages pointed to a great need for fuelwood, which is their main source of energy. According to Quigley (2016), the average daily use of fuelwood was 1.8 kg per person. The necessity to cook the food rations forced women living in the camp to look for firewood. In search of it, they walked as far as 13 km outside the camp boundary.

Soil degradation: The soils in the area are very susceptible to erosion and are fertile for a very short period. All erosion prevention systems in Mtendeli have proven ineffective. This has greatly reduced the ability of residents to adaptively restore crops after droughts and floods. Since the vast majority of the region's residents rely on agriculture for their livelihoods, ongoing soil degradation has a significant impact on their food security.

Vegetables plantations
Photo credit: S. Aleksandrowicz (CBK PAN)/ARICA

The large population living in the region and the need to constantly fight food shortages, leading to intensive farming, has resulted in a significant reduction in land area. This, in turn, has directly resulted in a decline in productivity and has exacerbated erosion. For example, after the refugees had been in the area for five years, a large ravine of 1.75 km in length and up to 12 m deep had formed (UNHCR 2002). It was dangerous - among other things, people suffered injuries during the rainy season. It became also a place where waste was dumped, which later contaminated the water, causing many diseases in the area.

Bangladesh - Kutupalong-Balukhali Refugee Camp
In the case of Bangladesh, consequences for the environment were also severe. The region where the camp is located lies in a low altitude area with low slope hills (up to 50 m), in close proximity to the Teknaf Wildlife Sanctuary, a rich biodiversity area, and the Naf River. The rapid influx of refugees in late 2017 and lack of adequate shelter and resources to settle hundreds of thousands Rohingyas heavily impacted on the environment in the area and changed its landscape because of deforestation and hill cutting.

Water quality and quantity: Extreme demand for water and its irresponsible usage caused stress on limited water resources. It led to groundwater depletion, but also its contamination from latrines leakage, seepage and overflow, especially during monsoon periods (GMI 2018; Honeth *et al*. 2017; Kudrat-E-Khuda 2020). Additionally, due to insufficient waste management systems, particularly at the beginning of the camp establishment, waste was thrown into the channels. Food and other supplies distributed among camp inhabitants were often packed into plastic, creating additional difficulties in managing garbage, as the plastic was later thrown into the canals. Streams that were sources of potable water became sewage full of garbage, which stretched to bigger streams going through the agricultural fields of local communities.

Inside the camp
Photo credit: K.Sobczak-Szelc(CMR)/ARICA

Cox's Bazar District where Kutupalong-Balukhali camp is located, is prone to flooding. The construction of the camp had a negative impact on rainwater absorption and increased the danger of wastewater overflow and further groundwater pollution in the whole area (Honeth *et al*. 2017). Despite recent attempts to improve the water management, a lot of damage has been done. Groundwater depletion, seasonal floodings or surface water contamination are still the main problems.

Deforestation: Expansion of the refugee camp caused a total forest loss of 18% or 2060 hectares in the 10 km buffer zone surrounding the settlements in only 12 months between December 2016 and December 2017 (Hassan *et al*. 2018; Quader *et al*. 2021). Increased deforestation and the appearance of open areas near the first camp (Kutupalong RC) could already be observed before the massive influx of new Rohingya refugees. Nonetheless, it is clear that the construction of shelters and later infrastructure for almost one million people was the main reason for the destruction of the forest. From July 2017 these cleared areas changed into heavily populated settlements (Braun *et al*. 2019). Some studies indicate that the forest cover in the Ukhiya Upazila (subdistrict of Cox's Bazar) decreased by 66,25% (Quader *et al*. 2021) due to the construction of the camp.

Soil degradation: Rapid deforestation and hill cutting caused soil erosion which became one of the significant environmental challenges in the camp area. The situation is especially dangerous during the monsoon season. It leads to many landslides and flooding but also pollution of existing water resources (Hassan *et al*. 2018; Quader *et al*. 2021; Rahman 2019) used by local population living in the close proximity to the camp. Moreover, large usage of various plastic types in the camp and lack of proper waste management is one of the main sources of soil pollution and can cause flooding by blocking drainage systems (UNDP and UN Women 2018) not only in the camp but more importantly on agricultural fields used by the local community.

Protection against erosion
Photo credit: J.Haarpaintner(NORCE)/ARICA

What is being done?

Kutupalong-Balukhali refugee settlement, Camp 4-4Ex
Photo credit: D.Wach (CMR)/ARICA

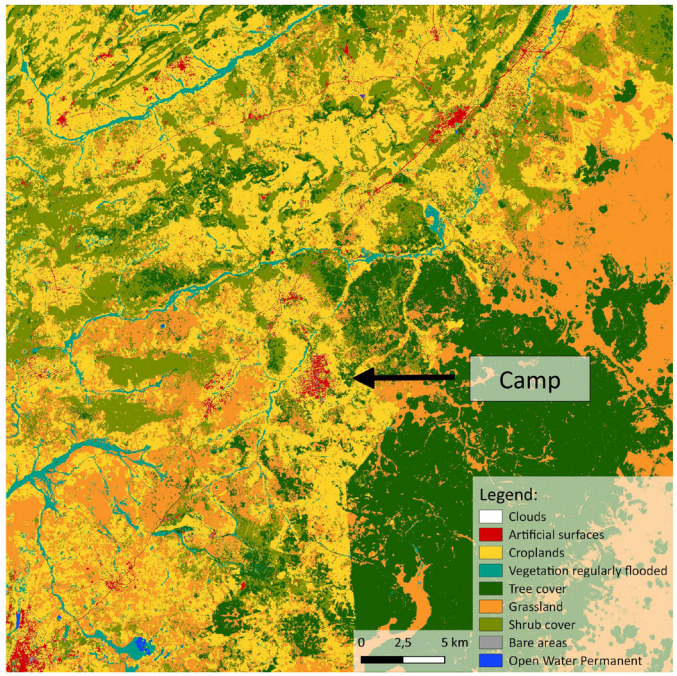
In order to protect the environment both in and around refugee camps, state authorities and various international and local institutions and organizations are taking several measures. As an example, before the closure of Mtendeli camp in United Republic of Tanzania, representatives of different national and international organizations, together with host community village leaders and refugee community leaders, conducted regular patrols around the camps to prevent illegal logging and charcoal production. At the same time, they were conducting educational and tree-planting campaigns as well as river and soil conservation activities. The latter activity involved, amongst others, the construction of gabions (rectangular wire mesh or stone-filled wooden baskets that are placed on slopes to create retaining walls) and dams (a small dam in a ravine or other small watercourse made of bags filled with sand) - both of which mitigate the effects of soil erosion (REDESO website). An important part of environmental restoration was delivered by nature itself. For example, in the five years following the initial closure of Mtendeli and the repatriation of refugees, most of the land remained uncultivated. The Government of the United Republic of Tanzania has not granted anyone the right to use it. Although charcoal burning and farming, continued informally, the scale of these activities was limited. By this time, forest cover had increased to 31%, suggesting the possibility of complete restoration within the next three decades (Gwamagobe 2015). Remote sensing analysis can be used to monitor restoration of the environment after closure of the camp.

Kutupalong-Balukhali camp in Bangladesh delivers even better practices that were implemented. For example, the provision of LPG gas for cooking to the camp inhabitants decreased the demand for firewood. Moreover, some projects aimed to increase vegetation in the camp area by planting trees or the creation of small gardens next to the shelters or on their roofs. It is also clear that newer parts of the camp are better organized, have better infrastructure which is less prone to natural hazards. These measures will not restore the natural land cover and biodiversity of over 500 species of plants and 600 species of wildlife (Rahman 2019) that were destroyed since the camp was established, but can have a positive impact on the current situation. It can only raise awareness about the need to protect the natural environment.

Both of these cases, Mtendeli Refugee Camp in United Republic of Tanzania and Kutupalong Refugee Camp in Bangladesh show how a crucial and important role remote sensing data analysis results can play a crucial and important role, especially combined with socio-economic research and demographic data. It can provide, not only critical information that is essential for effective planning and management of refugee camps, but also supports evidence-based decision-making and helps to ensure that the needs of refugees are met in a timely and adequate manner.

A multi-temporal and multi-source remote sensing analysis performed so far for the areas of Mtendeli Refugee Camp and Kutupalong Refugee Camp resulted in acquiring the information about camp areas extent,

Kuputalong Refugee camp, Cox's Bazaar, Bangladesh (27 November 2018)
Photo credit: Shutterstock / bgrocker



Land Cover classification map, Mtendeli, 2020 (Gromny *et al*. 2022)

spatial occupancy estimation, including residential areas and transportation networks as well as change in land use/cover, including forest, woody vegetation, and cultivated areas.

Such information obtained on the basis of data from different periods of time is now combined with socio-economic and demographic data in order to perform further multidisciplinary analysis that will provide a comprehensive understanding of the interactions between human behaviour and the environment.

In order to enable the use of such analysis and data, a specially dedicated geo platform is being developed to provide free access to multi-temporal data showing the field situation of a given camp, both in the context of infrastructure and the environment. As has already been mentioned, geospatial analysis needs to be supplemented by the perspective of camp inhabitants, host community and experts from the field. Such a platform can be an important source of decision-making support for stakeholders and humanitarian agencies, as well as a tool for expanding awareness among citizens. International Resource Panel (IRP) points to an example of using such tool within humanitarian mapping project for Bidibidi refugee camp in Uganda where geospatial data platform is used, based on MapX – a dedicated platform backed by the UNEP.

What are the implications for policy?

People living in the refugee camps are often blamed for negative changes in the environment, such as wide scale deforestation of areas surrounding the camps or poaching. Giving voice to both, them and representatives of the host community, can prevent such oversimplifications and sometimes false assumptions, and point out the complexity of the interrelationship between all actors; the camp inhabitants, the local communities and the environment. Data collected in preparation for field research shows that what poses a threat to the environment is not exclusively the presence of refugees, but improper management of the camps

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and many restrictions placed upon their inhabitants. In addition, and maybe more importantly, the large influx of people, both refugees and service personnel from NGOs and other stakeholders, entrain an economic development of the region that also strongly impacts the environment. Consequently, it's important to ensure gender-responsive solutions by recognizing and supporting vital contributions of women in environmental protection efforts such as in sustainable resource management, reforestation, water conservation and sanitation and promoting the use of alternative energy sources hence contributing to the overall well-being and resilience of communities.

It's also important to understand the needs of displaced persons, through meaningful participation in program and policy design as well as addressing intersectionality of gender and displacement and responding appropriately to close gender gaps.

Photo credit: Shutterstock

As the IRP reports, activities of camp residents (e.g., firewood collection, subsistence farming) have a significant impact on both the land use changes themselves and the rate of change. Therefore a comprehensive analysis of the impact of socioeconomic vulnerability, freedom of movement and relations with the host community on access to natural resources in refugee camps is important. The results of such analysis can be crucial for research and effective policy formulation. It is worth noting that refugees often have no control over the choice of the location of the camp and thus the natural resources in the area.

Management of the dynamically evolving camps requires a broad view, not only of the site itself, but also of the areas located around it. Resource management systems as noted by IRP, especially supported with the remote sensing analysis results, can help to better understand the relationship between the environment and human mobility and thus can help to maximize the benefits of natural resources. Tools such as geoportals, considered as a key tool for convenient access to spatial data (Vahidnia and Vahidi, 2021), can significantly improve camp logistics and management. This online solution can provide access to geospatial information and results of the multidisciplinary analysis described in the section above as well as geographic services via the internet, such as displaying, analyzing and editing uploaded spatial data.

Spatial representation of changes occurring in the environment around the camp can not only provide a clear overview of the camp's current condition and be a tool to support day-to-day management issues. It can also help to identify potentially vulnerable areas, as well as the direction and intensity of changes, allowing an early response and long-range planning.

Geoportals can have a wide range of useful applications in the daily operations of the camp, with the ever-increasing amount of spatial big data available at one's fingertips (Jiang *et al*. 2020). For instance, combining a geoportal with weather data can help provide early warning of the most vulnerable areas, while land cover analysis will help identify firewood gathering sites with the least impact on the surrounding environment.

Conclusion

Mass displacement of people due to various crises is still persisting. These displacements, affecting regions worldwide, have led to significant humanitarian challenges and environmental degradation. Poor management of refugee and internally displaced persons (IDP) camps has often overlooked the environmental aspect, resulting in consequences such as deforestation, water pollution, and soil degradation.

Attributing environmental degradation solely to camp residents oversimplifies the issue. Management of refugee camps should consider the broader context, including the economic development of the host region and the socio-economic factors impacting resource access.

Satellite imagery and remote sensing techniques can support monitoring population dynamics and environmental transformations in and around camps. Such technologies, when combined with socio-economic and demographic data, offer valuable insights into the complex interactions between human behavior and the environment and thus playing a crucial role in shaping effective policy.

Photo credit: Shutterstock / Vadim Sadovski

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Author's note
This Early Warning Brief is based mainly on the experiences of ARICA Consortium from their ARICA research project. The project has relatively narrow objectives regarding any social research aspects. Ideally, it would be preferable to explore social aspect more broadly, taking into account political issues, social and cultural issues from a systems perspective. This would require a longer and qualitatively deeper study and a broader analysis which goes beyond the limited scope of this brief.

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