Médecins Sans Frontières benefits from Earth Observation satellite data in humanitarian action

Médecins Sans Frontières (MSF, "Doctors Without Borders") is an independent and international humanitarian organisation which provides emergency medical aid to vulnerable people around the world. Through a long-term collaboration with the University of Salzburg's Department for Geoinformatics (Z_GIS), MSF has been benefitting from a suite of services which make use of satellite Earth Observation (EO), including from Copernicus, to supply information on refugee and IDP camps. The services provided focus on monitoring population dynamics, with a complementary view on contextual, environmental issues in order to serve the information needs of other organisations as well.

Population displacement is a global and growing concern for humanitarian aid organisations. The total number of people forcibly displaced from their homes by conflict, persecution, violence or human rights violations surpassed 65 million in 2015 – the highest number since the United Nations' Refugee Agency (UNHCR) began maintaining such records[1].

Médecins Sans Frontières (MSF, "Doctors Without Borders") is an independent and international humanitarian organisation which provides emergency medical aid to vulnerable people around the world. The organisation recruits thousands of health professionals (e.g. doctors, nurses, midwives, surgeons, anaesthetists, epidemiologists, psychiatrists, psychologists and pharmacists) and support staff (e.g. laboratory technicians, logistics experts, water and sanitation engineers, administrators) which provide assistance to populations in distress: victims of armed conflict, natural or man-made disasters, epidemics or healthcare exclusion. These people are often forcibly displaced, either as refuges (i.e. having crossed an international border) or as IDPs (internally displaced people) within the boundaries of their own country, and a significant portion of MSF's work therefore takes place in the context of refugee/IDP camps or informal, temporary settlements.

Crucially, humanitarian organisations need to keep constant watch over how many affected people are situated in a particular area, and what their needs are. This information is essential for planning purposes, both for the provision of medical services such as healthcare and vaccination campaigns, and for the installation of necessary infrastructure and facilities (e.g. clinics, hospitals, water and sanitation, site planning). Efficient humanitarian aid interventions are only possible when reliable information about the on-site situation is available, yet it is often difficult for humanitarian aid actors to obtain a clear, accurate and up-to-date picture of the current (and evolving) situation on the ground. Refugee camps often arise quickly and spontaneously and existing camps can grow (or shrink) rapidly in size; IDP camps are particularly dynamic. In addition, humanitarian organisations are often unable to physically access areas where vulnerable people are located, and may have only informal, unconfirmed reports on the location and size of affected populations.

Satellite information to the aid of humanitarians

Through a long-term collaboration with the University of Salzburg's Department for Geoinformatics (Z_GIS), MSF has been benefitting from a suite of services which make use of satellite Earth Observation (EO) to supply information on refugee and IDP camps. The collaboration, which began through informal bilateral contacts some eight years ago, has evolved to become a fully-fledged initiative ("EO4HumEn"), with some services being funded directly by the Karl Kahane Foundation as a donor since 2011. Current research activities to provide scientific and technological baselines for the service portfolio are supported by the Austrian Space Applications programme, funded by the

[1] http://www.unhcr.org/en-us/news/latest/2016/6/5763b65a4/global-forced-displacement-hits-record-high.html

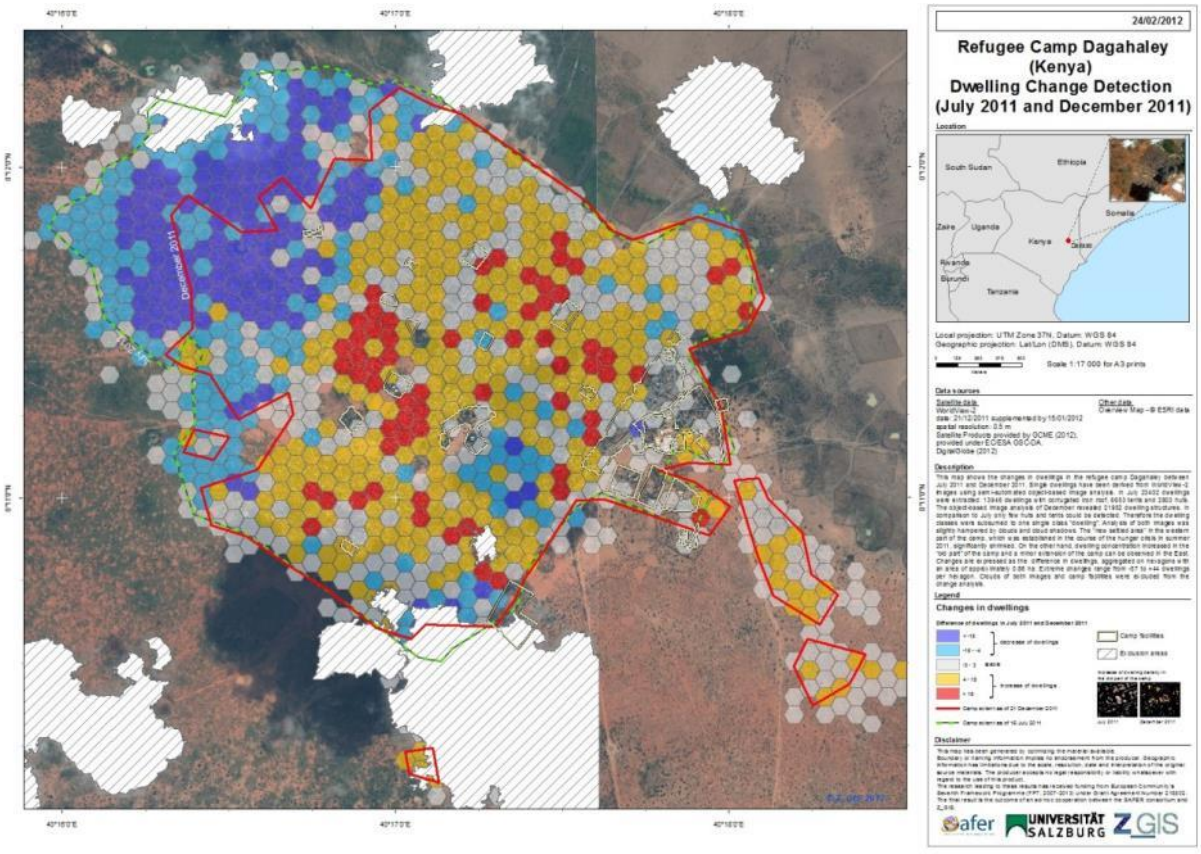
Austrian Ministry for Transport, Innovation and Technology (BMVIT) and the Research Promotion Agency (FFG).
Three types of information service are supplied to MSF under this collaboration, each of which plays an important role in supporting the organisation's work: population dynamics, hydrogeological reconnaissance and environmental impact analysis.

Population dynamics: counting people and understanding the scale of the challenge

Since the situation on the ground at refugee and IDP camps can change rapidly, it is extremely important to understand how the population of such camps is changing, since this directly impacts the number and nature of facilities required. If the camp is growing, it is necessary to know whether the population is approaching a critical threshold (with respect to available resources and infrastructure) and in which direction it is expanding (which affects the planning of new infrastructure).

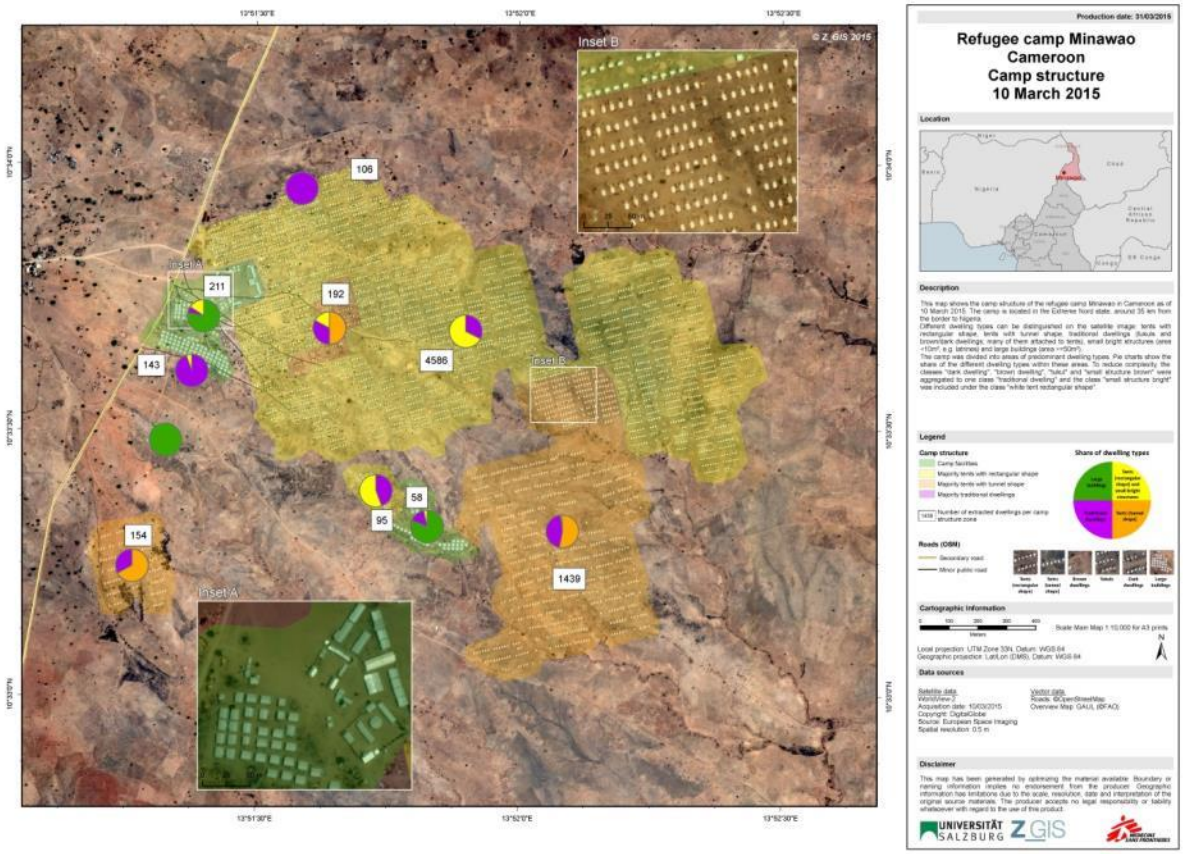
Very high resolution (VHR) satellite imagery can be used to count and classify dwelling structures, which enables an estimation of overall population numbers and their density to be performed. Depending on the camp structure, the degree of contrast in the satellite image and other factors such as the presence of clouds, this work can, to a certain extent, be carried out automatically by image processing algorithms. Imagery analysis of this type serves as the basis for maps like the one below, produced by Z_GIS in the course of FP7 projects such as G-MOSAIC and SAFER (the precursor to the Copernicus Emergency Management Service).

In the example below (produced during the SAFER project), the change in the density of dwellings in the Dagahaley Refugee Camp in Dadaab, Kenya is shown, between July and December of 2011. The camp covers some 8 km^2, and the map reveals that whilst the overall size of the camp had decreased over the time period (shown by comparison between the red and dotted green borders), the density of the camp had actually increased. This type of information supports humanitarian aid planning on a range of issues such as vaccination, nutrition, disease vector control, the deployment of mobile clinics, and the number of health workers required on a site.



Change detection map of dwelling density in Dagahaley Refugee Camp, Dadaab, Kenya in 2011. Red and yellow hexagons indicate an increase in density, blue and purple indicate a decrease. Whilst the overall area of the camp decreased, the density of the dwellings increased. © Credits Z_GIS, MSF.

A more detailed analysis is presented below. Camp structure within specific zones of the camp is shown, based on the distribution and prevalence of certain dwelling types. The Minawao refugee camp in Cameroon spans approximately 2.5 km and is located some 35 km east of the Nigerian border. The zoning map representing and quantifying various internal structures provides an overview of the internal organisation of this camp and its and phases of growth.



Zoning map of Minawao refugee camp in Cameroon showing distribution and share of different dwelling types. © Credits Z_GIS, MSF.

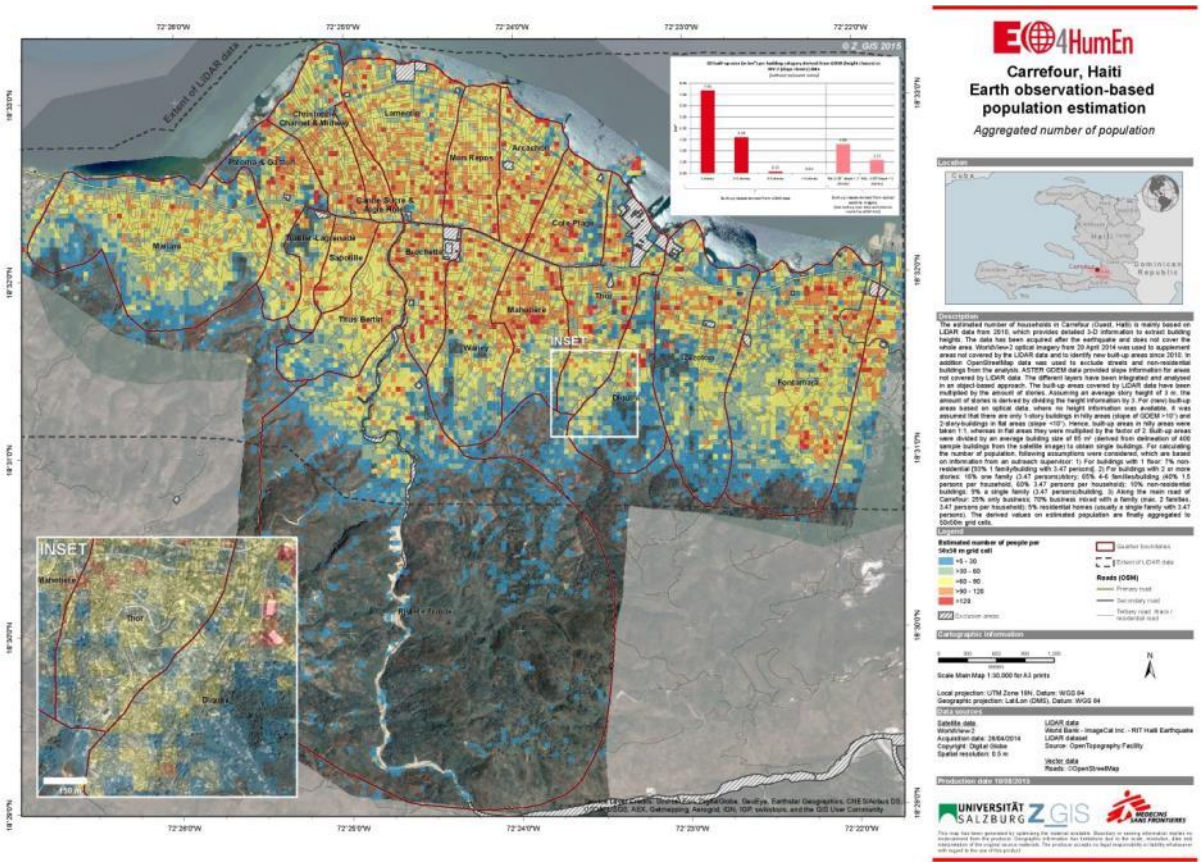
Maps showing the spatial distribution of infrastructure and facilities such as water points and latrines are also provided, and help camp managers to ensure that guidelines (such as those published by UNHCR[2]) on minimum and maximum distances between dwellings and facilities are maintained.

Satellite images are also used to verify information received on the ground about the potential presence of vulnerable populations in remote areas[3]. Whilst such information (which is often delivered by word of mouth) cannot be ignored, it is essential to be able to verify it, in order to deploy the appropriate numbers and types of staff and resources.

Further development work has been carried out in order to adapt this so-called 'population tool' to situations even more complex and difficult to assess, such as those occurring in urbanised areas. In these situations, the temporary shelters of displaced people intermingle with the local host community's dwellings, in semi-structured or informal settlements. The tool can also perform population estimates in urban settings by taking into consideration the heights and functional use of multi-storey buildings; information which can be derived from stereo satellite imagery or in combination with airborne laser scanning data, as in the case of Carrefour in Haiti shown below.

[2] E.g. http://wash.unhcr.org/download/design-guidelines-for-piped-water-networks-in-refugee-settings/

[3] See Füreder et al. 2015, Monitoring Displaced People in Crisis Situations Using Multi-temporal VHR Satellite Data During Humanitarian Operations in South Sudan.



Population estimation derived from Earth Observation in the municipality of Carrefour, Haiti. This kind of spatially detailed information provides a solid basis for supporting decision-making in medical treatment campaigns. © Credits Z_GIS, MSF.

Mapping environmental resources in the surroundings of the camps

The following case illustrates the potential for further application areas which fulfil the general information requirements of other humanitarian NGOs as well. Research at Z_GIS continues to extend the service portfolio to cover more of the diversified needs of the humanitarian action community.

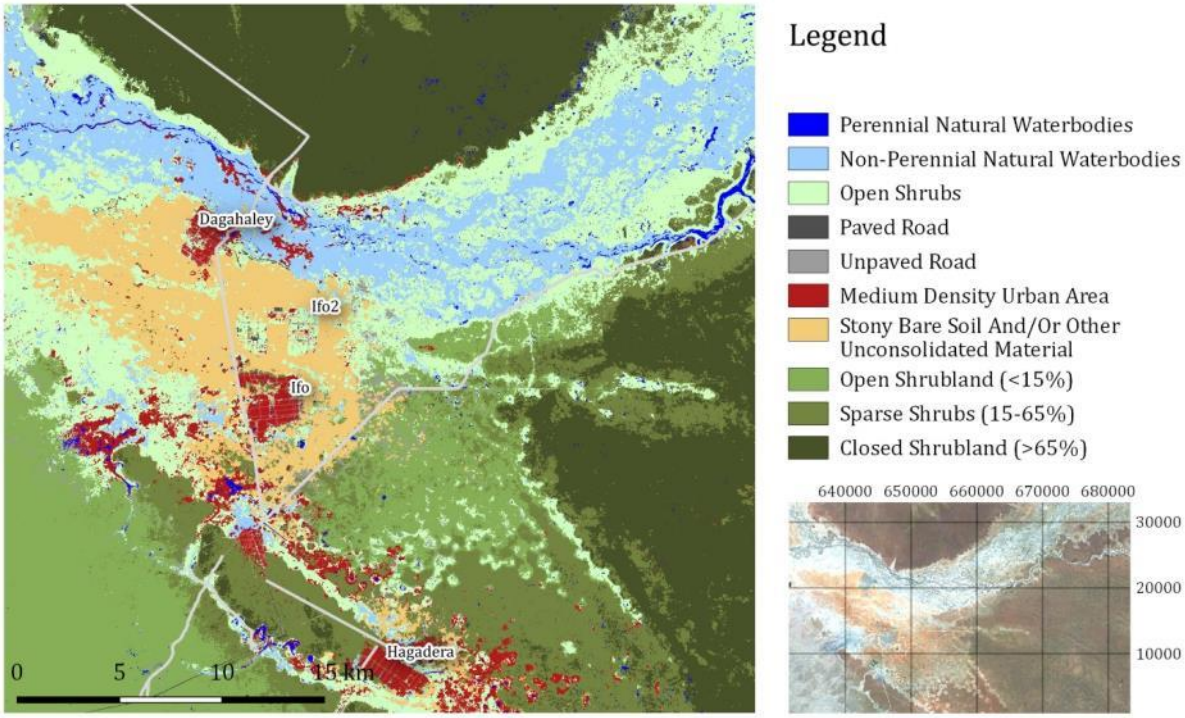
One of the most important resources for ensuring safe and healthy living conditions in temporary settlements is potable water. It is vital for nutrition (drinking and cooking), hygiene (bathing, cleaning of food) and sanitation, and access to water is therefore one of the main considerations for humanitarian aid workers involved in camp management or planning. Finding new sources of water can be a challenging task, but satellite imagery can reduce the burden of work required and improve the effectiveness of groundwater exploration activities. Imagery from satellites, such as Copernicus' Sentinel-2, is used alongside several other sources of information (available borehole data and geological maps, digital elevation models, road network, local expertise, etc.) to supply maps which help to detect the locations of potential drilling sites, or which offer recommendations for further investigation on the ground. Satellite images can also be used to understand whether there are seasonal water bodies in the vicinity of the camp.

The image below shows part of a hydrogeological reconnaissance map in the area surrounding the Kule camp hosting South Sudanese refugees located near Gambella, Ethiopia. It indicates the presence of two potential drilling sites for new boreholes, the location of an existing camp and borehole, and the potential site of a second camp.

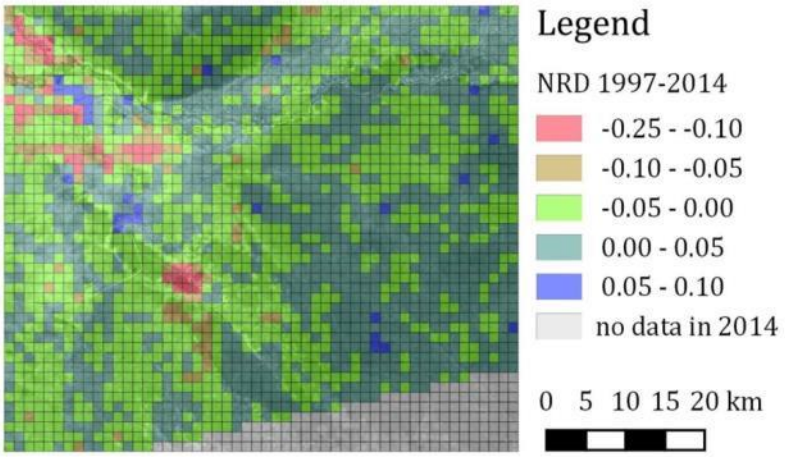
Hydrogeological reconnaissance map, Gambella, Ethiopia. © Credits Z_GIS.

As camps grow, it is important to have an updated overview of the long-term impact on the natural environment and its resources in the surrounding area. The impacts on the environment of displaced populations include deforestation, soil erosion, and the depletion and/or pollution of water resources, all of which can take a toll on the local population, and even on the camp itself.

The two images below demonstrate the kinds of analysis possible using satellite imagery, such as that obtained from the Copernicus Sentinels, including radar data obtained by Sentinel-1 which was used as complementary information. The first image shows the land use and land cover in the area around the Dagahaley Refugee Camp in Kenya, mentioned above. The second is an analysis published by Hagenlocher et al. (2012) and Braun et al. (2016) which shows the Natural Resource Depletion Index (NRD) for the same camp.



Land use and Land Cover Map, Dagahaley Refugee Camp. © Credits: Z_GIS, Uni Tübingen.



Natural Resource Depletion (NRD) index, Dagahaley Refugee Camp (Hagenlocher et al. 2012 and Braun et al. 2016). © Credits Z_GIS, Uni Tübingen.

This kind of information can be invaluable for monitoring the impact of the camp on the immediate environment, as well as for planning reconstructive interventions after camps have been dismantled.

Conclusion

The examples above demonstrate how satellite-based information products have come to support the work of Médecins Sans Frontières in managing and analysing displaced populations or people in need, in the context of a collaboration which has gradually evolved from a proof-of-concept to an operational reality. Further research widens both the scale and the context for which those information products are designed, including the exploitation of satellite data provided by the Sentinel family.

Stefan Lang, Z_GIS research coordinator, and initiator of the MSF cooperation stated: "*From the early days of our collaboration we believed that geospatial technology would make a change in the domain of humanitarian action. Within just a few years, it has turned out to be quite true. Spatial data is widely available nowadays from various sources, but it does not necessarily meet the real requirements 'in the field'. A long-standing partnership characterised by mutual understanding and trust allows these information needs be to revealed, and enables the transformation of raw data into genuinely valuable information.*"