Monitoring Refugee/IDP Camps to Support International Relief Action

Olaf Kranz[1], Gunter Zeug[2], Dirk Tiede[3], Stephen Clandillon[4], Denis Bruckert[5], Thomas Kemper[2], Stefan Lang[3], Mathilde Caspard[4]

1 German Aerospace Center (DLR), German Remote Sensing Data Center (DFD), Civil Crisis Information & GeoRisks, Oberpfaffenhofen, Germany
2 European Commission Joint Research Centre, Global Security and Crisis Management Unit, Geospatial Information Analysis for Global Security and Stability, Ispra (VA), Italy
3 University of Salzburg, Centre for Geoinformatics, Salzburg, Austria
4 Sertit, Illkirch, France
5 European Union Satellite Centre, Torrejon de Ardoz Madrid, Spain

Introduction

According to the United Nations High Commissioner of Refugees (UNHCR), approximately 42 million people were forcibly displaced worldwide at the end of 2008. This includes 15.2 million refugees, 827,000 asylum-seekers and 26 million internally displaced persons (IDP) (UNHCR, 2009c). IDPs are people who had to flee or to leave their homes but stayed within their country of origin without crossing any international state border (IDMC, 2009).

Darfur is only one of many conflict areas in Sudan, the country with the single largest internally displaced population in the world (IDMC, 2009). The conflict in Darfur is caused among other factors by fights for diminished drought affected resources and demands for greater political autonomy; almost 50% of Darfur's total population of about 6 million people, were internally displaced by January 2009. An additional 250,000 people are living in refugee camps across the border in Chad (IDMC, 2009).

Figure 1: Makeshift shelters and new tents in a section for new arrivals at Ifo, one of the three refugee camps at Dadaab in north-east Kenya (UNHCR/E. Hockstein 2009).

Refugees and IDPs live in widely varying conditions, from well-established camps to provisional shelters or at worst in the open. Besides the UNHCR many other mainly non-profit organizations address the problems of refugees and IDPs. The management of refugee camps is of particular concern. Uncontrolled growth and arrival of new migrants, environmental pollution and degradation, water supply and sanitation, health and hygiene, plus security are only a few of the challenges facing the humanitarian community (fig. 1 and fig. 2).

This underlines that the establishment and management of refugee/IDP camps require joint efforts by the aid agencies involved and if possible local authorities. The supportive role of geoinformation and mapping tools within this context has been demonstrated in various situations that will be outlined in more detail in the following.

A refugee/ IDP camp monitoring service

Within the recent European Commission funded GMES- project LIMES a working group was established addressing especially humanitarian issues. Among others a specific service supporting refugee/IDP camp management with geoinformation products was successfully set up. Partners brought together their expertise in humanitarian relief, earth observation, geodata processing and analysis, statistics and modelling, to monitor the status of the camps, their growth over time and the environmental situation in the vicinity of the camps. Estimation of population figures from satellite data was another objective of the service providers. Population numbers are crucial information to enhance the logistical support of relief organisations to provide water, shelter and security.

In the present stage of the project (2006 2009) the LIMES refugee/IDP camp monitoring service was requested three times to monitor a total of eight refugee/IPD camps throughout Darfur and Eastern Chad. The work was requested by the Directorate-General for External Relations of the European Commission (DG RELEX), the European Forces (EUFOR) Chad/RCA and the World Food Programme (WFP).

DG RELEX asked for support to monitor the camps of Zam Zam, located 10 km southwest of El Fasher, the capital of North Darfur, and Zalingei a city in West Darfur home to the two large IDP camps at Hassa Hissa and Hemidya. The camps of Kerfi and Abdi are located in eastern Chad and were requested to be mapped by EUFOR. The WFP also intended to launch a pilot-project for camp population estimates. The camps selected for an initial investigation were Dorti and Ardamata in West Darfur close to the city of El Geneina as well as Um Dukhum about 250 km further south close to the Chadian border (fig. 3).

Figure 2: Thousands of people flee the IDP site at Kibati, in Democratic Republic of the Congo's North Kivu province, after hearing gunfire (UNHCR/P. Taggart 2009).

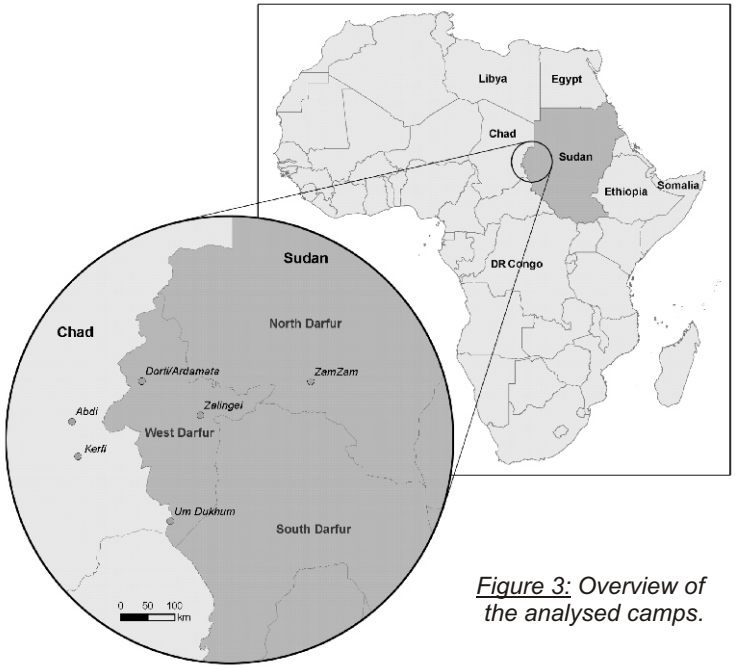

Figure 3: Overview of the analysed camps.

The requirements

The general requirements expressed by the requesting organisations were to gather information facilitating a better view of the situation in and around the camps. DG RELEX and EUFOR were interested in assessing the current size of the camps by means of their geographical extents, recent developments, as well as an estimation of the population currently living in the camps. Furthermore, the growth of the camps over time was analyzed to obtain a better understanding of the situation and to draw conclusions for potential further developments.

Another topic of great interest was the impact of the camp development on the surrounding environment. In combination with population figures this might indicate a potential source of future conflict about natural resources, thus mitigating conflicts between refugees/IDP's and host communities.

Besides the above-mentioned two organizations, WFP requested an evaluation of the use of satellite imagery for deriving reliable population estimates of refugee camps for the entire Darfur. The case study aimed to assess the ability of very high resolution (VHR) satellite data together with limited field surveys, to estimate the overall camp population. Furthermore, the scalability of the earth observation methodology should be tested to cover all IDP camps in the three Darfur regions in a future study and for periodic updates.

The Solutions

The monitoring of the size and growth of the camps made it necessary to acquire very high resolution (VHR) satellite imagery. State-of-the-art very high resolution optical satellite sensor technology can provide imagery with a spatial resolution between 0.5 and 1 metre. These resolutions allow a detailed view of the situation on the ground. Buildings, tents, walls and streets as well as vegetation can be visually clearly distinguished. As most camps have existed since the beginning of the conflict in 2003, the monitoring of the camp growth started with satellite imagery from around that year, depending on the availability of data.

Additional geoinformation such as camp boundaries were provided by the customers, as well as digitised by the team. Further information was obtained from published literature, the internet and oral communications with members from relief organisations such as Médecins Sans Frontières (MSF), UNHCR and Intersos. WFP provided GPS ground control points as well as photographs from the respective camps.

Together with a visual interpretation, the analyses utilised semi-automated information extraction methods. Two different object-based image analysis methods (OBIA) combined segmentation, class modelling and knowledge representation techniques. A third approach was based on the analysis of shape and form of the dwellings using mathematical morphology (Kemper et al., 2010). For the camp structure and dwelling density mapping two aspects of the evolution of the camps were analysed (Kranz et al. 2009a): firstly, the growth of the camps from 2002 (Zam Zam), 2004 (Zalingei), and 2006 (Kerfi & Abdi) until 2008, including the structure of the entire populated area in terms of camp area, traditional settlements and dwelling densities; secondly, the number of dwellings in the camps in order to derive an estimate of the number of people present.

Initially an OBIA rule set was developed for the 2004 Zam Zam imagery. Afterwards it was modified and optimized to be transferable to the other regions/camps and different satellite images. In addition, another OBIA rule set was developed for the camps in Chad (Kerfi & Abdi) to cope with the different structure of the camps and for combining the expertise within the group of researchers in the most effective way (Kranz et al., 2009b). This approach of joining the expertise of different research groups was continued and extended to a comparison of different methodologies at the request of WFP. The overall aim was besides generating relevant information for the costumer to further optimize the developed methods and

processing chains to finally derive a more robust OBIA rule set, leading to more reliable results in general. The camp areas were delineated automatically according to a certain threshold in dwelling density.

IDP or refugee camps themselves have an impact on the surrounding environment due to the additional demand of the scarce local resources such as water, grazing areas and firewood. Estimating the magnitude of such impact is of considerable importance with respect firstly to the sustainability of camps and secondly to conflict prevention. There is growing concern about the environmental impact of Darfur's conflict, in particular the impact on Darfur's wood resources which were already being depleted at an estimated rate of 1% per annum before the conflict (UNEP 2008). In situations such as Darfur this depletion also has an impact on the security of the IDPs because the depletion of resources forces them to collect firewood further away from the camps, increasing the risk of attack (UNEP, 2008). The detection and, where possible the quantification of this impact, may provide important information for the management of these camps. A standard application for the detection of changes with satellite imagery is the analysis of archive satellite data with coarse geometric but high temporal resolution for a defined observation period. Such an analysis aims to detect spatial trend patterns, which are an important factor in long-term environmental studies. In this study a time-series analysis of MODIS satellite data from January 2002 to July 2008 was based on the calculation and comparison of the Enhanced Vegetation Index (EVI) of 16-day maximum value composites with a spatial resolution of 250m.

Results

Camp population estimates

Satellite-based extraction of dwellings does not provide rigorous evidence of the actual number of people present at the time of data capture. However, the number of satellite data derived "dwellings" provides a proxy for the number of people present at the time of data acquisition. As no field data about the average household sizes per tent were available for Zam Zam and Zalingei, three different scenarios were generated for the estimation of population figures. These were based on the number of extracted dwellings, various figures from published literature (Giada et al., 2003; Bush, 1988; UNHCR, 2006) and oral communications with Médecins Sans Frontières (MSF), Intersos and UNHCR. Depending on the particular scenario used for the dwelling extraction from the satellite images, these figures have shown good agreements with official population data from the Humanitarian Needs Profile (HNP) of UN OCHA (United Nations Office for the Coordination of Humanitarian Affairs) (OCHA, 2007).

One of the main requests of the WFP was the estimation of population using the number of dwelling structures as a proxy. To obtain a reference dataset, visual interpretations were carried out, as it was assumed that this method would provide the most accurate results for mapping single buildings within the IDP camps. This reference data served then as a comparison of four automatic or semi-automatic extraction approaches. The four methods showed different results. A common problem with all methods was that side-by-side buildings were detected as a single building leading to an underestimation of the number of dwellings. Some buildings were not automatically recognized, because they have similar spectral characteristics as ground. In contrast, an overestimation was observed in other parts because potential "buildings" proved to be fences, shadows or bare soil.

The results show a large variation between the different approaches, reaching more than ± 30% difference between automatic and visually counted dwellings (Table 1).

Method	*Dorti*	*Ardamata*	*Um Dukhum North*
Visual Interpretation	3636	6394	14257
OBIA 1	2352	4869	10281
OBIA 2	2523	3965	15349
Pixel-based Approach	2142	3368	12277
Mathematical Morphology 1	2806	6938	14032
Mathematical Morphology 2	2800	5800	18650

Table 1: Dwelling estimates for the three camps using different approaches

The largest differences occur in the northern part of Um Dukhum, which can be attributed to the fact that this camp is much more widespread, including more open spaces, trees and rock outcrops compared to Dorti or Ardamata sites. Also there is no clear separation between host community and IDP's and there was no camp map available that would allow the exclusion of public facilities. The table shows that there is no clear pattern to be followed. A final assessment of the accuracy will be possible only with field assessments (the field validation planned for October 2009 had to be interrupted for security reasons).

IDP camp structure and dwelling densities

For the Zam Zam and Zalingei camp sites the monitoring of developments between 2002, 2004 and 2008 reveals a major increase in the number of dwellings between 2004 and 2008. Further analysis encompassed density calculations to create dwelling density maps (dwellings per square km), based on the semi-automatically extracted dwellings (fig. 4).

Rapid, partly automated mapping techniques were also applied to analyse the situation in the two camps of Kerfi and Abdi. Results were provided well within 44 hours after data reception as requested by EUFOR. Operational products were generated, highlighting areas of high density dwellings and tents as well as newly settled areas. Up-to-date land use/cover information maps were derived using the surroundings, camp limits, settlement infrastructure and single dwellings as indications of human presence.

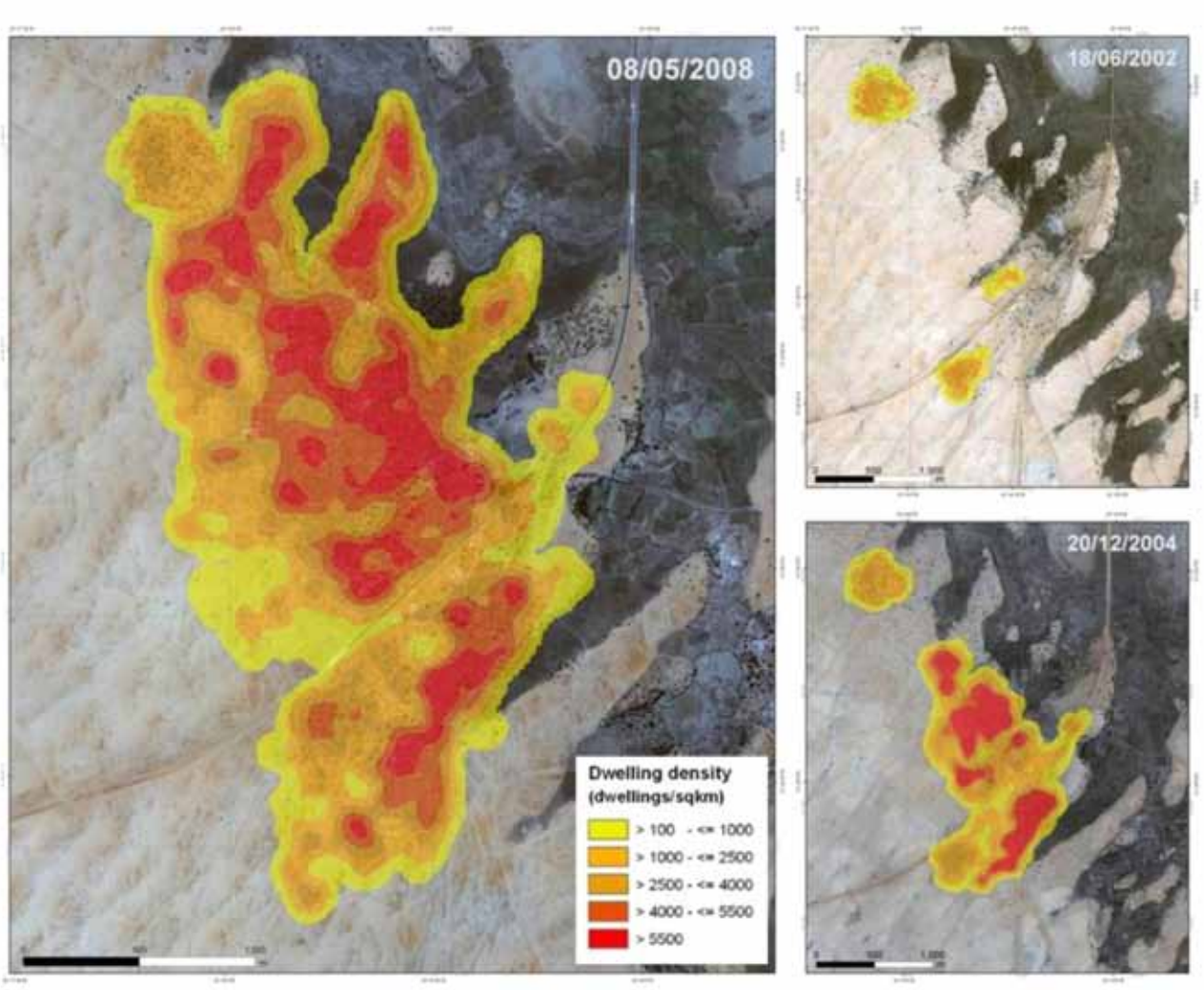

Figure 4: Dwelling density map for Zam Zam IDP camp at three different dates (2002, 2004, 2008).

Environmental impact assessment

The impact analysis for the Zam Zam camp is illustrated in Figure 5. The significantly degraded areas are all on the western side, within 5 to 10km of the camp. Areas closest to camps are generally more secure and are hence the most exploited. IDP's from a camp at Abu Shouk in Al Fashir (approximately 20km away) recently reported that it takes seven days to collect one cart-load of wood (UNEP, 2008). Despite the coarse resolution, the MODIS satellite data provides valuable information for evaluating the impact of IDP camps due to its ability to identify even subtle changes and the availability of long time-series over large areas. The quantitative information may be used to enhance the qualitative information (e.g. UNEP, 2008) available from higher resolution data.

Conclusions

The requests described in this paper were prepared in close cooperation with the end user to ensure that the final maps and interpretations provided the maximum possible benefit and support for the planning of the mission of the respective organizations in the conflict region. The general feedback from the user organizations was very positive but nevertheless there is still space for further improvements.

Remote sensing offers a safe way of analysing refugee/IDP camps and gathered information can be an important contribution to logistical issues of relief organisations. Optical satellite data can be used for an extraction of camp extents, infrastructure, numbers and types of buildings as well as population estimations and monitoring of refugee/IDP camps. However, improvements in single automatic processing steps are still necessary, e.g. the extraction of single dwellings from the imagery, which serves as basis for obtaining reliable population estimates.

Cooperation between a number of partner organizations in these joint activities has demonstrated the advantages of bringing together their different capacities and areas of expertise to provide rapid support to mission planning within the context of a complex crisis situation. Such mutual efforts result in sound and reliable information products that can be rapidly distributed to the requesting organisation. Improvement and expansion of future services, would include the detection and monitoring of other important natural resources such as water.

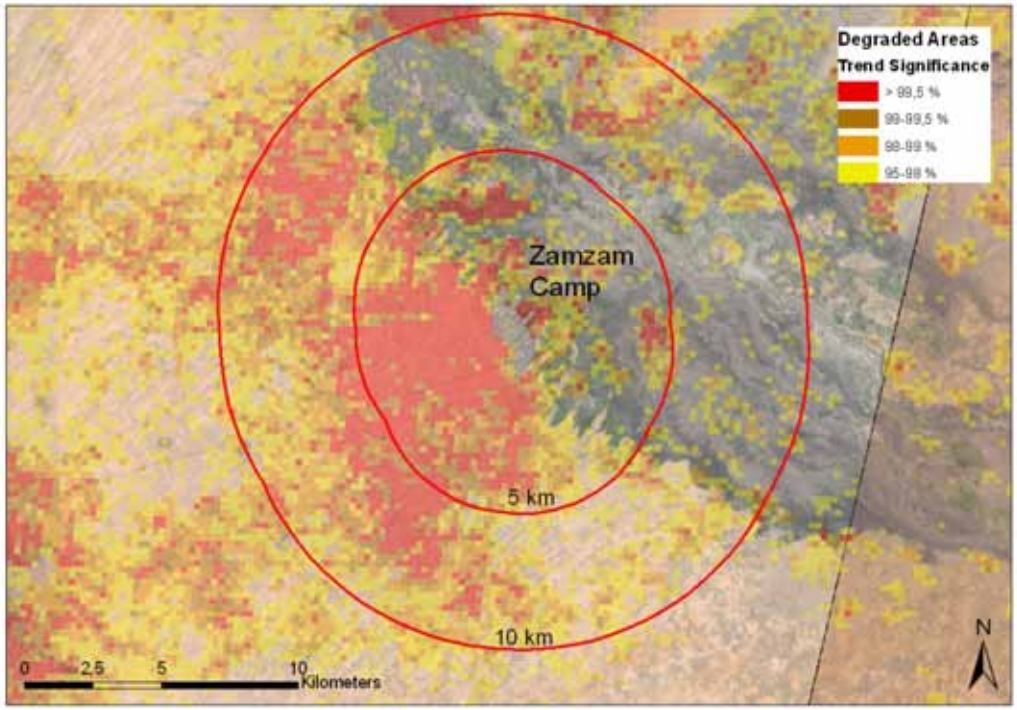

Figure 5: Trend analysis results for Zam Zam camp (orange) withy a 5 km buffer around the camp. The coarse red-transparent pixels show areas with a significant negative trend derived from a modified seasonal Mann-Kendell test.