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Report

Supporting Management of Refugee Streams by Earth Observation and Geoinformation

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Keywords: Refugee streams, data mining, Earth observation, detecting habitation reserves

Summary: The sharp increase in refugee numbers arriving in the European Union has recently caused major and manifold challenges for the member states and their administrative services. Location based situation reports and maps may support the refugee management from local to European level. The first support is mapping of the geographical distribution of migrating people which needs more or less real time data. The actual data sources are location related observations along the routes of refugees, actual satellite observations and data mining results. These tools and data are used to monitor spatial distributions as well as extrapolate the arrival of refugees for the subsequent weeks. The second support is the short-term update of the location of initial registration facilities and first reception facilities, their capacities, and their occupancy. The third support level is the systematic inquiry for unoccupied housing facilities and for empty places within build-up areas. For this purpose Geo-coded datasets of house numbers have to be cross-referenced with city maps and communal inhabitants address data. However, the paper will not disclose scientific progress in Earth Observation and GIS, but will actually demonstrate that a new combination of existing methods is required to support actual data needs for improved refugee management and integration. The examples show that EO/GIS cannot only theoretically provide societal benefits. The results can play an important role in factual political, administrative and humanitarian day-to-day reality.

Zusammenfassung: *Unterstützung des Flüchtlingsmanagements durch Erdbeobachtung und Geoinformationstechnologien*. Der starke Anstieg der Anzahl der Flüchtlinge, die in der Europäischen Union ankommen, stellt aktuell die Mitgliedsstaaten und ihre Verwaltungen vor vielfältige Herausforderungen. Standortbezogene Berichte und Karten können das Flüchtlingsmanagement sowohl auf europäischer als auch auf kommunaler Ebene unterstützen. Die erste Unterstützung ist die Kartierung der räumlichen Verteilung von Migranten, was mehr oder weniger Echtzeitdaten erfordert. Die derzeitigen Datenquellen sind standortbezogene Beobachtungen entlang der Flüchtlingsrouten, aktuelle Satellitenbeobachtungen und Ergebnisse des so genannten Data-Mining, d.h. Wissensentdeckung in Datenbanken. Diese Werkzeuge und Daten werden verwendet, um sowohl räumliche Verteilungen zu überwachen, als auch die räumlichen Flüchtlingsankünfte der folgenden Wochen zu extrapolieren. Die zweite Unterstützung ist die kurzfristige Aktualisierung von Personenregistrierungseinrichtungen und Erstunterkünften, ihrer Kapazitäten und ihrer Belegung. Die dritte Unterstützungsebene ist die systematische Erfassung von Leerständen und Baulücken. Zu diesem Zweck werden Gebäudekatasterdaten mit den Einwohnermeldedaten verknüpft. Der Artikel zeigt keinen wissenschaftlichen Fortschritt der Erdbeobachtung und Geoinformation auf, sondern demonstriert, dass eine neue Kombination existierender Methoden erforderlich ist, um den aktuellen Bedarf für verbessertes Flüchtlingsmanagement und die Flüchtlingsintegration zu unterstützen. Die Beispiele erläutern, dass Erdbeobachtung und Geoinformation nicht nur theoretisch gesellschaftlichen Nutzen liefert. Diese Ergebnisse können eine wichtige Rolle für die tatsächliche politische, verwaltungstechnische und humanitäre, tägliche Realität liefern.

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1 Introduction

The sharp increase in refugee numbers arriving in the European Union has recently caused major and manifold challenges for the member states, their security forces and administrative services. The actual situation of refugees in Europe will require long-term collaboration of different member states and, in Germany, the collaboration at all administrative levels and territorial units. Location based situation reports and maps may support the refugee management from local to European level.

Persons arriving at the outer borders of the European Union have had mostly endured enormous stress and pain during their migration. They have dared to leave their home environment because of severe circumstances such as famine, natural hazards, political pressure, ethnical or religious conflicts, warlike operations, destruction of infrastructure and housing or other aspects of living in misery.

The following contribution aims at outlining the challenges in the management of the refugee streams that currently are or can be met with the aid of what is called GeoIT. GeoIT comprises the totality of hardware, software, techniques and/or methods for the acquisition, analysis and presentation of geographical data and spatial information in diversified technological pillars like remote sensing, satellite navigation or Spatial Data Infrastructures (SDI).

2 Actual Challenges and Solutions in Europe

2.1 *Monitoring Migrating People*

Earth observation is an appropriate tool to monitor migrating people, especially due to the flexible acquisition capabilities of the satellites with a ground sampling distance smaller than one metre. Fig. 1 shows a time series of such images with the northern part of the train station of Idomeni, a Greek town just south of the border with Macedonia, indicated by the red dotted line in the Fig. 1a.

Figs. 1b – 1d show at the bottom some houses of the northern fringe of the town and the train station with several parallel tracks which are merging at the level crossing into one single track departing towards Macedonia. Between the two level crossings there are on the East side some sheds or bigger tents, already some more than on the November image. Additionally three bigger tents have been built up west of the railway. Two months later the number of white greater tents has increased and several fields are crowded by hundreds of small shelters and even people walking and resting on railway dams (Fig. 1c). Finally, Fig. 1d of 19.3.2016 shows further development with greater containers and provisional shelter buildings, but also additional shelters and tents with more than thousand persons estimated.

Fig. 1: Time series of World-View-2 satellite images of the northern part of the train station. Images a) from 4.11.2015; b) from 21.1.2016; c) from 2.3.2016; d) from 19.3.2016. © Digital Globe, provided by European Space Imaging.

Such an evaluation and appropriate interpretation of images needs experienced experts of remote sensing, which are not necessarily available in all administrations concerned by such a crisis. Therefore, it has turned out very helpful to provide value-added information products through specialized expert services even to those who are not familiar with the interpretation of satellite images.

The first level of support is the supply of value added information on the geographical distribution of migrating people which needs more or less real time data to deal with the exceptional circumstances in Central Europe. Therefore, a bundle of methods and techniques on the GeoIT sector needs to be applied under special legal frame conditions for access to administrative data and their incorporation into spatial processing. Within the European Union there is a legal basis for the administrative data exchange established through the INSPIRE directive (European Parliament and Council of the European Union 2007) under which not only the administrative framework but also the harmonization of data exchange formats were developed.

Esri Germany has developed an international relief program: the Esri Disaster Response Program (DRP). This is a complete GeoIT software which will be granted free of charge to build up an integral information platform reserved to administrative application (Esri 2016). The actual data sources are location related observations from police forces of different member states along the routes of refugees between the Mediterranean shores and the Northern member states of the EU, from NGOs, private observations by cellular phones, actual satellite and aerial images and further information from data mining activities. These tools and data are already used to monitor the southern spatial distributions of refugees as well as to extrapolate impending arrivals in subsequent weeks.

The International Organization for Migration (IOM) was created in 1951 out of the chaos and displacement of people across Western Europe following the Second World War under the name of the "Provisional Intergovernmental Committee for the Movement of Migrants from Europe". Today, it has the status of a worldwide operating agency with 162 member states and an annual budget of 1.3 billion USD (IOM 2016). Among others IOM provides different surveys on migration updated nearly weekly, like the example of stranded migrants and refugees between Turkey and south-eastern Europe (see Fig. 2).

Another example is taken from IOM survey activities with migrant questionnaires about routes, organization and prices paid for the transfers to the date of 14 March 2016 (see example Afghanistan in Fig. 3).

Furthermore within the member states concerned, the administrations have already installed online platforms for existing infra-

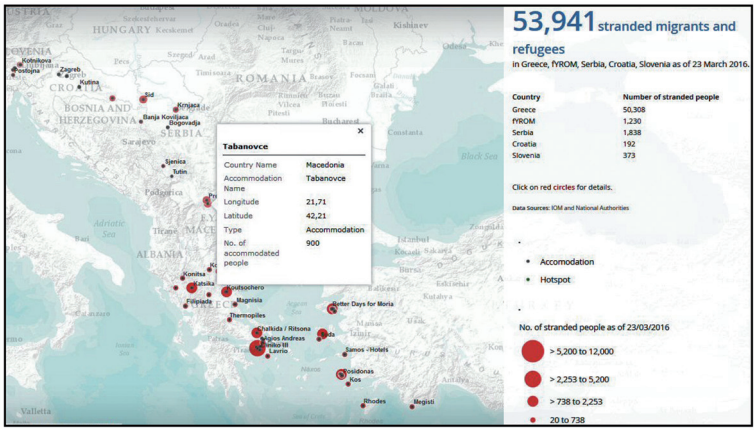

Fig. 2: Interactive map monitoring of stranded migrants as of 23 March 2016 published by IOM platform for monitoring and analysis (IOM 2016).

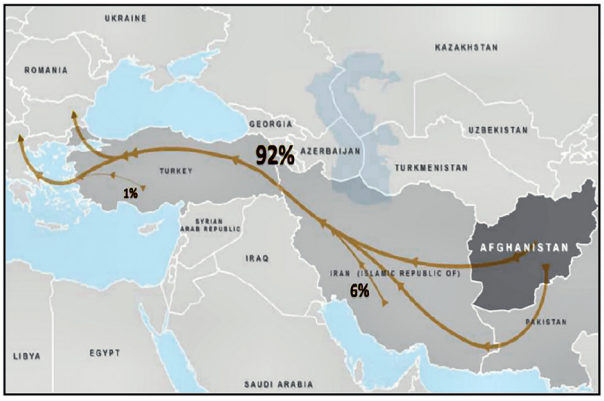

Fig. 3: Survey of migrant flow monitoring – results for Afghanistan migrants (IOM 2016).

structure for arriving refugees such as interactive maps of initial reception facilities and local immigration offices. While in Germany the central services are organized by the BAMF – Federal Office for Migration and Refugees and the GeoIT services by the BKG – Federal Agency for Cartography and Geodesy (BKG 2016), there are various local initiatives developing migrant oriented city maps for mobile devices.

2.2 *Migration Potentials in the Regions of Origin*

The ad hoc reaction on streams of migrating persons between Turkey, the Maghreb states and Europe is only one side of the problem. A closer view on the regions of origin will become more important in the forthcoming years. The knowledge of actual trends in settlement sprawl and urbanization, rural land use and agricultural production in relation to population dynamics, employment, health and educational infrastructure needs to be urgently improved and updated regularly. Earth Observation in combination with geo-statistics and GIS techniques can be supportive to increase that knowledge which in turn can be used for an improved decision making towards better living conditions in Africa as recently pointed out by Komp et al. (2010).

There is a constant growing migration potential in sub-Saharan Africa for various reasons. The growing numbers of war lords and Islamic terror groups besides tribal conflicts have deteriorated the living conditions for wide areas. Dangerous prospects of survival following the burning down of villages, kidnapping and tortures have often hindered the agricultural work and the cattle transhumance. These were the widespread reasons why agricultural areas could not be tilled in due time which can be seen as an additional factor for yield reduction besides agro-climatic failures. Today, the Famine Early Warning System network (FEWS Net 2016) publishes worldwide geospatial analyses to anticipate impending famines and advise policy makers on how to prevent or mitigate such famines. More than 20 institutions collaborate to analyze different satellite data, agro-climatic reports, environmental and food market issues, rainfall estimates and weather patterns such as El Nino and La Nina events. Besides several American agencies, partners also include the Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel in West Africa and the Food Security and Nutrition Analysis Unit in Somalia.

One of the service products of FEWS Net is the analysis of the actual food insecurity in countries under observation in Central America, tropical Africa and Middle East. Besides the actual evaluation, FEWS also creates a prediction for the forthcoming period, for instance the publication in March (October) 2016 of food insecurity for the period June to September 2016 (October 2016 to January 2017) displayed in Fig. 4 (FEWS Net 2016).

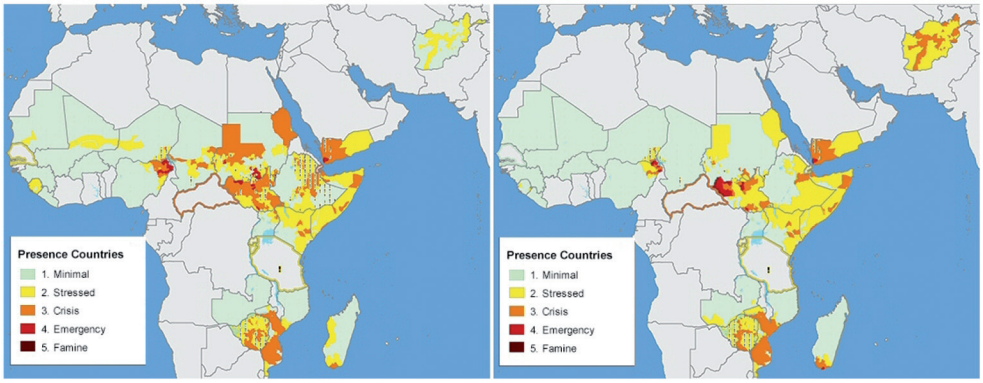

Fig. 4: Acute food insecurity in Africa and Middle East predicted in March 2016 for period June – September 2016 [left] and in October for period October 2016 – January 2017 [right] (FEWS NET 2016).

The regions classified as "emergency" or "crisis" are concentrated around the Lake Chad, the western and eastern parts of Sudan, South Sudan, the northern part of Ethiopia, Djibouti and the western part of Yemen. With respect to the political and economic situation in those countries, there will be no major change without aid from outside, which means that there is an increasing probability that parts of the population concerned will try to emigrate.

In 2003, another approach to the problem was launched by the European Space Agency (ESA) as a contribution to the joint EU/ESA program Global Monitoring for Environment and Security (GMES), recently renamed COPERNICUS. It is called Global Monitoring for Food Security (GMFS) and was an ESA Earth Watch GMES Service Element, initially designed for nine African countries and coordinated by VITO from Belgium. With a focus on remote sensing, the methods and results have already been reported to the ISPRS in Melbourne by KOMP & HAUB (2012). Furthermore, the combination of evaluated SAR data, classified SPOT data and stratified agro-statistical ground sampling (cf. LUCAS method at EUROSTAT 2016) has been developed and implemented by EFTAS in its role as GMFS coordinator for East Africa (HAUB et al. 2013). The adapted method and all tools were handed over as a result of the technology transfer to the responsible user, the Federal Ministry of Agriculture and Irrigation of Sudan.

2.3 *Locational Inventory of Facilities and Capacities*

The second level of support comprises the short-term update of the location of initial registration and initial reception facilities, their capacities, and their occupancy classified according to ethnical or national criteria. In the case of Germany, there is a Federal Coordination Office (KoSt FV Bund) which is mandated to support the management and distribution of refugee streams by coordination on the federal level. This office is supported by the Federal Office of Civil Protection and Disaster Assistance (BBK) through graphical transfer of listed data into geo-spatial views on the actual situation of refugee arrivals. Additionally, the Center for Satellite Based Crisis Information (ZKI), located at the German Aerospace Center (DLR), provides actual satellite data from the relevant border checkpoints.

The federal state Rheinland-Pfalz for instance has established within its central data processing center a GeoIT infrastructure for the management of refugees in the shortest delay, based on the participation in the DRP program. The actual demand for spatial information is concentrated on the design and operation of initial reception centers, their capacity and occupancy, identification of public immovables and the update of that information. With respect to copyright and privacy restrictions, Fig. 5 does not show up-to-date details

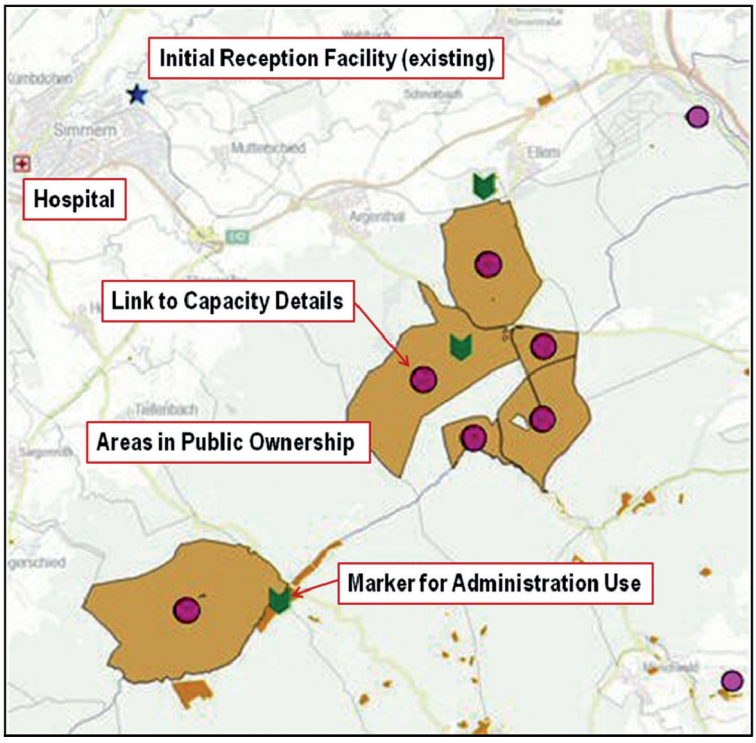

Fig. 5: Administrative Web Portal for infrastructure and potential areas for refugees in public ownership (Bernkastel-Wittlich 2016).

but has been selected to give a good impression of the working results.

Presently, such GIS-based solutions are under operational application in the Ministry of Interior Affaires and subordinated services. Further applications will be made available through personalized accounts to interested user groups within the administrations of regional or communal level. The services of the state central data processing center of Rheinland-Pfalz will be made accessible through a cloud service by Esri Germany.

Another geo-spatial application is going to be distributed on communal level, but in relation to central design. In the federal state of Niedersachsen the publication of special city maps for refugees is promoted based on the model of the city of Obernkirchen. The thematic content of the city map has here and in other places always been developed local citizens in voluntary work to help the refugees in orientation and integration. The regional directorates within the State Office of Geoinformation and Surveying Niedersachsen (LGLN) support interested cities that plan to prepare annotated city maps considering the basic needs of refugees (following the example displayed in Fig. 6). Indications and map signatures for doctors, pharmacies, bus stops, schools or second hand clothing are mapped and explained in a multilingual legend that comprises German, English, French, Arabic, Russian, and Albanian.

3 Supporting mid-term Integration Strategies

As those initial reception facilities should have only transitional character, people have to be offered specific and affordable housing facilities which will allow integration, education, vocational training and employment. Because labour in many parts of Europe main-

Fig. 6: Special City Map for Refugees of the City of Obernkirchen with a legend in six languages (Stübke 2015).

ly focus on sectors other than agriculture, it is very likely that immigrants will apply for work in towns and cities and will also seek urban housing space. The environmental development targets to limit additional land consumption require nota bene urban densification. This can be done primarily by filling up existing vacancies and secondly by activating gap sites within the urban perimeters.

Furthermore, the fact that a considerable part of refugees could not benefit from school education during war and migration, they not only have to learn a new language, but in many cases also catch up basic alphabetization. All infrastructures necessary for obtaining language command, school-leaving qualification and professional qualification in the European frame will only be available in towns or cities. Therefore, European cities will have to deal with a remarkable increase in population, which will again require increasing capacities of crèches, day care centers, schools and vocational training centers.

3.1 *Geospatial Detection of Housing Vacancies*

The third level of management which is going to be implemented is the systematic inquiry for unoccupied housing facilities and for empty places within build-up areas. Geo-coded datasets of house numbers in streets have to be cross-referenced with large scale city maps and the communal inhabitant's address data. Legal soil occupation plans, additional satellite or aerial images plus communal horizontal street views allow a first categorization of suspected vacancies in potentially eligible houses.

Basically, those postal house addresses with no person registered to, are suspected to be vacant. And if such a vacancy will not unmask an illegal occupancy or turn out to be a temporal vacancy, there are administrative possibilities to motivate the owner to rent the vacant space. Another approach can be the utilization of underused commercial buildings, which could be rented temporarily for living.

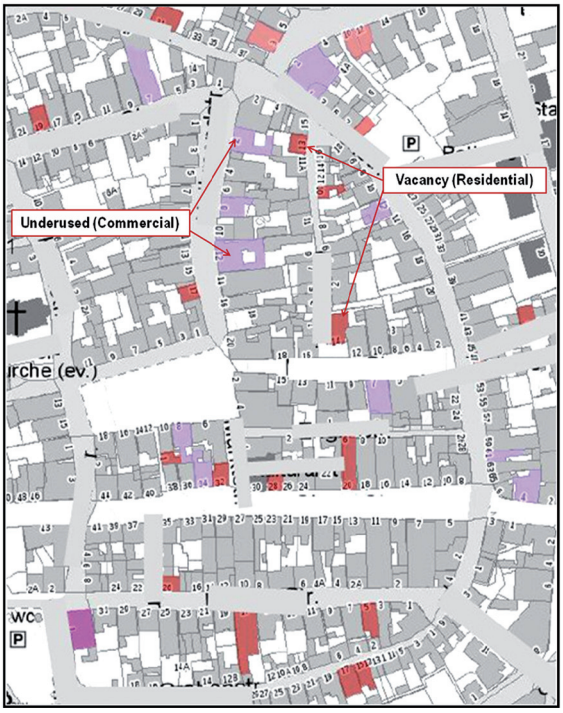

Fig. 7: Example of an inventory on vacancy (LGLN 2016).

The State Office of Geoinformation and Surveying Niedersachsen (LGLN) has developed administrative software packages which allow the described evaluations while the use of personal data from the inhabitants register is controlled legally.

With regard to the public presentation, the map basis of Fig. 7 has been cleared from street names and similar identifiers. The results show in red colours those plots with vacancies in parcels dedicated to be used for living. The blue colour shows "underused" parcels with commercial assignment, where subsequent local inspections have to clarify the residential possibilities. The basic statistic data of the registered inhabitants contains among other data also the birth date, which has allowed the LGLN administration to extract the youngest inhabitants per address and geo-coordinate. This data can then be displayed not only in specific maps, but also allows computing the number of inhabitants within a certain perimeter that will enter primary school within a three years' timeframe.

3.2 *Geospatial Detection of Construction Potentials*

The following example has been taken from the same administrative working group. Within build-up areas there are a certain number of parcels which have not been used for construction for different reasons. In the first decades after World War II those parcels often consisted of bombed buildings which were not reconstructed because of unclear heritage or ownership, or just lack of funds.

Whereas in city centers such gap sites have disappeared by infill, in towns and outskirts of cities such building reserves still exist. These reserves usually have all the technical infrastructure like water supply, connection to sewage system, electricity and street access. Therefore, the personal and public investment for new construction will always be lower than opening any new perimeter for construction.

The evaluation starts with overlaying urban or cadastral basic map data with building layer and limits of the legal boundaries for build-

Fig. 8: Inventory of potential construction sites (Kleinwächter 2014).

up area. The parcels without any building recorded will be highlighted and differentiated according to possible use for housing, commercial, or other. Subsequently, the highlighted parcels will be inspected in orthophoto or VHR satellite data to find out whether there are other obstacles like a ditch or power line to be taken into account. Fig. 8 shows such a case in a suburban environment where the communal administration may negotiate with the owner(s) the potential for housing investment at that place.

This example also shows how EO methods in combination with data mining from urban data allow a first detection of vacant lots and their potential for additional housing construction. Normally the discovery of such potential densification potential will lead to amicably negotiations without having to take legal action in the interest of the general public.

4 Societal Benefits of EO & Data Mining

4.1 *Societal Benefit Areas of Earth Observation*

Upcoming trends in Earth observation include not only more continuity of data with higher resolution, the harmonization and standardization of mapping procedures, but also emerging user demands and new user communities related to web services. The schematic triangle of interaction and promotion of trends in Earth observation has been explained by Komp (2015, 406f). Finally, these prospects will broaden the user community who sees the Societal Benefit Areas (SBA) of Earth Observation like they have been defined by the international Group of Earth Observations (GEO) in nine Societal Benefit Areas (GEO 2009). This will be the common mandate for all researchers and experts involved to support the advancement of Earth Observation (cf. Mora et al. 2014). Especially their involvement in

the support for refugee management and in monitoring the countries of future migrants will be necessary for reduction of migration not by fences but by improvement of the living conditions in the Middle East and in Africa.

4.2 *Legal Aspects of Data Mining to support Refugee Integration*

The acquisition, processing, storage and dissemination of person related data have become an important issue in the European Union, because it affects not only the "processing of personal data in various spheres of economic and social activities" but also the administrative procedures (European Commission 1995, article 4). The general provisions and rules for processing personal data have been adopted through the Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Certain procedures and techniques of data mining with respect to the management of refugee demands thus require the application of this Directive through Article 13 concerning (i) national security, (ii) defence, (iii) prevention, investigation, detection and prosecution of criminal offences to adopt measures by the Member States (European Commission 1995). That means that specific concerns as described above may be adopted by national laws without offending the European rights on the protection of personal data.

To safeguard national security, public security etc., the Federal Republic of Germany has passed the Data Exchange Improvement Law on 14 January 2016 (Bundesrepublik Deutschland 2016), which allows and requires registration of each migrating person in a way that multiple identities will be excluded in future. Both legal provisions constitute the administrative basis for the application of the geo-data evaluations described above (Bernsdorf et al. 2015).

Large parts of Central Europe can rely on accurate geo-data, housing and infrastructural information as well as citizen registers, which will more or less allow the widespread application of the described system of a powerful GeoIT which should not be restricted to the border of member states. However, there are still member states that lack cadastral data, maps and geo-coded household data, like parts of Portugal and Italy, or Greece (Hellenic Cadastre 2016) which is just about to start the basic surveys in selected municipalities. In those areas other non-governmental sources have to be used, such as car navigation data, web based map data, address data of post and parcel services or VHR satellite data, in short, data that can be geo-coded to allow similar evaluations. The latter are urgently needed by the administrations dealing with the management of refugees.

Even if the actual wave of refugees will calm down, the observation of food insecurity combined with economic weakness in sub-Saharan Africa is clearly indicating the next waves of migrants towards Europe. There, the lack of data due to the termination of systematic mapping by French and British services following independencies throughout the 50ies and 60ies of the last century still prevails. In these areas, the primary source of information will be up-to-date satellite data of different type to monitor agro-meteorological conditions, land use change and urbanization. Fortunately, the Landsat continuation policy and the European series of Sentinel satellites will provide an affordable stream of actual data, which could be used to observe and to mitigate the situation in the countries concerned.

5 Conclusions

The increased number of migrating persons arriving in Central Europe during the last two years has initially created overwhelming sympathy and compassion, but has also created an unexpected burden for public security and administrations. Even if sympathy and compassion have cooled down due to a decreasing migratory flow we can see that the professional integration of elements of GeoIT results into the work of security forces and voluntary citizen groups has helped to establish working routines to handle the first reception of migrants. In the meantime the arrival of refugees in Germany has calmed down from over one million in 2015 to actual one thousand daily in

2016. Now, the mid- and long-term integration is coming more into the focus of public planning but will be a major task, at least for the next ten years. Subsequent to the learning of the language as other basic competences, the challenge will be to organize housing, alphabetization, education, vocational training and employment for these migrants.

Several examples outlined in this paper could demonstrate the benefit of GeoIT application for the German administration as well voluntary groups to supply these demands. At the example of actual use of Earth Observation/GIS support to the management of refugee integration, it becomes obvious that the societal benefits of EO/GIS are no longer just potential possibilities, but actual results in real political, administrative and humanitarian day to day reality.

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