

# ANALYTICAL 3D VIEWS AND VIRTUAL GLOBES – PUTTING ANALYTICAL RESULTS INTO SPATIAL CONTEXT

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## ABSTRACT:

In this paper we are introducing analytical 3D views as a means for effective and understandable information delivery, using virtual globes and the third dimension as an additional information carrier. Four case studies are presented, where information extraction results from very high spatial resolution (VHSR) satellite images has been conditioned and (dis-)aggregated to certain spatial aggregation units. These case studies are embedded in the context of (1) urban life quality assessment (Salzburg/Austria) (2) contingency planning (Harare/Zimbabwe) (3) emergency response (Lukole/Tanzania) and (4) disaster management (faked crisis scenario/Germany). The results are made available in different virtual globe environments, using the high spatial resolution contextual data of these virtual globes (satellite imagery, aerial photographs, auxiliary geodata) as valuable additional context information. Both day-to-day users and high-level decision makers are addressees of this kind of conditioned information. The degree of abstraction required for understanding a complex analytical content is balanced with the easiness and the appeal by which the context is conveyed.

## 1. INTRODUCTION

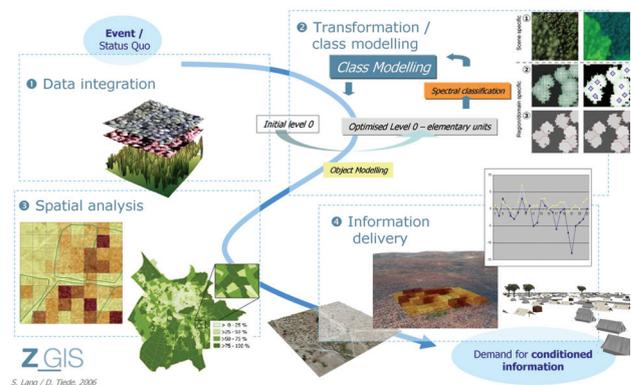
Analytical results from geographical studies are usually presented on digital or analogous thematic maps. Whereas maps are more readily to be understood as descriptive text or tables, there is still much left for better, more direct and more appealing communication. A map is an isolated product, which obviously cannot provide the wider spatial context beyond its margins. Even if well designed, maps do require from readers a high capability of abstraction, they are not compellingly understandable.

Contrarily, virtual globes or digital globe viewers (like Google Earth, NASA World Wind, ArcGIS Explorer etc.) are appealing, very intuitive and easily understandable, yet ‘real’ (cf. Butler 2006, Goodchild 2005). Freely available virtual globes with high spatial resolution contextual data enable to disseminate analytical information derived from earth observation (EO) data to a broad audience. Advantages of this are: (1) the amount of data to be integrated is reduced; (2) this saves time in situations where rapid information delivery is required; (3) data rights of original data are respected.

Digital maps can be put on globe viewers. But maps, simply put on a globe viewer, either cover the real situation displayed underneath, or, if made transparent, will suffer from clarity. Instead, analytical 3D views are information layers showing one particular spatial phenomenon, on different spatial aggregation (administrative or grid based units), and using extrusion as a means for displaying the respective spatial variable. The magnitude of the variable being investigated is transformed into an intensity value, expressed by height and supported by semi-transparent graduated colour.

## 2. APPROACH

The layers are generated using object-based information extraction from very high spatial resolution (VHSR) data by means of a workflow for information delivery (cf. Lang et al. 2006a, Lang et al. 2006b, Schöpfer et al. 2007, Blaschke et al. 2006, Tiede and Blaschke, 2005 – see fig. 1).



**Figure 1.** Workflow for high-standard information delivery (Lang et al., 2006a, modified)

Object-based image analysis (OBIA, Lang and Blaschke, 2006) provides GIS-ready vector layers, ready-to-use for further analysis and for visualising the results. Processing makes them available in an adequate mode, depending on the envisaged virtual globe software used for publishing. Accordingly, the appropriate data format (like *kml/kmz*, *nmf*, ESRI *multipatch*, extruded *shapefile* etc.) is chosen. Processing will further include spatial aggregation or disaggregation of the results onto either significant or neutral spatial units (administrative units, raster grids, etc.). Depending on the demand expressed by users or receivers, conditioned information is derived (fig. 1). GIS analysis techniques are used like dasymetric mapping and the

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LIST extension for ArcGIS (ESRI). LIST (Landscape Interpretation Support Tool, Schöpfer and Lang 2006) provides algorithms for object quantification, object (dis-)aggregation and object-based change analysis. In the following case studies, both, regular grid cells and administrative units are used as (dis-) aggregation basis for meaningful information delivery.

### 3. CASE STUDIES

Analytical 3D views meet a range of purposes, from fostering geographical understanding in basic education, over general communication purposes for raising spatial literacy in the public, to the provision of crucial information for management and spatial planning, policy-oriented decisions and monitoring. Four studies are selected to illustrate the spectrum of application; they are embedded in the context of urban life quality assessment, contingency planning, emergency response and disaster management:

- (1) Salzburg / Austria: Urban green structures for urban life quality assessment.
- (2) Harare / Zimbabwe: Change indication for detecting likely destroyed areas between 2004 and 2005
- (3) Lukole / Tanzania: Distribution of dwellings in refugee camps for population estimation.
- (4) Southern Germany: Population distribution within a fictitious plume of radio-active contamination, dasymetrically mapped on land use classes.

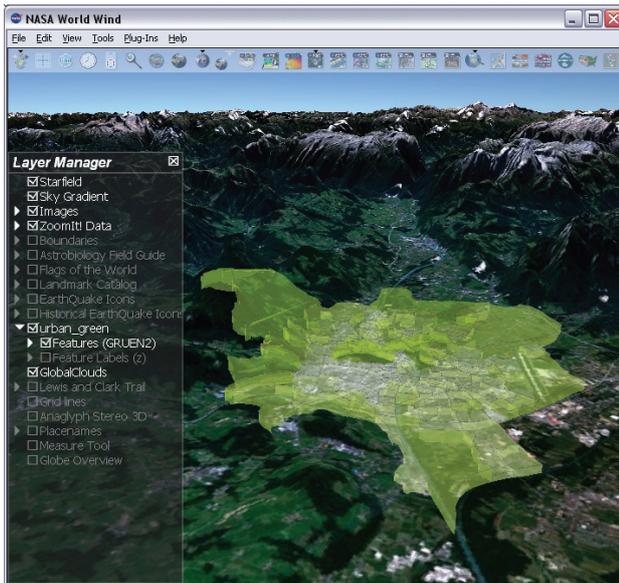
#### 3.1 Salzburg / Austria: Urban green structures for urban life quality assessment

Urban green is a substantial structural element of sustainable urban planning in fast growing urban environments. In highly transformed urban settings, green spaces play a significant role for the comfort of the citizens. Quantifiable information about green structures and the amount and distribution of green spaces is therefore essential. In preceding research a weighted green index (GI<sub>w</sub>) has been developed, which integrates both the automated delineation of relevant green structure types using VHSR satellite imagery (Quickbird 07/2005) and a complementary survey on the importance of these types as perceived by citizens (Lang et al., 2006c). Using the object-based approach the relevant green structures were provided as single objects that could be flexibly aggregated to arbitrary units (in this case: districts, enumeration areas or regular raster cells).

In figure 2 and figure 3 only the percentage of a specific set of green structures is shown, aggregated to enumeration areas. Rates are indicated by colour and height. In figure 2 the analytical layer is streamed over the internet using an ArcGIS Server (ESRI) based globe service. We used the freely available ArcGIS Explorer (ESRI) as virtual globe client providing additional information (satellite data, elevation data and other (ge-) information data). In figure 3 the analytical layer is imported as *kml* into NASA World Wind.



**Figure 2.** Percentages of urban green structures in Salzburg/Austria, semi-automatically derived from Quickbird data, aggregated per administrative unit (here: enumeration area), visualized in ArcGIS Explorer using an ArcGIS Server based globe service.



**Figure 3.** Percentages of urban green structures in Salzburg/Austria visualised in NASA World Wind

### 3.2 Harare / Zimbabwe: Change indication between 2004 and 2005

In Harare, the capital city of Zimbabwe, an operation called *Murambatsvina*, also known as *Operation Restore Order*, has been carried out by the Zimbabwean government. This has resulted in mass evictions, the demolition of homes and informal businesses (Amnesty International 2006). Estimations of the United Nations (UN, 2005) assuming that 700,000 people across Zimbabwe lost their homes as a consequence of this operation between May and July 2005. In some areas entire settlements were razed to the ground.

Schöpfer et al (2007) used QuickBird data from August 25, 2004 and June 22, 2005 for object-based change detection in urban areas of Harare. The methodology aims for a fast change indication on a higher level, i.e. a kind of ‘pre-screening’ of the image to facilitate further change detection inspections. The results are aggregated to 500 m x 500 m raster cells and visualised according to the standard deviation of urban change per cell which reflects a higher probability of change.

Figure 4 shows the resulting analytical 3D view implemented as a *kml* file in Google Earth. Darker shades indicate areas with a higher probability of destruction whereas brighter cells represent areas with minor to no change of urban area between 2004 and 2005. This way of visualising changes supports rapid mapping and the detection of likely affected areas so that further interpretation and critical review can be focused on these areas.

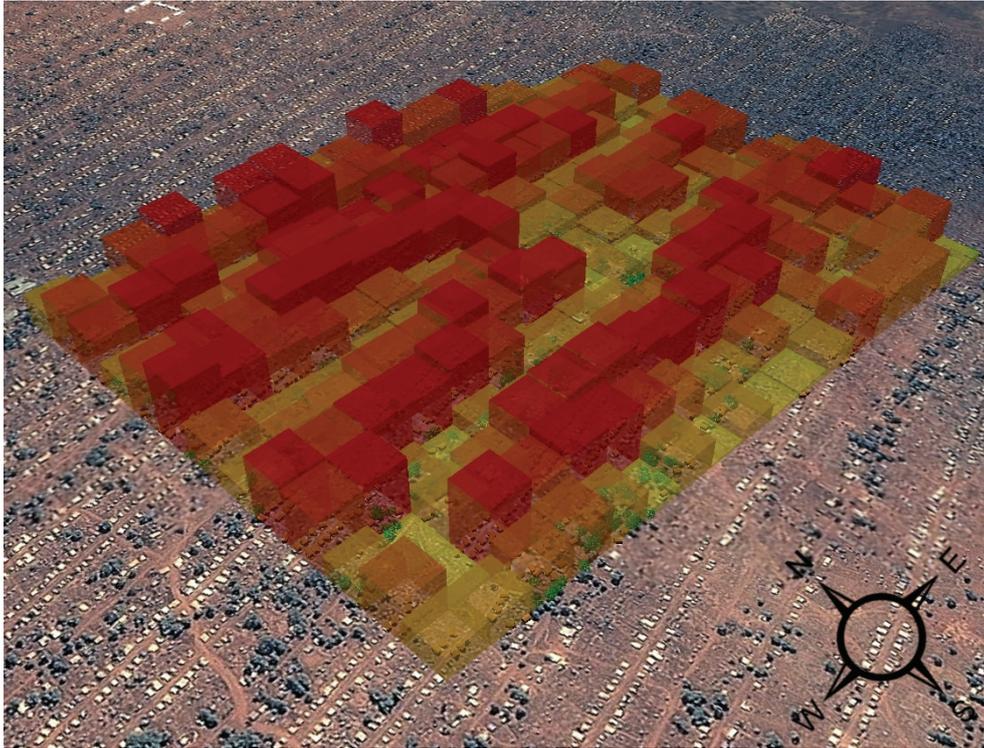


**Figure 4.** Visualisation of change in the urban area of Harare / Zimbabwe between 2004 and 2005.

### 3.3 Lukole / Tanzania: Distribution of dwellings in refugee camps for population estimation

Large numbers of refugees (> eight millions by the end of 2005, UNHCR 2005) and internally displaced persons (IDPs) have been mobilised by civil wars and assaults of the civil population. Refugee camps are often areas where information, e.g. population figures, is hard to obtain, especially in regular intervals, unbiased and at low costs. In that case Earth Observation (EO) data and derived products can play a key role for information delivery at policy level (Lang et al., 2006b). The authors have demonstrated approaches to semi-automatically extract relevant dwelling units in refugee camps from very high spatial resolution (VHSR) data (ibid.). Work was partly conducted using IKONOS data (9/2000) from the twin camp in Lukole (A and B) in Western Tanzania. Most of the refugees were Burundians, leaving their homes during the civil war between Hutu and Tutsi in 1993/94. The refugee camp hosted still about 50,000 people in 2005 (WFP & UNHCR, 2005).

The analytical 3D view in figure 5 shows the extracted dwelling units by Lang et al. (2006b) as 3D symbols (huts, smaller houses and trees) in ArcGlobe (ESRI). The 3D symbols are automatically placed on the very location derived from the feature extraction by OBIA. 3D symbol creation was done in the Google Sketchup software based on photographs of the Lukole refugee camp. The dwelling units are overlaid by extruded 50 m x 50 m raster cells to which the dwelling units are aggregated. Extrusion height reflects the estimated population figure per cell. In this case data are made available in a commercial GIS product (3D Analyst extension of the ArcGIS software), which allows further GIS analysis on the virtual globe itself.



**Figure 5.** Visualisation of extracted dwellings (3d symbols) and aggregated density of dwellings in the Lukole refugee camp visualised in ArcGlobe.

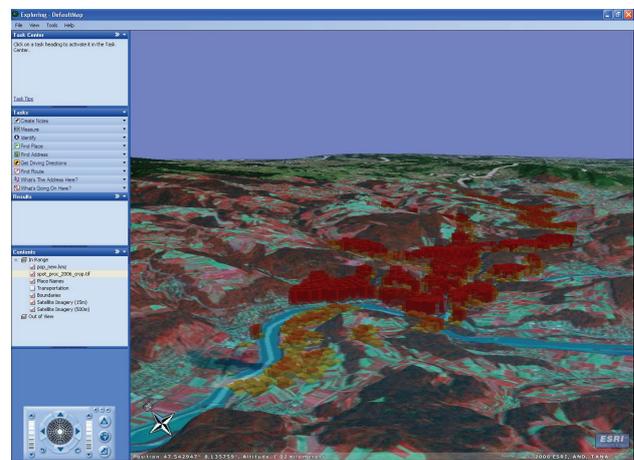
### 3.4 Southern Germany: Population distribution mapped dasymetrically on land use within a fictitious plume of radio-active contamination.

The last case study was part of a real-time exercise in the context of the European Commission funded Network of Excellence (NoE) on Global Monitoring for Stability and Security – GMOSS. In a faked crisis scenario teams across Europe were asked to reply within 33 hours to a fictitious information request by the European Commission on a nuclear leakage scenario. Satellite imagery as well as auxiliary geo-information were provided to the teams, from which up to date information on infrastructure, urban areas and land cover should be extracted and provided.

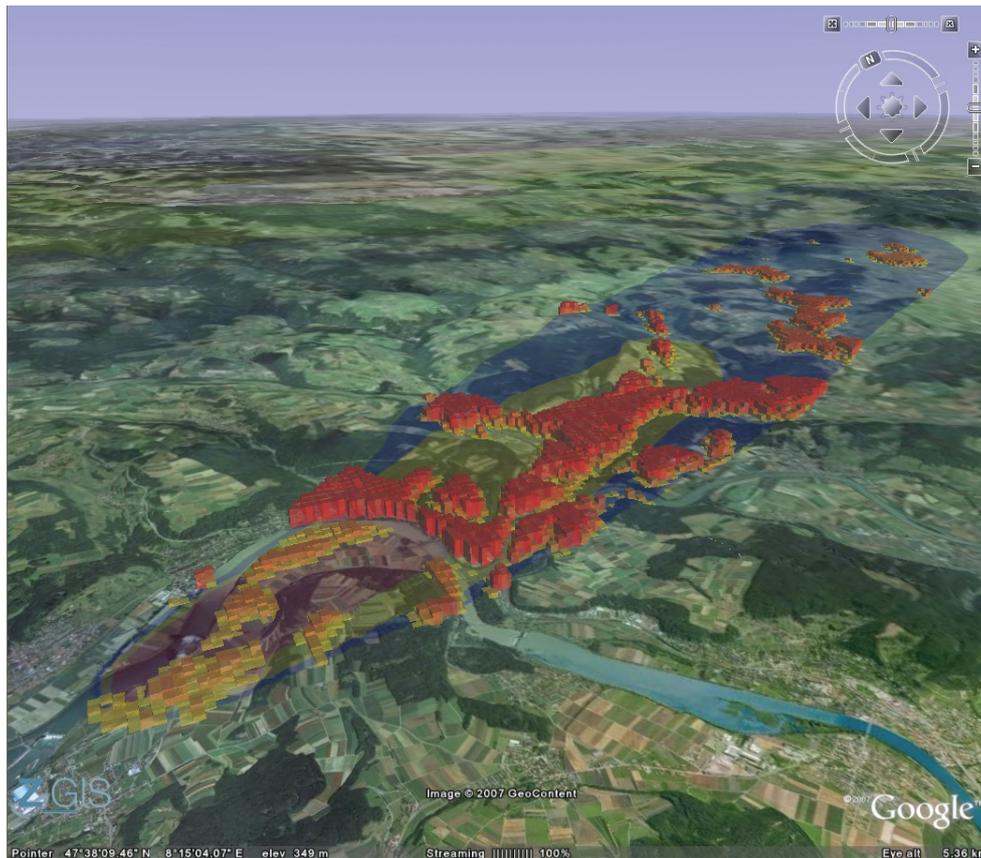
One of the goals was the estimation of affected population: By dasymetrically mapping utilizing (1) information of population figures on municipality level and (2) a land cover classification based on SPOT 5 data the population distribution in the fictitious plume of radio-active contamination could be estimated.

The resulting analytical 3D view (ArcGIS Server based globe service in the ArcGIS Explorer client, figure 6) shows the population figures disaggregated to raster cells (100 m x 100 m) for the affected urban area within the contamination plume. The extrusion height is controlled by the number of people per raster cell derived from the SPOT 5 data. In this case, population density data and the underlying SPOT data are streamed over the internet, allowing a fast and comprehensive overview of the

situation and the conditioned information being derived. Figure 7 shows the same result as *kml* file in Google Earth with an underlying fictitious plume of radio-active contamination.



**Figure 6.** Dasymetrically mapped population density in ArcGIS Explorer. Both SPOT data and population density are streamed over the internet using an ArcGIS Server based globe service. The legend and information about attribute data as well as a number of possible queries are controlled via the left hand arranged tools.



**Figure 7.** Dasymetrically mapped population density in Google Earth with underlying fictitious plume of radio-active contamination

#### 4. DISCUSSION AND OUTLOOK

In this paper we introduced analytical 3D views as a method for the effective delivery of conditioned information using third dimension as an additional carrier of information. Both the variety and widespread availability of new and often free available virtual globes provides a broad and solid basis for this approach. Analytical 3D views are not limited to certain software environments; instead they are supposed to meet the demands of the users in terms of (1) fast and effective information accessibility and (2) fast graspable added value supply.

Today, globe viewers strongly support the vision of a digital earth (Gore, 1998), where information is made available to a broad public and democratised through a literate, well-educated audience. Next, globe viewers scale real world phenomena down to a concise representation in form of a handy sphere (nearly a play ball). This effect of bringing phenomena occurring in remote places of the world closer together may be, in the opinion of the authors, one of the reasons, why people are more affected and appealed by virtual globe displays.

Our analytical 3D views combine the advantages of globe viewers (seamless spatial context, 3D representation) with the value of analytical spatial information. Information residing in continuous geospatial data is extracted and made explicit in an appealing way. An abstract product is directly planted into a real world situation. Unfamiliar academic content describing a spatial phenomenon is embedded in a familiar spatial context, seamlessly connected to any other place of the world.

Analytical results presented in such a way can be grasped in a much more direct manner. Analytical results depicted in 3D on a globe viewer make the reader perceive the analytical reality more actively and self-referenced.

The underlying data of the analytical 3D views are relatively small vector files which can be easily deployed or streamed over the internet. But usually, the different globe viewers require broadband internet connections, due to an enormous amount of context data (like satellite images, aerial photographs, (geo-) information layers). Thus, some cases do exist, where this kind of information delivery would be very useful (e.g. rescue and relief operations in remote areas), but its provision is not realistic due to infrastructural problems but also (at the moment) lacking interaction with mobile devices.

For effective information delivery it needs to be understood that analytical 3D views should not be provided isolated and without relevant additional information with regard to (1) the underlying processing chain, the data sets used, reliability figures and (2) attribute values of the aggregation units. Otherwise the added value of this kind of information is dropping substantially and only “nice pictures” are left over.

Day-to-day users and high-level decision makers are likewise susceptible receivers of this kind of conditioned information. The degree of abstraction required for understanding the analytical content, is balanced with the easiness by which the context can be grasped. It is strongly believed that abstract, partially complex real world spatial phenomena will be communicated much more effectively and thus perceived much more intensively.

## REFERENCES

- Amnesty International 2006. Zimbabwe Lawyers for Human Rights, Zimbabwe Shattered lives - the case of Porta Farm; *AFR 46/004/2006*, International Secretariat, London, UK.
- Blaschke, T., Tiede, D. and Lang, S 2006. An object-based information extraction methodology incorporating a-priori spatial information. In: *4. ESA conference on image information mining*, November 2006, CD-ROM. Madrid
- Butler, D. 2006. Virtual globes: The web-wide world. *Nature*. <http://www.nature.com/news/2006/060213/full/439776a.html> (accessed 05/2007)
- Goodchild, M.F. 2005. What Does Google Earth Mean for the Spatial Sciences? Keynote Address, Annual Conference, IRLOGI, Dublin, October 2005
- Gore, A. 1998. The Digital Earth: Understanding our Planet in the 21 Century. Retrieved from [http://www.isde5.org/al\\_gore\\_speech.htm](http://www.isde5.org/al_gore_speech.htm), (accessed 04/2007)
- Lang, S. and T. Blaschke 2006. Bridging remote sensing and GIS - what are the most supportive pillars? In: *Proceedings of the 1st International Conference on Object-based Image Analysis*, July 4-5, 2006 in Salzburg. CD-ROM
- Lang, S., D. Tiede and F. Hofer 2006a. Modeling ephemeral settlements using VHSR image data and 3D visualisation – the example of Goz Amer refugee camp in Chad. In: *PFG - Photogrammetrie, Fernerkundung, Geoinformatik*, Special Issue: Urban Remote Sensing, 4/2006, 327-337.
- Lang, S., D. Tiede and G. Santilli 2006b. Varying sensors and algorithms – an information delivery approach for population estimation in African refugee camps. In: *6th African Association of Remote Sensing of the Environment Conference (AARSE)*, Oct 30 - Nov 2, Cairo, Egypt.
- Lang, S., T. Jekel, D. Hölbling, E. Schöpfer, T. Prinz, E. Kloyber & T. Blaschke 2006c. Where the grass is greener – mapping of urban green structures according to relative importance in the eyes of the citizens. In: *First Workshop of the EARSeL SIG on Urban Remote Sensing „Challenges and Solutions“*. CD-ROM
- Schöpfer, E., D. Tiede, S. Lang and P. Zeil 2007. Damage assessment in townships using VHSR data - The effect of Operation Murambatsvina / Restore Order in Harare, Zimbabwe. *Urban Remote Sensing Joint Event*. Paris 2007, CD-ROM
- Schöpfer E and S. Lang 2006. Object fate analysis – a virtual overlay method for the categorisation of object transition and object-based accuracy assessment. In: *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. No. XXXVI-4/C42, Salzburg, Austria
- Tiede, D. and T. Blaschke 2005. Bringing CAD and GIS together: A workflow for integrating CAD, 3D visualization and spatial analysis in a GIS environment. In: Buhmann, E., Paar, P., Bishop, I, Lange, E. (eds.): *Trends in Real-time Visualization and Partizipation*. Wichmann-Verlag, Heidelberg, 77-87.
- UNHCR, 2005. Statistical overview of populations of refugees, asylum-seekers, internally displaced persons, stateless persons, and other persons of concern to UNHCR. Retrieved from [www.unhcr.org](http://www.unhcr.org) (accessed 04/2007)
- UN Report 2005. Fact-finding mission to Zimbabwe to assess the scope and impact of Operation Murambatsvina, [http://www.un.org/News/dh/infocus/zimbabwe/zimbabwe\\_rpt.pdf](http://www.un.org/News/dh/infocus/zimbabwe/zimbabwe_rpt.pdf) (accessed 04/2007)
- WFP & UNHCR, 2005. *Joint Assessment Mission, Great Lakes Region – Tanzania*, 8-14 November 2005. Final Report

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