D 3.3
Systematization/capitalization of the experience with UAV data

Consultancy for developing/updating of the database + web platform + geoportal | ECHO/-SF/BUD/2017/91009

General information	
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RE	Restricted to a group specified by COOPI
CO	Confidential, only for members of the consortium

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1.0	30/11/2018	11	Final version

1. Introduction

The context of this study is based on the signed supply contract / Consultancy: Consultancy for developing/updating of the database + web platform + geoportal ECHO/-SF/BUD/2017/91009 made between Cooperazione Internationale (COOPI) and the Paris Lodron University Salzburg, Department of Geoinformatics – Z_GIS.

This is part of the ongoing project "Strengthening the Disaster Risk Management System at the National and District Level to reduce future humanitarian needs by decreasing risk to vulnerable population in Malawi" (ECHO/-SF/BUD/2017/91009. The Directorate General for European Civil Protection and Humanitarian Aid Operations (ECHO) grants funding for this project.

Subject of the contract is to strengthening disaster-related information management, knowledge and skills for disaster preparedness and response at National and local level in Malawi.

The aim of this deliverable is to support COOPI within the systematization and capitalization based on the experience made with UAV data within the project. This deliverable partly builds on *D3.1 Guidelines and technical specifications for the data collection through UAV*.

The use of UAV-based remote sensing has been well established for a variety of applications in the last couple of years (Shahbazi, Théau, and Ménard 2014; Nex and Remondino 2014; Lucieer, Jong, and Turner 2014; Rango et al. 2006; Colomina and Molina 2014; Kalacska et al. 2017). One example is the application of monitoring soil erosion in Morocco with UAV-based data (d'Oleire-Oltmanns et al. 2012).

Cost-effective and robust hardware that is easy to handle, developed, improved, and constantly being available on the market extends an already stable basis with regard to availability, applicability and increase of applications.

2. Understanding of systematization/capitalization in the context of this study

In the context of this study, one major objective is to make use of spatial data in various contexts. The approach of PPGIS assumes that spatial data supports different stakeholders in their respective decision making processes (Jankowski 2011). Due to the existing link to social sciences within this project it is advisable to also refer to fundamental concepts of spatial thinking that adds value to such interdisciplinary perspectives arising within social sciences (Janelle and Goodchild 2011). Following Elwood, Schuurman, and Wilson (2011) the difference from traditional GIS to qualitative GIS lays in the exceeded systematization of images and anecdotes without providing a whole story but a situated storytelling.

Adapting these statements to UAV-based remote sensing within this project enables the following definition of systematization and capitalization:

- Systematization refers to the efficiency of the data acquisition, data analysis, and data visualization
- Capitalization is linked to the added value the information derived from the acquired data generates, e.g. during its application within roundtables and similar PGIS events with stakeholders from different fields. These fields would - within this context - relate to flooding and its implications.

3. Systematization and added value of UAV-based data and information products

This chapter consists of four sections that treat the aspects of repeatability/transferability, the results of the flight campaigns, the derived information products, and the data basis for future analysis. In each section, the benefit is highlighted and connections to other deliverables as well as work carried out within this project or future tasks are illustrated.

a. Repeatability and transferability

In the context of UAV-based remote sensing to support the topic of flooding the first and most fundamental step is to develop a standardized workflow for the data acquisition. Any kind of adaptation of the workflow in different missions has multiple drawbacks:

- the data may differ to previously acquired UAV based imagery and is therefore not comparable
- the working time spent for the data acquisition increases and therefore the data acquisition is more cost-intensive
- establishing a monitoring for specific locations is limited
- the transferability of the data acquisition to new locations is hardly possible

During the first couple of iterations of the developed workflow there may occur several points that have to be adapted. This finally ensures to reach a stable, robust and reliable workflow.

As for the technical aspects of the UAV-based data acquisition, a detailed description has been provided in D 3.1[1] already. Main points to be considered are

- Spatial resolution (per-pixel resolution)
- Georeferencing /Ground control points (GCP)
- Data processing

Deriving the stable workflow reveals its further potential. The application on different study areas with no or only very minor adaptation, briefly transferability. Transferability of the workflow to different study areas enables comparison of results and continuous mapping, briefly monitoring. Additionally, any short-term request may be fulfilled with this stable, transferable workflow, which is of benefit in the context of flooding or similar.

[1] D 3.1 Guidelines and technical specifications for the data collection through UAV

b. Results of flight campaigns

The data from the flight campaign for the study area in Mangochi was sent via mail to Z_GIS. It included the optical UAV-imagery as complete orthoimage mosaic as well as in tiles of the whole orthoimage mosaic to reduce the processing time due to less data. The extent of the area covers approximately 52.5 km². The optical imagery has a spatial per-pixel resolution of 7 cm x 7 cm. See a subset of the orthoimage in Figure 2.1.

In addition the calculated DSM was provided with the data. The DSM has a spatial per-pixel resolution of 7 cm x 7 cm. This data was used to derive a coarse information layer containing the settlement areas, which is described in the next section.

Figure 2.1. Orthoimage data at a scale of 1:5000.

c. Information products derived

The resulting orthoimage from the UAV campaigns served as input for subsequent analysis.

For the extraction of information on settlements, an object-based image analysis approach was applied. This approach not only includes spectral information in the classification process but extends this traditional remote sensing approach by the possibility to incorporate neighborhood information, geometry and knowledge.

In a first step, the generation of objects within the software environment of eCognition Developer (Trimble) is required. This was processed using the multi-resolution segmentation approach (Baatz and Schäpe 2000). The concept is to create objects that are best possible homogeneous within the object borders whilst being best possible heterogeneous towards neighboring objects. This creates a first object level to work on.

In a second and third step, the object level as derived from the segmentation process was processed, large objects were merged and the focus towards extracting settlement structures was sharpened. The classification of settlement structures was based on the approximated extent of one building and the white reflection values. The classification results are shown in Figure 2.2 and Figure 2.3 illustrating the extracted settlement structures in light blue color. During the development of the classification routines, the priority was to develop a stable and reliable approach. This means that houses in between the classified ones are likely to be missed due to issues such as shading, overlap with vegetation or colors that are to similar to the surrounding bare soil. This is a classical problem in optical remote sensing and could unfortunately not be avoided by the inclusion of the DSM data.

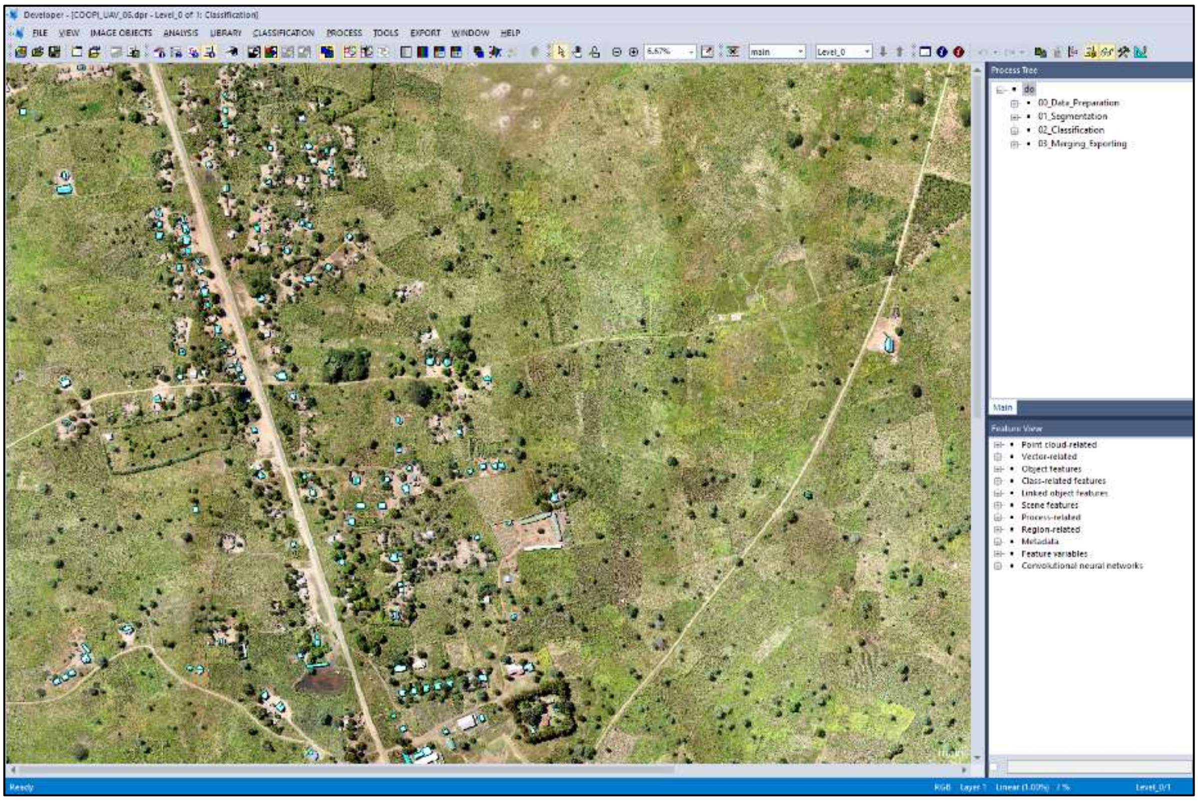

Figure 2.2. Classification of settlement structures in object-based image analysis software environment (eCognition Developer, Trimble).

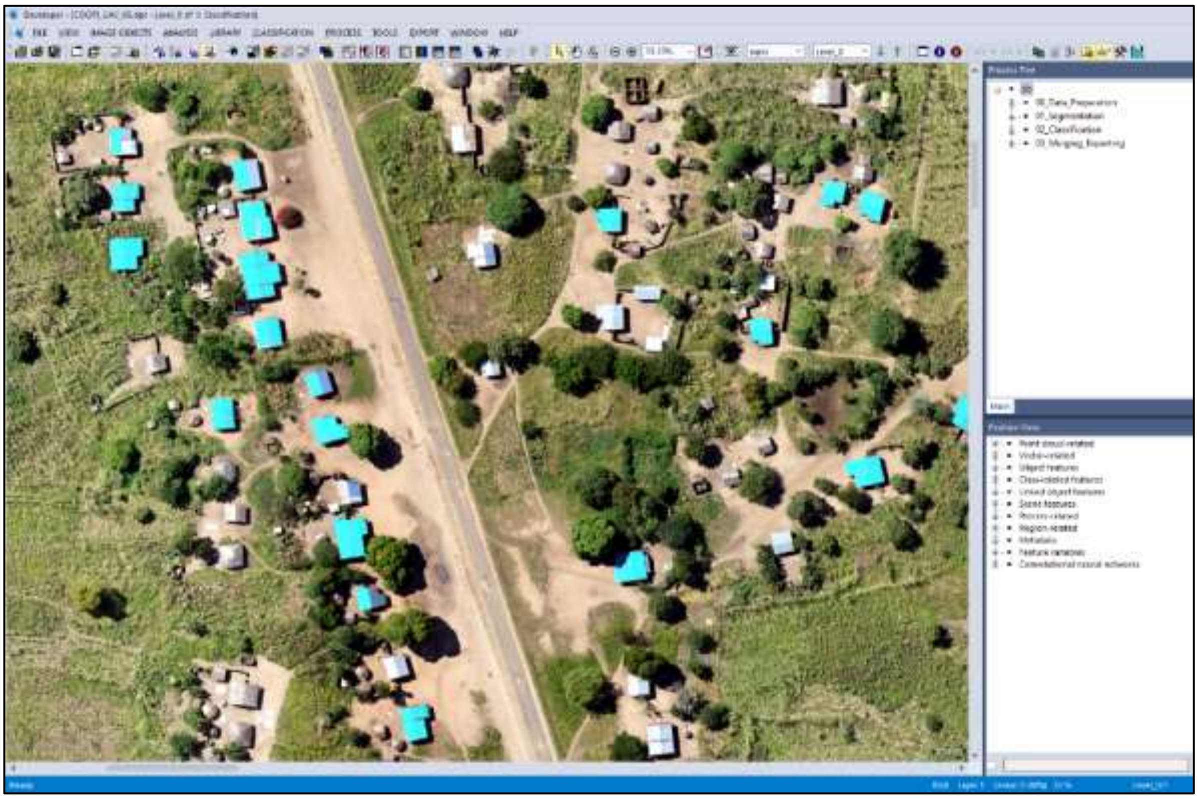

Figure 2.3. Detailed view of subset showing classified houses in light blue.

The classification results were in a fourth and last step exported from the software environment as point shapefile. This enabled the subsequent analysis of the data in a GIS software environment.

A qualitative layer showing settlement hot spots based on the calculation of a Kernel density map was derived from the extracted houses from the previous analysis step. In Figure 2.4 the kernel density map is showing red areas as hot spots containing a large number of houses, orange and yellow areas containing fewer houses and blue areas representing areas with almost no houses. The extent of UAV data for this study area is illustrated with the red rectangular. A more detailed view is shown in the subset illustrated in Figure 2.5. Houses are illustrated as pink points in both figures.

This information supports the qualitative delineation of risk areas in the context of flooding, and could serve as additional source of information in any PGIS approach. The information is freely available online on the Malawi Disaster Management Portal.

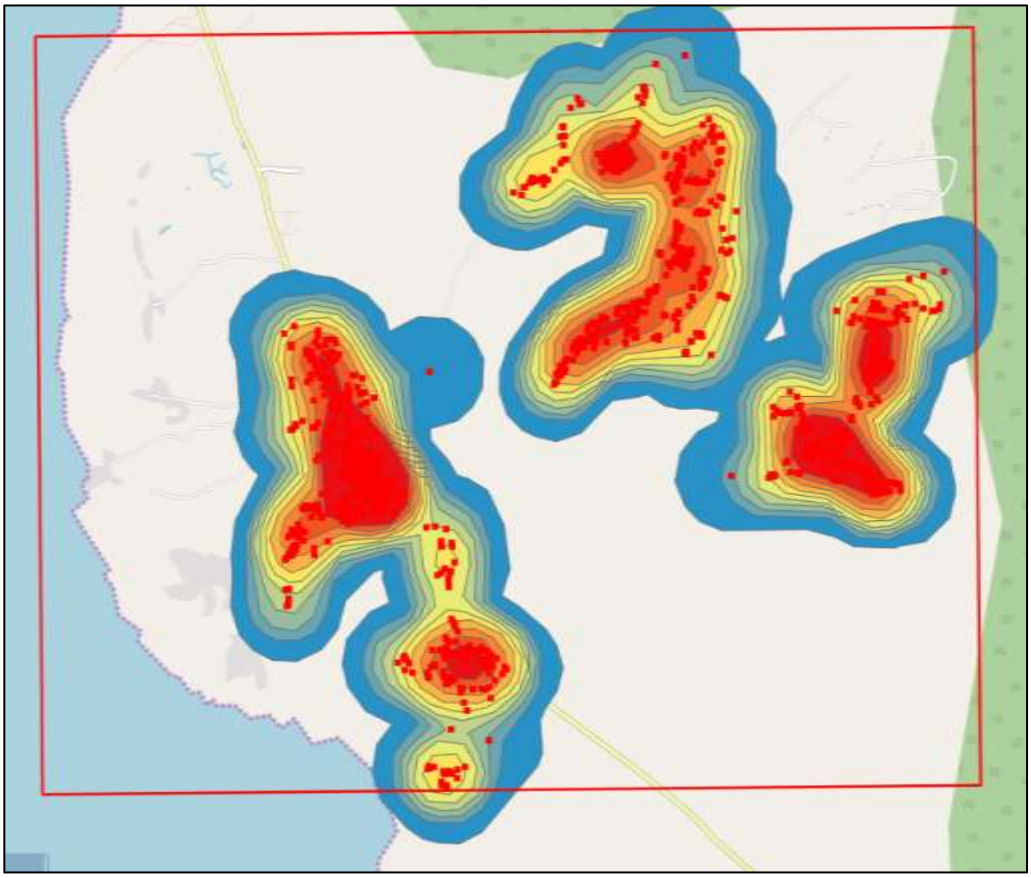

Figure 2.4. Kernel Density Map with houses in red overlaid. Supporting a qualitative estimation on risk of flooding and its impacts (Malawi Disaster Management Portal, 2018).

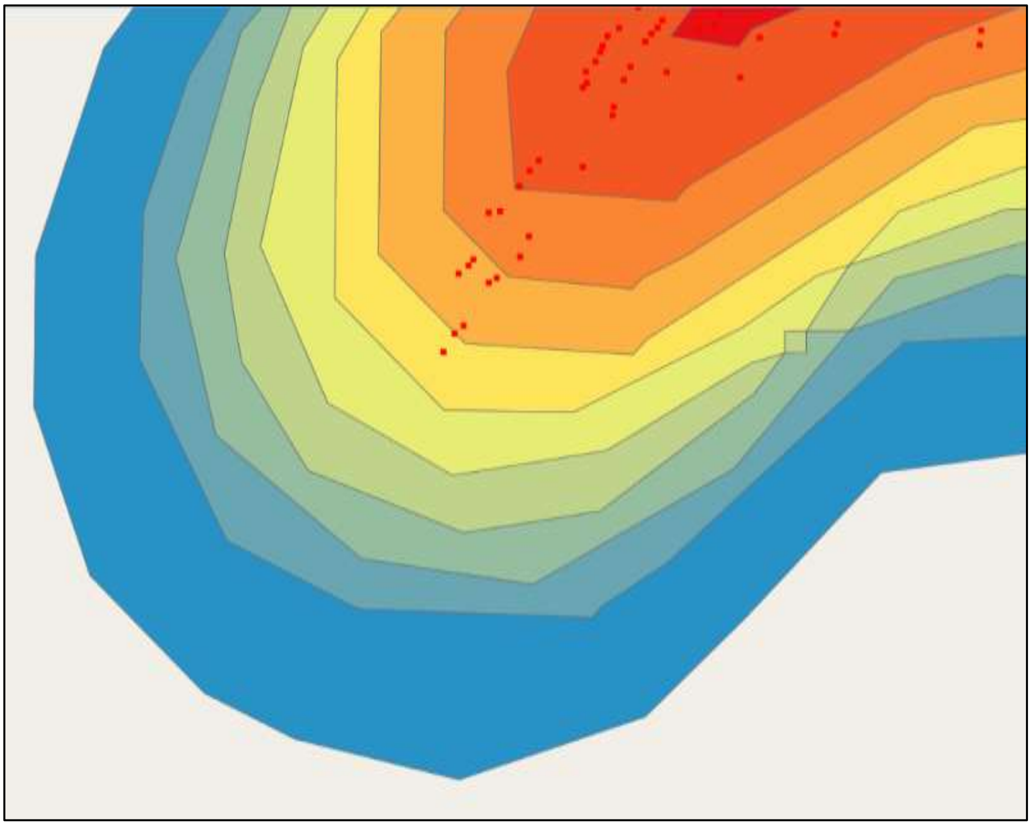

Figure 2.5. Detailed view of subset showing different risks impacts, decreasing from red to blue (Malawi Disaster Management Portal, 2018).

d. Data basis for future analysis

The potential of UAV-based data and therefrom-derived information packages is not limited to the examples shown in the previous section. Unleashing further potential of such data and information may be conducted by the growing experience from previous missions and analysis processes. This experience may directly be compared with different stakeholders during discussions and workshops. It is not necessarily required that experience is derived always from the same location. The monitoring aspect mentioned also in the previous section adds loads of value to all stakeholders here and even beyond. This will be illustrated on the following example: Stakeholders initially want to have detailed information for a specific location and carry out a UAV-based mapping campaign with a subsequent analysis of the acquired data. The derived products may be similar as the ones shown in the previous section. The stakeholders then include these information products to support their decision processes on specific topics. After a certain period the sustainability of the previously made decisions may be evaluated. Therefore a UAV-based mapping campaign acquires the current state of the same location. Therefrom derived data and information products may be compared to the initially acquired data and information products from the first mapping campaign. This enables the evaluation and potential adaptation of measures. Having incorporated this in a commonly accessible data basis also offers further stakeholders to learn from these experiences and avoid the same mistakes. Hence, a sustainable development of measures e.g. for reducing the risk of damage due to flooding may develop. The Malawi Disaster Management Portal[2] may act as such a data basis also in the future.

e. Potential additional (data) sources to be considered

In addition to the acquired UAV-based data as well as therefrom-derived information products, the incorporation of additional available data provides a very useful approach to increase the reliability of the information within the results and findings. One example is data provided by local stakeholders that reflect well the situation on a very large spatial scale level in the context of individual communities or natural local characteristics.

Another option is the incorporation of freely available information from databases being available online. One example were the Copernicus core services (Online: www.copernicus.eu). Also freely available data from OpenStreetMap may support the analysis (Online: www.openstreetmap.org). The portal of MASDAP may also provide different data that was of great use (Online: www.masdap.mw).

Please see also deliverable D1.1. Baseline Report for further information on potential data sources.

[2] http://isi.zgis.at/malawi_atlas/

4. Conclusion and lessons learnt

The inclusion of UAV-based data and information products provides a powerful basis supporting numerous topics. Stakeholders with very different backgrounds benefit from the systemized data and information basis and may support their decision-making processes.

Several points that may slow down such a UAV-based mapping approach have been identified during the project and should be considered beforehand in the future.

Legal aspects within the country have to be respected and flying permission has to be on hand in advance to any field missions. Particular attention has to be paid. in areas that are close to national borders. This may also affect the accessibility of study sites. A timely discussion on the respective administrative level has be to be initiated to avoid legal and/or formal issues regarding planned missions.

Weather conditions change quickly and may prevent field missions and prolong the work within projects that is depending on such input data. This aspect also has to be addressed very early in the planning phase of envisaged projects and field missions.

In case of not having the possibility to carry out UAV-based flight campaigns on one's own, the discussion with external service providers has to be started. Here, the systemized workflow is required as this serves as an information basis to create and define the contract specifications, its workload and finally the financial dimension. The reliability of the service provider has best possibly to be confirmed in advance and legal aspects have to be checked in advance to ensure a smooth delivery of the requested products.

5. Disclaimer

This document intends to help and support in the context systematization and capitalization of UAV-based data. However, the authors take no responsibility for any legal issues. All legal aspects have to be taken into account from the pilot(s) and persons carrying out the flight campaigns or deriving measures based on this information products. This also applies for any insurance issues.

This document was authored to the best of one's knowledge and belief.

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