JURSE 2022
Online Lounge

Work title: The growing threat: Earth Observation for reducing landslide risk from climate change

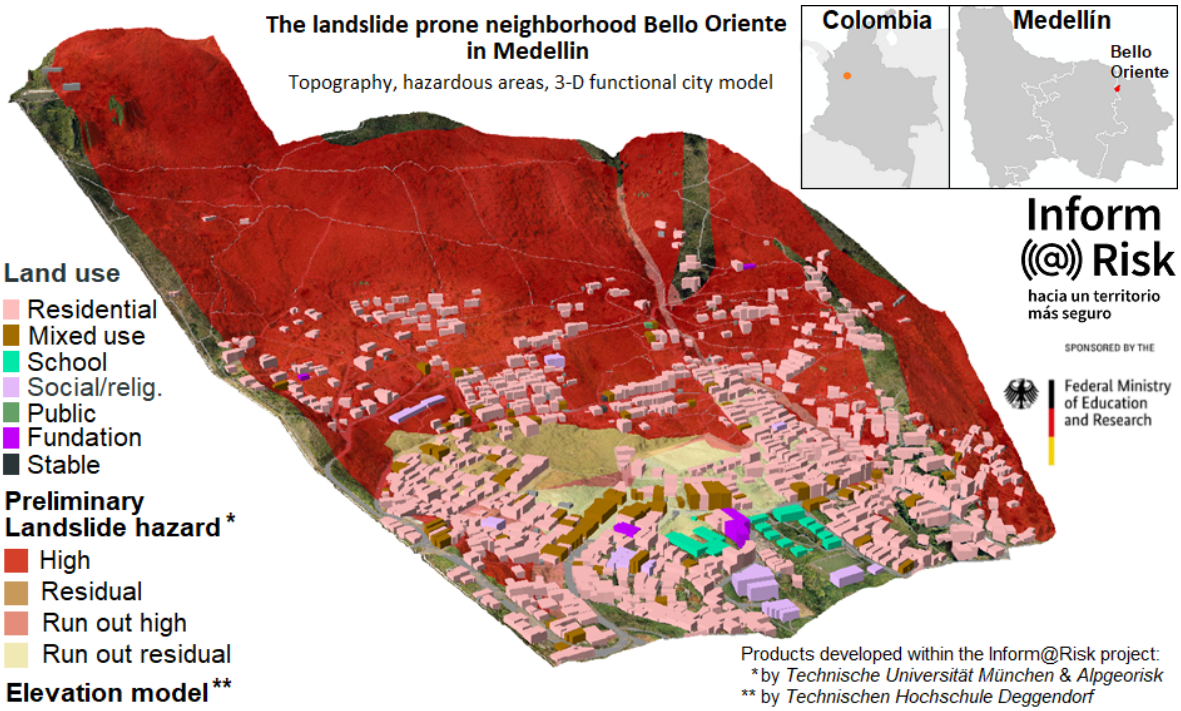
Authors: Marta Sapena[1], Marlene Kühnl[1,2], Klaus Martin[2], Hannes Taubenböck[1,3]

[1] German Aerospace Center (DLR), German Remote Sensing Data Center (DFD), Münchner Str. 20, 82234, Wessling, Germany

[2] Company for Remote Sensing and Environmental Research (SLU), Kohlsteiner Str. 5, 81243 München, Germany

[3] Institute for Geography and Geology, Julius-Maximilians-Universität Würzburg, 97074, Würzburg, Germany

Project Image:



Short project summary:

In this paper a specific case study is introduced illustrating how Earth Observation (EO) can be used to assess exposure and vulnerability to landslide hazards and to strengthen resilience. Combining heterogeneous EO data can greatly improve knowledge on natural hazard risks for many urban dwellers.

Organized by:

Sponsors:

The growing threat: Earth Observation for reducing landslide risk from climate change

Keywords:

Medellín, population, landslide exposure and vulnerability, natural hazard.

1. Introduction:

Climate change is affecting more and more people. It is disrupting and damaging lives and livelihoods and affecting economic development (Defries et al. 2019). Landslides are the most frequently occurring natural disaster in Colombia. Every year they cause human losses and damages to buildings and infrastructure (Hallegatte et al. 2017). This is coupled with cities growing unplanned and informal towards high-risk areas due to land scarcity (World Bank 2012).

Preventing and reducing risk, exposure and vulnerability to natural hazards and climate change, as well as strengthening the resilience, are global targets (UNDRR 2020; GFDRR 2020). Earth Observation (EO) is playing an important – but until now not fully exploited – role in providing crucial information for decision-making and supporting risk reduction and adaptation. Its strength is the capability to provide independent and objective, accurate, up-to-date and frequent spatial data on local as well as global level. A good example is the ongoing German-Colombian research project '*Inform@Risk*' taking place in Medellín, Colombia. This project is developing a low-cost and site-specific Early Warning and Evacuation Systems (EWES) in a low-income and self-built neighborhood (Gamperl et al. 2021).

The aim of this paper is combining multiple and heterogeneous EO data to better understand landslide risks of urban dwellers in Medellín.

2. Methods:

EO data have been applied transversally and multi-scalar, i.e. at the city, district and local level in Medellín. High resolution (HR) and multi-temporal land-use/-cover as well as topographic information were derived from multi-sensor remote sensing data (from drones, PlanetScope, Landsat and TanDEM-X data, etc.).

In this project, the focus is on low-income neighborhoods. These are often more vulnerable and need more time to recover after a disaster (Hallegatte et al. 2017). For the classification, formal and informal settlement developments were located, with informality as a proxy for low-income groups (Wurm & Taubenböck, 2018). The morphology, i.e. complex, dense, low-rise structures, was used to proxy low-income groups (Taubenböck et al. 2018) and these were classified in HR satellite data using a random forest classifier (Kühnl et al. 2021). Potential landslide prone areas were located by the steepness of slopes proxy derived from digital elevation models (Müller et al., 2020). Beyond the physical urban landscape, a joint analysis of HR

satellite data with official population counts was carried out. A population map of higher spatial resolution than available in census data was derived using top-down disaggregation methods. The combination of all these diverse datasets allowed for a city-wide localization of possibly exposed landslide areas and the related exposed settlements and people. The result allowed to up-date current knowledge of the city of Medellin, with better resolved quantitative exposure estimates even beyond the administrative city boundaries.

At the local level, EO data provided by drones were leveraged to create unprecedented detailed geo-information at centimeter resolution. This was carried out in Bello Oriente, the low-income, fast growing and informal neighborhood in a landslide prone terrain (cf. project image). A 3-D city model was created that included the functions (residential, schools, commercial, etc.). Beyond, road infrastructure information on slope and width were classified. This EO database is an essential tool for planning and designing EWES evacuation routes. Last but not least, daytime and nighttime population spatial distributions were estimated supported by local surveys for Bello Oriente. These were used to simulate exposure and evacuation scenarios in the case of various landslide scenarios.

3. Results:

At the city level, the analysis showed first of all, that urban expansion in Medellin increases the city's exposure. Settlement areas were found to have more than doubled in the last 25 years in landslide prone areas. Beyond, it is striking to see that in 2018, 40% out of the total population of Medellín were living in precarious settlements. With respect to risks, we found 10% of the city population is living in precarious settlements and at the same time also in areas exposed to high and medium landslides risk.

At the local level, in Bello Oriente, we have traced the development in detail: In the last 25 years in this high risk-prone area of 40 hectares on average 50 houses were built per year. This exemplifies the informal dynamics in cities. Our population estimation determined nearly 4,600 residents in the EWES location, of which more than 40% are at very high risk of landslides based on a hazard map.

4. Conclusions:

We are living in the information age. However, we still often have little knowledge regarding the risks towards natural hazards of many urban dwellers. In the combination of EO data lies a huge potential to reduce these knowledge gaps. EO has the capabilities to bring the poor and exposed to the spotlight. Environmental, economic and social risks can be measured or approximated from space and in combination with other data sources allows to provide a comprehensive picture for decision-making leaving no one behind. This combination – from space and ground – is a necessity to improve knowledge as basis for better urban development and the improvement of human lives.

References:

Defries R, et al., 2019. The missing economic risks in assessments of climate change impacts, London School of Economics, Policy insight.

Gamperl M, Singer J & Thuro K, 2021. Internet of Things Geosensor Network for Cost-Effective Landslide Early Warning Systems', Sensors, 21(8), pp. 2609.

Global Facility for Disaster Reduction and Recovery (GFDRR), 2020. Bringing resilicience to scale, Annual Report 2020.

Hallegatte S, Vogt-schilb A, Bangalore M & Rozenberg J, 2017. Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters, Climate Change and Development Series. Washington, DC: World Bank.

Kühnl M, Sapena M & Taubenböck H, 2021. Categorizing Urban Structural Types using an Object-Based Local Climate Zone Classification Scheme in Medellín, Colombia. In REAL CORP 2021, 26th International Conference on Urban Development, Regional Planning and Information Society, pp. 173-182.

Müller I, Taubenböck H, Kuffer M & Wurm M, 2020 Misperceptions of Predominant Slum Locations? Spatial Analysis of Slum Locations in Terms of Topography Based on Earth Observation Data. Remote Sensing, 12(15), pp. 2474.

Taubenböck H, Kraff N & Wurm M, 2018. The morphology of the Arrival City – A global categorization based on literature surveys and remotely sensed data. Applied Geography, 92, pp. 150-167.

United Nations Office for Disaster Risk Reduction (UNDRR), 2020. United Nations Office for Disaster Risk Reduction - Annual Report 2020.

World Bank, 2012. Disaster Risk Management in Latin America and the Caribbean Region: GFDRR Country Notes, World Bank.

Wurm M & Taubenböck H, 2018. Detecting social groups from space – Remote sensing-based mapping of morphological slums and assessment with income data. Remote Sensing Letters. 9(1), pp. 41-50.

Acknowledgements:

This research was funded by the German Federal Ministry of Education and Research as part of the FONA Client II initiative, grant number 03G0883A-F, Inform@Risk – Strengthening the Resilience of Informal Settlements against Slope Movements. German partners: Leibniz Universität Hannover (Coordinator), Technische Hochschule Deggendorf, Technische Universität München, Deutsches Zentrum für Luft- und Raumfahrt e.V., AlpGeorisk, Sachverständigenbüro für Luftbildauswertung und Umweltfragen; Colombian partners: EAFIT University - URBAM, Alcaldía de Medellín, Área Metropolitana del Valle de Aburrá, Sistema de Alerta Temprana del Valle de Aburrá, Sociedad Colombiana de Geología, Colectivo Tejearañas, Corporación Convivamos, Fundación Palomá, Red Barrial Bello Oriente.