

Abstracts

2015

Jacobs, L., Dewitte, O., Poesen, J., Delvaux, D., Thiery, W., Kervyn, M., 2015. **The Rwenzori Mountains, a landslide-prone region?**. *Landslides*, doi: 10.1007/s10346-015-0582-5.

With its exceptionally steep topography, wet climate, and active faulting, landslides can be expected to occur in the Rwenzori Mountains. Whether or not this region is prone to landsliding and more generally whether global landslide inventories and hazard assessments are accurate in data-poor regions such as the East African highlands are thus far unclear. In order to address these questions, a first landslide inventory based on archive information is built for the Rwenzori Mountains. In total, 48 landslide and flash flood events, or combinations of these, are found. They caused 56 fatalities and considerable damage to road infrastructure, buildings, and cropland, and rendered over 14,000 persons homeless. These numbers indicate that the Rwenzori Mountains are landslide-prone and that the impact of these events is significant. Although not based on field investigations but on archive data from media reports and laymen accounts, our approach provides a useful complement to global inventories overlooking this region and increases our understanding of the phenomenon in the Rwenzori Mountains. Considering the severe impacts of landslides, the population growth and related anthropogenic interventions, and the likelihood of more intense rainfall conditions, there is an urgent need to invest in research on disaster risk reduction strategies in this region and other similar highland areas of Africa.

2016

Matthieu, K., Liesbet, J., Maes, J., Bih Che, V., de Hontheim, A., Dewitte, O., Isabirye, M., Sekajugo, J., Kabaseke, C., Poesen, J., Vranken, L., Mertens, K. 2016. **Landslide resilience in Equatorial Africa: Moving beyond problem identification!** *Belgeo*.

Landslides (LS) impacts are acute in Equatorial Africa, which is characterized by mountainous topography, intense rains, deep weathering profiles, high population density and high vulnerability. This study aims to move beyond the recognition of landslide occurrence and investigate effective risk reduction strategies. Based on 5 workshops with local stakeholders, we illustrate the widespread occurrence of LS on 4 representative study areas known for being severely affected by rainfall-triggered LS in Uganda (Mount Elgon, Mount Rwenzori) and Cameroon (Limbe and Bamenda urban regions). The findings highlight the good knowledge of local stakeholders on factors controlling the timing and spatial distribution of these events. Stakeholders identify a wide range of direct, but also far-reaching indirect and intangible cumulative impacts of LS. Finally, the project inventoried and categorized risk reduction strategies currently implemented in the targeted regions, as well as the factors identified by stakeholders as bottlenecks in the implementation of potential alternative strategies. The experience underlines the usefulness of involving stakeholders at an early stage in selecting study areas and defining specific research objectives.

Jacobs, L., Dewitte, O., Poesen, J., Maes, J., Mertens, K., Sekajugo, J., Kervyn, M., 2016. **Landslide characteristics and spatial distribution in the Rwenzori Mountains, Uganda**. *Journal of African Earth Sciences*

In many landslide-prone regions, data on landslide characteristics remain poor or inexistent. This is also the case for the Rwenzori Mountains, located on the border of Uganda and the DR Congo. There, landslides frequently occur and cause fatalities and substantial damage to private property and infrastructure. In this paper, we present the results of a field inventory performed in three representative study areas covering 114 km². A total of 371 landslides were mapped and analyzed for their geomorphological characteristics and their spatial distribution. The average landslide areas varied from less than 0.3 ha in the gneiss-dominated highlands to >1 ha in the rift alluvium of the lowlands. Large landslides (>1.5 ha) are well represented while smaller landslides (<1.5 ha) are underrepresented. The degrees of completeness of the field inventories are comparable to those of similar historical landslide inventories. The diversity of potential mass movements in the Rwenzori is large and depends on the dominant lithological and topographic conditions. A dominance of shallow translational soil slides in gneiss and of deep rotational soil slides in the rift alluvium is observed. Slope angle is the main controlling topographic factor for landslides with the highest landslide concentrations for slope angles above 25–30° in the highlands and 10–15° in the lowlands. The undercutting of slopes by rivers and excavations for construction are important preparatory factors. Rainfall-triggered landslides are the most common in the area, however in the zones of influence of the last two major earthquakes (1966: Mw = 6.6 and 1994: Mw = 6.2), 12 co-seismic landslides were also observed.

Mertens, K., Jacobs, L., Maes, J., Kabaseke, C., Maertens, M., Poesen, J., Kervyn, M., Vranken, L., 2016. **The direct impact of landslides on household income in tropical regions: a case study on the Rwenzori Mountains in Uganda**. *Science of the Total Environment*

Landslides affect millions of people worldwide, but theoretical and empirical studies on the impact of landslides remain scarce, especially in Sub-Saharan Africa. This study proposes and applies a method to estimate the direct impact of landslides on household income and to investigate the presence of specific risk sharing and mitigation strategies towards landslides in a tropical and rural environment. An original cross-sectional household survey is used in combination with geographical data to acquire detailed information on livelihoods and on hazards in the Rwenzori mountains, Uganda. Ordinary least square regressions and probit estimations with village fixed effects are used to estimate the impact of landslides and the presence of mitigation strategies. Geographical information at household level allows to disentangle the direct impact from the indirect effects of landslides. We show that the income of affected households is substantially reduced during the first years after a landslide has occurred. We find that members of recently affected households participate more in wage-employment or in self-employed activities, presumably to address income losses following a landslide. Yet, we see that these jobs do not provide sufficient revenue to compensate for the loss of income from agriculture. Given that landslides cause localized shocks, finding a significant direct impact in our study indicates that no adequate risk sharing mechanisms are in place in the Rwenzori sub-region. These insights are used to derive policy recommendations for alleviating the impact of landslides in the region. By quantifying the direct impact of landslides on household income in an agricultural context in Africa this study draws the attention towards a problem that has been broadly underestimated so far and provides a sound scientific base for disaster risk reduction in the region. Both the methodology and the findings of this research are applicable to other tropical regions with high landslide densities.

Jacobs, L., Maes, J., Mertens, K. et al. Nat Hazards (2016). **Reconstruction of a flash flood event through a multi-hazard approach: focus on the Rwenzori Mountains, Uganda.** Natural Hazards.

The increased use of complex and holistic modelling for multi-hazard analysis is in sharp contrast with a lacuna in hazard analysis in equatorial Africa. This study aims to increase understanding of multi-hazard events in poorly documented regions with low accessibility. We focus on the Nyamwamba catchment (107 km²) located in the Rwenzori Mountains (Uganda) where on May 1, 2013, a severe flash flood occurred. In this region, wildfires, earthquakes and landslides occur as well. Here we reconstruct the circumstances under which this flash flood event was triggered, characterize the different processes acting upon the catchment dynamics and estimate the damaging effects of the flash flood within the catchment. The combined occurrence of intense rainfall, a forest fire having burned 18 % of the catchment area and the occurrence of 29 landslides providing debris to the river system, induced a debris-rich and very destructive flash flood which caused several fatalities, the destruction of 70 buildings, several bridges, a hospital, a school, a tarmac road and several lifelines. Although the methodologies applied to estimate peak discharge, detect landslides and delineate wildfires are well established in their disciplines and sometimes limited in their precision, their combination is required to demonstrate the importance of the wildfire and landslides for the magnitude of this flood, unprecedented in decades but characterized by a low return period of the triggering rainfall event. This indicates that flash floods should not be considered as self-determined phenomena but as a result of several cascading and interacting hazard processes.

2017

Jacobs, L., Dewitte, O., Kabaseke, C., Kervyn, F., Maes, J., Mertens, K., Nobile, A., Sekajugo, J., Poesen, J., Samyn, D., Kervyn, M., 2017. **Landslide Diversity in the Rwenzori Mountains (Uganda)**. *Advancing Culture of Living with Landslides*, pp.79-86

In the Rwenzori Mountains, at the border between Uganda and the D.R. Congo, landslides frequently occur and cause fatalities and substantial damage to agricultural land and infrastructure. Up until recently, no information on the landslide characteristics, occurrence or spatial distribution was available. The use of archive inventories and field surveys however allowed identifying the key mass wasting processes in this region and their triggering and controlling factors. Here, we present the results of these multi-temporal archive and field inventories. The Rwenzori mountains are diverse in lithology, topography and land use patterns. This diversity in landslide controlling factors is also reflected in the types of landslides that occur in this 3000 km² large region. The majority of the Rwenzori Mountains consists of steep slopes on gneiss, mica-schists and amphibolite lithologies. A dominance of shallow translational soil slides is observed in gneiss while the amphibolite is found not to be prone to such landslides. This is in sharp contrast to the lowlands, which are characterized by gentle slopes and a rift alluvium lithology. In contrast to what was expected, the largest landslide densities are found in these lowlands where large, deep-seated rotational soil slides with head scarps up to 30 m depth prevail. In both the lowlands and the uplands, slope gradients appears to be the main topographic predictor for the spatial occurrence of landslides. Finally, concerning landslide triggering events, in both the archive inventory and the field surveys, rainfall-triggered landslides are the most common but co-seismic slides were also observed.

Maes, J., Kervyn, M., de Hontheim, A., Dewitte, O., Jacobs, L., Mertens, K., Vanmaercke, M., Vranken, L., Poesen, J., 2017. **Landslide risk reduction strategies: A review of practices and challenges for the tropics**. *Progress in Physical Geography*, 41(2), 191-221

Landslides constitute a serious problem globally. Moreover, landslide impact remains underestimated especially in the Global South. It is precisely there where the largest impact is experienced. An overview of measures taken to reduce risk of landslides in the Global South is however still lacking. Because in many countries of the Global South disaster risk reduction (DRR) is at an emerging stage, it is crucial to monitor the ongoing efforts (e.g. discussions on the Post-2015 Framework for DRR). The first objective of this study is to make an inventory of techniques and strategies that are applied to reduce risk from landslides in tropical countries. The second objective is to investigate what are the main bottlenecks for implementation of DRR strategies. In order to achieve these objectives, a review of both scientific and grey literature was conducted, supplemented with expert knowledge. The compilation of recommended and implemented DRR measures from landslide-prone tropical countries is based on an adapted classification proposed by the SafeLand project. According to Vaciago (2013), landslide risk can be reduced by either reducing the hazard, the vulnerability, the number or value of elements at risk or by sharing the residual risk. In addition, these measures can be combined with education and/or awareness raising and are influenced by governance structures and cultural beliefs. Global landslide datasets have been used to identify landslide-prone countries, augmented with region-specific datasets. Countries located in the tropics were selected in order to include landslide-prone countries with a different Human Development Index (HDI) but with a similar climate. Preliminary results support the statement made by Anderson (2013) that although the importance of shifting from post-disaster emergency actions to pre-disaster mitigation is acknowledged, in practice this paradigm shift seems rather limited. It is expected that this is especially the case in countries with a low HDI. Thus far,

identified bottlenecks for implementation and maintenance seem to be: 1) no access to capital for government and households, 2) limited awareness of possible measures, and 3) lack of law enforcement. This contribution presents an overview of the potential and applied landslide DRR measures in tropical developing countries as a crucial step towards more knowledge sharing in reducing landslide risks.

Jacobs, L., Maes, J., Mertens, K., Sekajugo, J., Thiery, W., van Lipzig, N., Poesen, J., Kervyn, M., Dewitte, O., 2017. **Flash Floods in the Rwenzori Mountains—Focus on the May 2013 Multi-Hazard Kilembe Event.** *Advancing Culture of Living with Landslides*, pp.631-641.

Over the past 50 years, at least seven major flash floods have affected catchments of the Rwenzori Mountains. The Rwenzori Mountains are not only subject to flash floods; forest fires, earthquakes and landslides occur as well. Many of the flash floods therefore co-occurred with other hazards. One of the most devastating of these events occurred on May 1st 2013, in the Nyamwamba catchment. Here we reconstruct the circumstances under which this flash flood event was triggered and its effects in this multi-hazard region. This includes the identification and characterization of different processes acting upon the catchment dynamics, their controlling and triggering factors and the estimation of the damaging effects of the flash flood within the catchment. The combined occurrence of intense rainfall, a forest fire having burned 18% of the catchment area and the occurrence of 29 landslides providing debris to the river system, induced a debris-rich and very destructive flash flood which caused several fatalities, the destruction of 70 buildings, several bridges, a hospital and a school, a tarmac road and several life lines. Peak flow discharge is estimated between 850 and 1300 m³/s. This case-study demonstrates that flash floods in the region should not be considered as self-determined phenomena but as a result of several cascading and interacting hazard processes including wildfires and landslides, occurring within a short time period.

Maes, J., Poesen, J., Parra, C., Kabaseke, C., Bwambale, B., Mertens, K., Jacobs, L., Dewitte, O., Vranken, L., de Hontheim, A., Kervyn, M., 2017. **Landslide Risk Management in Uganda: A Multi-level Policy Approach.** *Advancing Culture of Living with Landslides*, pp.395-403. DOI: 10.1007/978-3-319-53487-9_46

While landslides constitute a major risk in Uganda, this geomorphological hazard has been largely neglected by national and local authorities in West Uganda. Nowadays, disaster risk management is emerging in Uganda. Monitoring the on-going efforts is therefore crucial in this region. We identify the actors involved in landslide risk management in West Uganda and examine their roles and interactions by investigating both policy and practice. This paper describes a qualitative multi-policy level approach, based on extensive field work and literature on systems analysis and scalar politics. The results show that in theory, landslide risk management in this region consists of a well-structured National Policy (2010), including the establishment of horizontally structured platforms at different administrative levels and a focus on pre-disaster mitigation activities. In practice, however, the implementation is insufficient, as most platforms at local level remain dysfunctional or only meet after a disaster occurred. The dominant arena for landslide risk management remains at national level, despite the promotion of decentralisation, and the focus remains on post-disaster emergency measures, such as providing relief. At local level, bottom-up landslide risk reduction efforts are made that are disconnected from the national policy, scattered and done haphazardly. Thus, discrepancies exist between policy and practice regarding landslide risk management in West Uganda but efforts are moving gradually towards disaster risk reduction.

Submitted articles

Maes, J., et al. Questioning network governance for disaster risk management: Lessons learnt from landslide risk management in Uganda. Submitted to *Environmental Science & Policy*

Decentralised platforms are promoted as an indispensable strategy to achieve effective and efficient disaster risk management by the Hyogo Framework for Action and the Sendai Framework for disaster risk reduction (DRR). Based on empirical data from landslide risk management in West Uganda, we question the implications for disaster risk management of this type of network governance. We argue that in Uganda, decentralised platforms co-produce unequal risk as they are used as spatial tactics to cunningly centralise power for the ruling party. This legitimisation of centralised power is done through three processes of scale structuration: incomplete decentralisation, blame dissolution and scale jumping. In this study, these observations are embedded in an analytical framework that combines network governance literature with insights from scale theory, politics of disaster and blame theory. Using this analytical framework allows us to draw broader conclusions on the political economy of the implementation of disaster network governance in countries that are primarily governed hierarchically and that endorse the international frameworks of DRR.

Maes, J., et al. Socio-political drivers and consequences of landslide and flood risk zonation: A case study of Limbe city, Cameroon. Submitted to *Environment and Planning C: Politics and Space*

Risk zonation is often proposed as a long-term disaster risk reduction (DRR) strategy by international treaties and academic research. This strategy has been implemented in the city of Limbe in Cameroon, which is known to be disaster-prone. Citizens are forced to settle in unsafe terrains, ranging from wetlands to unstable hillslopes due to the city's geographical location and economic attraction. Following the fatal landslides and floods in 2001, a local crisis committee identified affected areas and declared them 'risk zones' to prevent further exposure. Empirically, this manuscript narrates the production and implementation of risk zonation policy in the city of Limbe. Theoretically, it uses urban political ecology (UPE), which incorporates science and technology studies, post-foundational theory and disaster research to interpret the socio-political drivers and physical consequences of the mismatch between policy and practice. This paper argues that authorities from national to local level use a post-political discourse to promote and implement DRR in the city of Limbe through the development of risk zonation policy. As a consequence, risk zonation leads to risk accumulation. Finally, this paper contributes to the 'second wave' of UPE by moving beyond the political trap of UPE and to the debate on effective DRR.

Mertens, K., Maes, J., Jacobs, L., Kervyn, M., Poesen, J., Vranken, L. Why are households in landslide-prone areas less inclined to plant trees for landslide susceptibility reduction? submitted to *Global Environmental Change*

Natural hazards have a large impact on household livelihoods worldwide, especially in the Global South. Yet, literature on the adoption of risk reduction measures at household level remains scattered and inconclusive. This study combines geographical data with an original cross-sectional household survey to investigate the relation between risk reduction intentions and both exposure to and experience with a natural hazard. Regressions are used to test the protection motivation theory (PMT) and to investigate the link between intentions to plant trees to reduce landslide risk and past experiences, actual exposure, perceived threat and perceived capacity to prevent the occurrence of landslides. The results show that respondents in our study area in Uganda are well aware of landslide

risk and believe trees are effective in landslide susceptibility reduction. Yet, those farmers that would benefit most from reducing landslide susceptibility by planting trees have the lowest intention to do so. A low self-efficacy among exposed farmers is proposed to explain this result. This finding has important implications for disaster risk reduction policies and leads to recommendations on how governments and development agents should communicate about landslide risk.