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Flood Risk Awareness in the Digital Age: Virtual Reality and Geovisualization for the Next Generation

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Abstract:

Floods are among the most devastating natural disasters, causing extensive damage to infrastructure, disrupting communities, and posing severe risks to human lives, as seen e.g. at the Ahr Valley flooding (Germany) in 2021. The intensity of these events is constantly increasing due to climate change (Deumlich & Gericke, 2020).

As river floods (fluvial floods) often occur at regular intervals, they remain present for people affected and are not forgotten. If an event is too far in the past, a kind of "flood dementia" occurs in many parts of the population. This involves the risk that, in the event of a disaster, the procedures are no longer internalised, and people put themselves in danger through a lack of knowledge and routine. This phenomenon occurs not only with fluvial events, but particularly often with pluvial events. Pluvial floods occur at irregular intervals and their intensity is difficult to predict. They occur when large amounts of precipitation occur locally in a short period of time, even without direct presence of rivers (Kutschker & Glade, 2016). If the rainfall greatly exceeds the infiltration rate of the soil, flash floods occur, resulting in a flood wave that can cause enormous destruction (Beyer, 2016). Due to the poor predictability of these pluvial events, prevention is of particular importance.

One of the challenges of preventive actions is the need to balance different target groups. To raise awareness and reach as many parts of the population as possible, it is necessary to gain knowledge of the different groups, their respective levels of knowledge and their accessibility. The identification of these factors was carried out in a survey as preparatory work in the BMBF-FloReST project. The results show that the population aged 20 and younger was hardly or not at all reached by the survey, in contrast to the population aged 50 and older. Therefore, particular attention should be paid to the population aged 20 and younger, as they were hardly reached and often lack imagination regarding the effects of a pluvial flood event due to their limited experience.

Virtual Reality (VR) as an emerging technology that blends the physical and digital worlds, could be one technology to attract the young citizens to deal with the flood-topic (Sermet & Demir, 2018; Sanni et al.,2025). VR is a computer-simulated reality that represents a 360-degree environment, which can be interacted with through controllers. The aim of VR applications is to create an immersive experience which should be as realistic as possible. This means that the user should get the feeling of being completely immersed. To achieve this it is possible to get a haptic feedback in the form of heat or pressure or through additional audio signals like for example the sound of rain and thunderstorm.

To sensitize especially young citizens for extreme flood situations in their own municipalities a VR application that mimics flash flood scenarios was created. To make the application as flexible and customisable as possible, open data formats such as OpenStreetMap (OSM) data or Google Earth are used. This allows users to implement their own familiar environment into the application to get a realistic picture of flooding in their neighbourhood.

The 3D modelling of the landscape was done with the software Blender. As data basis, the Global 30 Arc-Second Elevation model (GTOPO30) for the terrain, and for building geometries the data stock of OSM is used. Additionally, satellite images from Google Maps/Earth are overlaid onto the terrain to provide visual context. Another way of creating the landscape is to export a snippet from Google Earth via the 3D-Tiles API from Google. The 3D landscape created in Blender is then transferred to the Unity software for further logic processing, such as inserting the flood scenario and teleportation to get a different angle/view of the scenario. Additionally, a water level display has been implemented, so that the user may read the current water level in the scenario. To enhance the level of immersion, a suitable sky with a thunderstorm scenario as well as audio files containing rain and thunder sounds were inserted. To create an even better immersion a rain shader was developed which shows running droplets within the vision field. In the final step, the application had to be transferred to a head-mounted display. To achieve the greatest possible flexibility for later applications with citizens, untethered VR glasses (stand-alone VR glasses, such as the MetaQuest 3) are used. These

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glasses are completely independent and no longer require a computer since they take over the entire computing effort themselves and even include tracking.

In a first step, a usability test was conducted with students from the Faculty of Environmental Planning to gather feedback on the level of immersion and the usability of the application. Based on this feedback, an improved version of the geovisualization is now available for selected sites and is regularly presented at municipal citizens' meetings and in schools for educational and participatory purposes. Workflow descriptions and documentation on how to create a personalized scenario, for example for one's own backyard, are publicly available on the project's website (https://www.umwelt-campus.de/iss/projekte/laufende-projekte/florest-starkregen-hochwasser). In conclusion, the developed VR application has proven highly effective in engaging the young audience and generating considerable interest. However, due to the lack of a systematic evaluation, it was not yet possible to assess the specific impact of the application on flood risk awareness. While the application shows strong potential in terms of user engagement, its effectiveness in improving young users' understanding and awareness of flood risks remains unclear and calls for further empirical investigation.

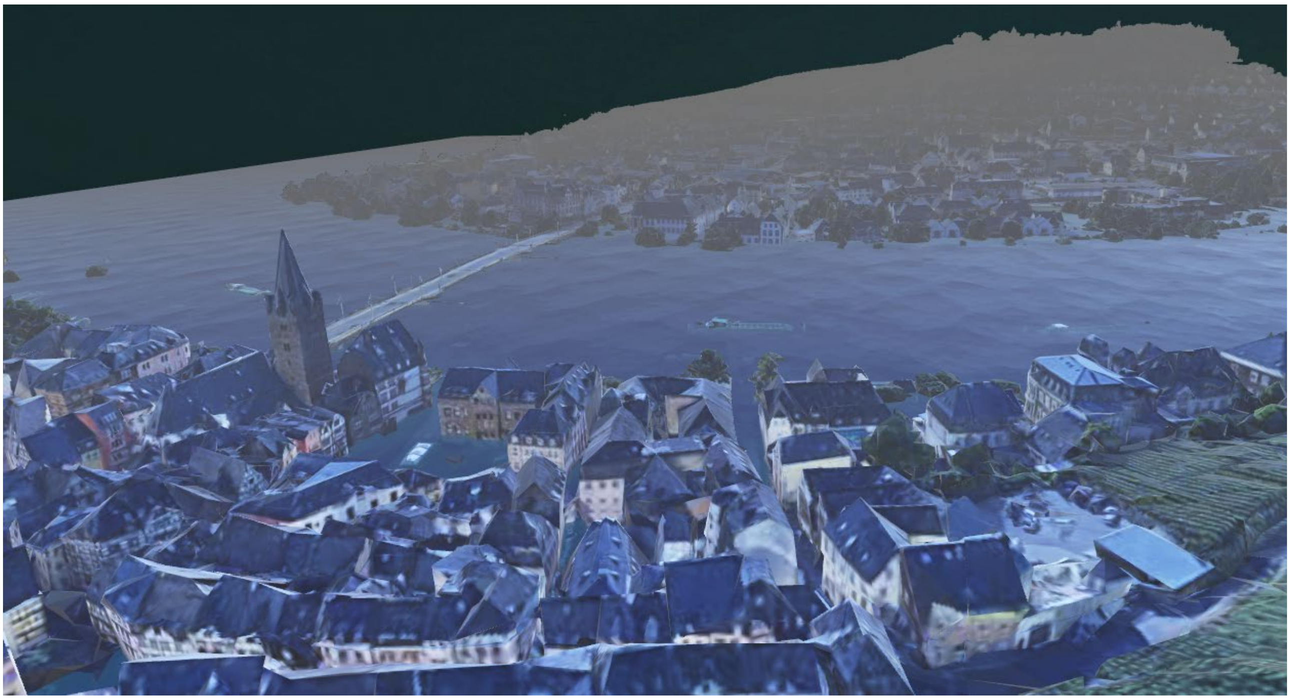

Figure 1. Screenshot of a 3D-model depicting the city of Bernkastel-Kues (Rhineland-Palatinate, Germany) during a simulated flood event of the Moselle River (Rhineland-Palatinate, Germany)

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References

Beyer, R. (2016). *Starkregen und Sturzfluten*. ecomed-Storck.

Coelho Alexandre Hering (2004): Erweiterte Realität zur Visualisierung simulierter Hochwasserereignisse.- Dissertation, Institut für Photogrammetrie und Fernerkundung (IPF), Universität Karlsruhe. DOI: 10.5445/IR/1000001685

Deumlich, D., & Gericke, A. (2020). Frequency trend analysis of heavy rainfall days for Germany. *Water (Switzerland)*, *12*(7). https://doi.org/10.3390/w12071950

Kutschker, T., & Glade, T. (2016). *Unwetter!-Starkregen als Herausforderung für den anwendungsbezogenen Bevölkerungsschutz Auswirkungen von Starkregenereignissen und deren Anforderungen an die Gefahrenabwehr*.

Sanni, Tolulope & Shao, Wanyun & Liu, Jun & Shi, Yangming. (2025). *Investigating the Feasibility of Adopting Virtual Reality as a Method for Natural Hazard Risk Communication*. International Journal of Disaster Risk Reduction. 119. 105296. 10.1016/j.ijdrr.2025.105296.

Sermet, Yusuf & Demir, Ibrahim. (2018). *Flood Action VR: A Virtual Reality Framework for Disaster Awareness and Emergency Response Training*. 10.1145/3306214.3338550.

https://doi.org/10.5194/ica-abs-10-76-2025