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Understanding urbanization's impact on flash flood risks from past to future: A Case study of a rapidly growing MENA city

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Jordan has experienced several flash floods in recent years, causing property damage and fatalities. Because of the high rates of urbanization since the 1950s, flash flood damage is more likely and the risk to infrastructure and people is increasing. However, the contribution of land use and land cover changes (LULCC) to flash flood risk in urban areas is still poorly understood. Our aims were, therefore, to (i) examine LULCC and urbanization trends and their drivers in Amman, the capital of Jordan (ii) simulate future land cover trends and (iii) investigate the impact of urban expansion on flash flood related damages in the past, present and future.

A mixed-method approach combining quantitative (remote sensing, statistical modelling) and qualitative methods (semi-structured interviews and stakeholder workshops) was used. Past long-term LULCC from 1968 to 2021 were analyzed via object-based classification of panchromatic Corona and multispectral Spot images. Semi-structured expert interviews were conducted to explore historic and current LULCC drivers and their dynamics. The simulation of future land cover trends was based on past LULCC and the identified main drivers using an MLP-MC model then refined with local experts' knowledge of future urban planning through stakeholder workshops. The resulting LULC-maps were used in hydrological modeling with HEC-HMS to assess LULCC effects on runoff generation.

In the last six decades, the built-up area in Amman's watershed has increased significantly, by a total of 203 km² between 1968 and 2021 (from 20 km² to 223 km²). This trend was mainly at the expense of rainfed cultivated plots and green retention areas (157 km² from 1968 to 2021), resulting in reduced water infiltration and accelerated rates of runoff. The LULCC and urbanization patterns stem from intricate feedback loops involving various socio-economic and bio-physical drivers. Key urbanization drivers include demographic trends (population growth and density), topographic conditions (slope, elevation) as well as the accessibility and location of an area (density of former built-up area, distance to formal/informal refugee settlements, major roads,

built-up areas, city centers, and employment hubs). The inadequate policy interventions coupled with mismanagement and unbalanced land-use allocations highly influenced the urbanization pattern that has favored the loss of retention areas in the past. For future land cover changes, the conducted stakeholder workshops revealed that development plans will focus particularly on the dry eastern region of Amman's watershed (areas that generally receive less rainfall). However, measures and actionable plans to maintain the remaining retention areas are still lacking. The simulated future land cover trend indicates a continued loss of retention areas while areas prone to flash floods will increase emphasizing an urgent need to integrate flash flood risk management in urban development plans. Here, our LULCC analysis gives decision support for urban planners, especially for spatial planning and allocation of future measures and retention areas.