ISOE Policy Brief — No. 11

Water

Flash flood management in arid and data-scarce countries

Lessons learnt from Jordan

ACTIONABLE RECOMMENDATIONS

1 — Overcome structural challenges: An overarching strategy for flash flood management is needed to better coordinate projects and government activities. Strengthening the relationship and communication between government agencies and local communities is important for effective law enforcement and implementation of flash flood measures.

2 — Improve data and make it accessible: Basic data on critical infrastructure, social aspects and environmental factors (in particular rainfall, runoff, and soil data) needs to be improved and integrated into vulnerability analyses to enable more robust risk assessment and planning.

3 — Use participatory approaches: To comprehensively integrate measures to reduce flash flooding into planning, broad stakeholder participation and better knowledge integration are required. A joint understanding of the planning goals such as flash flood risk reduction, quality of life or cultural heritage preservation helps to steer the participatory process.

4 — Make use of open space and foster nature based solutions: In view of the rapid urbanization trend, the remaining open spaces should be considered for implementing nature-based solutions (NBS). NBS help to improve climate resilience by retaining rainfall runoff and improving water infiltration.

EXECUTIVE SUMMARY

In many water scarce countries in the Middle East and Northern Africa (MENA), heavy rainfall has led to flash floods that have caused enormous damage. The increasing impact of climate change is further intensifying the region's vulnerability. One of the main tasks for climate change adaptation is, therefore, to minimize flash flood damages and maximize the benefits of heavy rainfall by improving rainwater retention.

Research findings from Jordan that can be applied to the MENA region demonstrate the need for integrated strategies and holistic approaches to improve risk assessment and planning, and to strengthen resilience. Mapping and modelling methods visualize areas at risk of flooding and vulnerability to climate change, even in countries where data is scarce, such as Jordan. When selecting measures to reduce vulnerability to climate change, it is important to consider a wide range of options, including nature-based solutions.

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Introduction and problem statement

Many countries in the Middle East and Northern Africa (MENA) are characterised by a hot and arid desert climate, which renders them highly susceptible to climate change and extreme climatic events (Lelieveld et al. 2014). Of these, flash floods often result in significant damage to people and the environment, caused by sudden intense rainfall events. Between 1950 and 2025, 302 flash flood events were recorded in the MENA region (Emergency Events Database, 2025, figure 1). The catastrophic flooding in the Persian Gulf region in April 2024 resulted in at least 46 deaths, high lighting the destructive danger of such events.

During international debates on climate adaptation, the provision of climate services for risk prevention is a high political priority, but they have not yet been put into practice sufficiently. Sound hydrological and meteorological knowledge is needed to predict the occurrence and intensity of flash floods more accurately. However, limited meteorological data and fragmented institutional coordination result in weak risk mitigation strategies that challenge effective response and preparedness. In addition, the increasing impact of climate change and the high urbanization pressure, combined with limited public awareness and constrained financial resources, intensify the region's vulnerability.

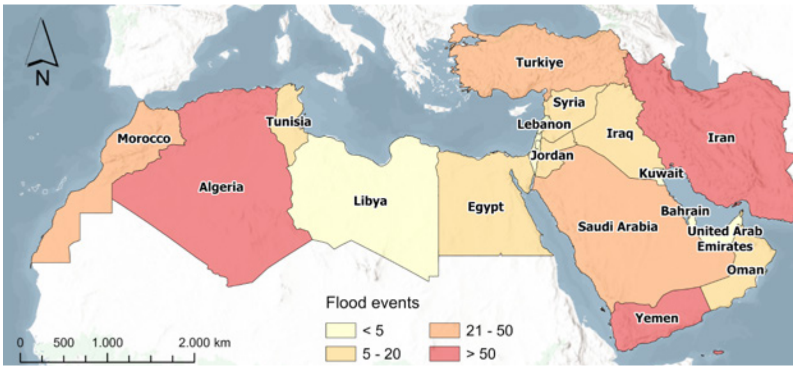


Figure 1: Map showing number of flood events in the MENA region from 1950 to 2025 based on records in EM-Data (Emergency Events Database, 2025).

Evidence and Analysis

Overcome structural challenges in flash flood management

Structural challenges include weak institutional coordination of flash flood management, overlapping or unclear responsibilities between government agencies, limited cooperation between government sectors (e.g. water, environment and civil protection) and inadequate enforcement of building and land use regulations (Loudyi and Kantoush 2020). To structure and better coordinate the projects and government activities on flash flood management it is key to enhance the coordination between government agencies, for example through an overarching strategy for flash flood management. Recent projects on flash flood management including CapTain Rain in Jordan (Brinkmann and Ziegler 2025) enhanced the coordination between government agencies and projects through their steering and technical committees and by workshops and participatory planning approaches. Capacity building for goverment officials was conducted to strengthen ownership and qualifications with the goal to sustain and build on project results.

The ownership of project results and rule compliance by local communities is low, because very few projects integrated local communities into project designs and decision-making processes. There are a few government incentives for local communities to construct flash flood measures. It is key to further strengthen the relationship between government agencies and local communities through participatory processes as well as joint projects to develop and establish future working routines. Only through close cooperation and involvement of local stakeholders their knowledge and needs can be considered and a solution addressing their requirements defined. Like this their acceptance and commitment is reached and a sustainable support and rule compliance guaranteed.

Improve risk and vulnerability assessment

A flash flood risk assessment is the first step in developing flood management plans and planning risk mitigation measures. **Hydrological and hydraulic models** are used to analyse flooding areas and depths. Hydrological models give a fast overview about runoff curves depending on rainfall events, topography, soil and land use. They are relatively easy to setup and fast to compute. Hydraulic models produce spatially detailed information about water levels and flow velocities in inundated areas, but require higher expert knowledge and computational power as well as detailed data on infrastructure. Combined with data about people, infrastructure, and ecosystem services, high, medium and low risk areas are identified. The unavailability and sometimes insufficient quality of data, especially for the calibration and validation of flood models, is a serious challenge for flood risk assessment in the MENA region (Loudyi and Kantoush 2020, Hohmann et al. 2024). It is therefore imperative to improve the data basis as well as the methodological standards and capacities for flash flood risk assessment.

In regions where data is scarce, open-source datasets such as OpenStreetMap (OSM) are a valuable addition, offering a flexible and cost-effective foundation, particularly for structural and land use data. Combined with DEMs, remote sensing data and measurement data, it can significantly improve data availability.

In addition to the risk assessment, a flash flood **vulnerability analysis and assessment** (figure 2) supports decision-making in urban planning by identifying vulnerable areas and areas with high adaptive capacity. Based on this assessment, both adaptation strategies and measures can be selected to reduce flash flood risks and vulnerability of the local population. Vulnerable areas would be priority areas for future implementation of flash flood mitigation measures.

Methods – vulnerability assessment cycle

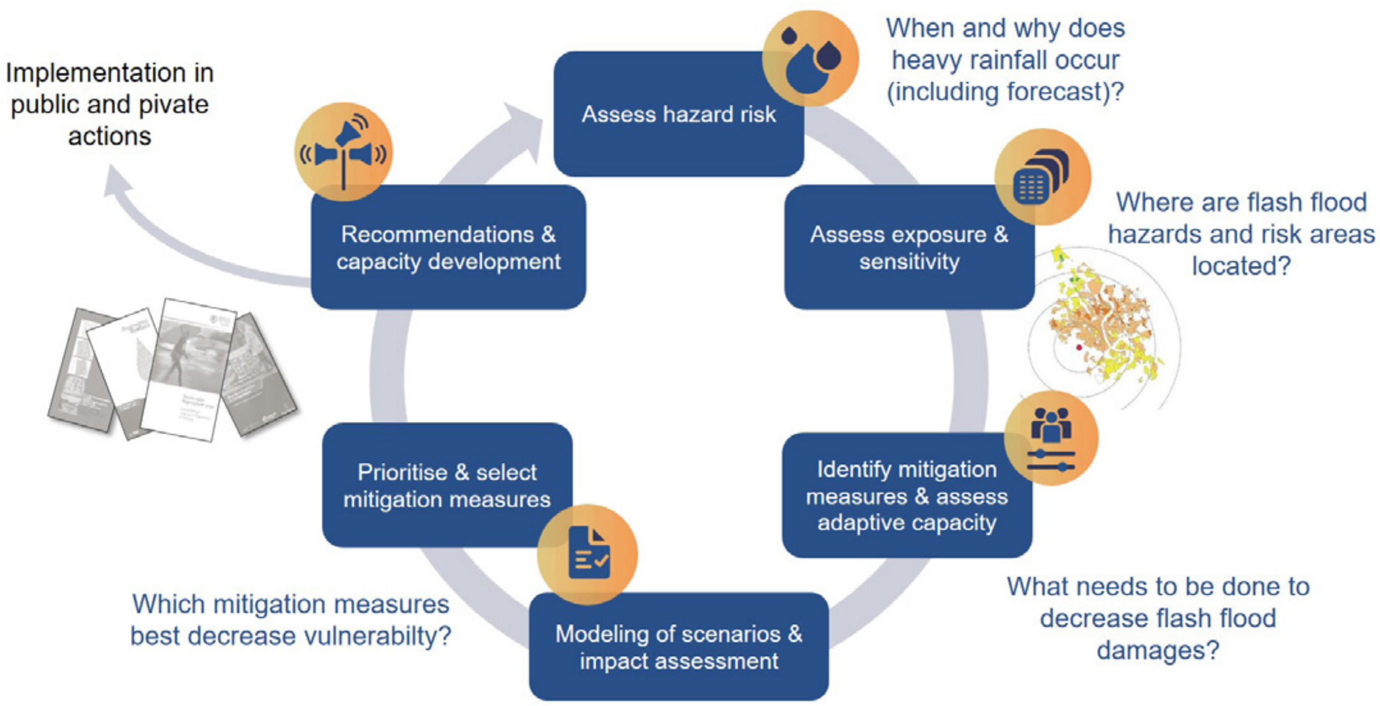


Figure 2: Conceptional framework of an integrated vulnerability analysis of flash floods and associated activities within the German Jordanian research project CapTain Rain (Brinkmann and Ziegler 2025).

INFOBOX 1

Example of an integrated vulnerability analysis in Jordan

Within CapTain Rain, the hydraulic modeling approach was based on the German standard DWA-M 119 (DWA 2016) and adapted to the local conditions in Jordan. Data gaps for hydrological and hydraulic modelling and the vulnerability analysis were compensated using Open Street Map (OSM) data for buildings and building types, land use information from satellite image analysis and socio-economic data extracted from interviews with experts and local residents.

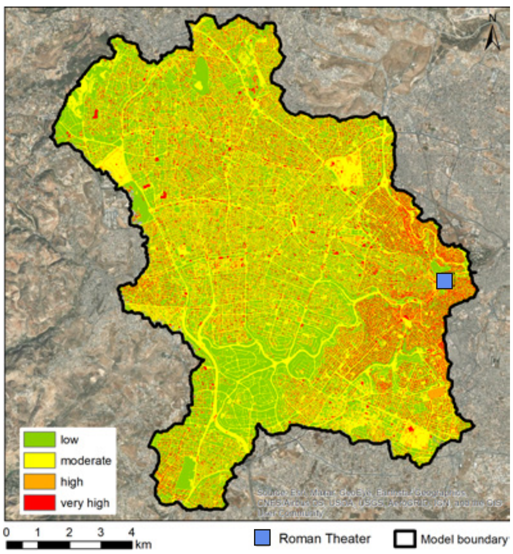
For the vulnerability analysis a social-ecological concept was used that account for the different vulnerability components (exposure, sensitivity and adaptive capacity; Thiault et al. 2021) and considers social, physical and ecological aspects. Special attention was given to adaptive capacity, which in our assessment indicates the economic potential and the availability of open space for future implementation of measures.

Results for a watershed in Amman

- The most vulnerable areas were detected in the east of the studied watershed (Downtown Amman): Highest built-up area, highest sensitivity of residents (many disadvantaged inhabitants) and many exposed areas (proximity to flood path).
- The highest adaptive capacity was found in the northwest and within the subcatchment area of Marj Al Hamam: Open space in public and private land available.

Given the great potential of open space on private property and the willingness of citizens to implement measures, it is suggested that more incentives should be created to promote the implementation of measures reducing flash flood damage. Public institutions should also demonstrate measures on public land. Moreover, new neighbourhoods should contain respective measures already in their planning process.

SENSITIVITY AND EXPOSURE



ADAPTIVE CAPACITY

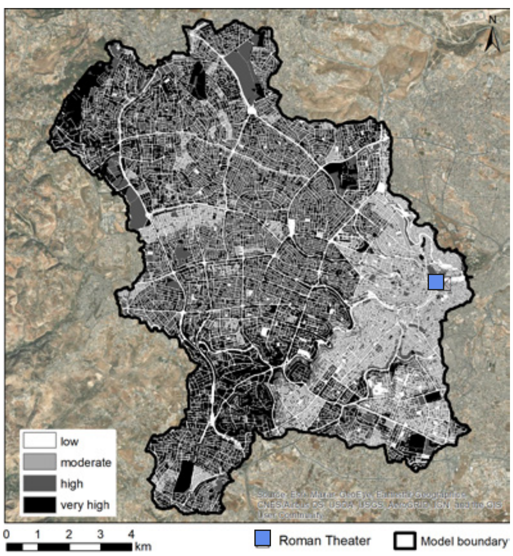


Figure 3: Combined vulnerability maps showing all domains for sensitivity and exposure (left) and for adaptive capacity (right) for a watershed in Amman. The location of the Roman theatre is shown for orientation purposes (Source: Brinkmann et al. 2025)

Participatory approaches for the selection and implementation of flood mitigation measures

The results of the risk and vulnerability assessment are used to inform the planning, selection and implementation of flood mitigation measures. This process requires broad stakeholder participation and the integration of different knowledge bases. When determining suitable measures, the various needs and perspectives of stakeholder groups must be taken into account and integrated by designing and evaluating promising measures in cooperation with local stakeholders and government officials with different areas of responsibility. This transdisciplinary approach to **participatory planning is an iterative process** (figure 4). It begins with the joint selection of the planning area and the subsequent data collection and analysis. On this basis, planning objectives (e.g. reducing damage from flash floods, improving quality of life, or preserving cultural heritage) are defined and suitable measures are identified, selected, and localized.

A range of different measures are available for flash flood risk reduction (mitigation) and thus adaptation to climate change. While large-scale technical measures, such as the construction of culverts, may offer a partial solution, they are constrained by limitations in construction methods, costs and the availability of space. Furthermore, purely technical measures are not sufficient to deal with the damage caused by flash floods in urban areas. When selecting measures, the multifunctional potential of nature-based solutions such as quality of stay, biodiversity or cooling is often overlooked (United Nations Global Compact, 2019). An integrated set of flash flood risk mitigation measures, ideally in public and private areas, is needed to significantly reduce the damage potential.

Steps of a participatory planning process

1 Data collection and analysis

- Identification of planning area and data collection
- Categorization of land use types
- Assessment of area potential

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2 Planning and localization

- Stakeholder engagement
- Identification of planning goals and measures
- Determination of entry points and focus areas
- Selection and localization of measures

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3 Development and strategy

- Scenario development and modelling
- Impact assessment and readjustment
- Integration into planning concepts
- Development of detailed plans

Figure 4: Overview of a stepwise planning process comprising data collection and analysis, planning and localization, and development and strategy (Schumann-Hindenberg et al. 2025).

INFOBOX 2

The potential of nature based solutions in Jordan

Within the CapTain Rain project a participatory planning process was used to highlight the potential of nature based solutions in Wadi Musa and Amman (figure 5). Hydraulic simulations of a watershed in Amman revealed that implementing blue-green infrastructure measures in both private and public spaces could reduce peak runoff by 75 % (Schumann-Hindenberg et al., 2025).

In Amman, undeveloped areas and areas under development can be adapted with blue-green infrastructure in addition to technical measures:

- Streets can be redesigned to accommodate bioswales and infiltration trenches.
- Public commercial buildings have a good potential to implement green or blue roofs.
- Spaces between the commercial building, initially proposed as a plaza, have potential to be converted into “green corridors”, multifunctional spaces used to retain the stormwater.
- Parking spaces have potential to increase infiltration: In permeable soils, paving can be laid in such a way that rainwater contributes to groundwater recharge.
- Incentives should be created for the implementation of measures on private land.

Figure 5: Examples of nature-based solutions in Jordan: Restored historic check dams in the Wadi Musa region (top), green roofs at the Central Mosque in Amman (bottom).

Conclusion and further information

Flash flood risks in the MENA region are increasing with climate change, and vulnerability is high. To reduce flash flood vulnerability, climate services can contribute to better information, decision-making and early warning. A major challenge for robust climate services is the limited access to and quality of data. Transdisciplinary collaboration and participatory planning tools improve data exchange, avoid duplication of work and enhance prediction, early warning and targeted responses. In this regard, establishing standards for modelling (infobox 1), as well as meteorological and hydrological monitoring is essential in order to synthesize (project) activities. Implementing nature based solutions should be integrated into participatory planning processes involving various stakeholders, starting with shared goals and incorporating a wide range of measures to be formalized in flash flood risk management plans.

About the project

The German-Jordanian research project CapTain Rain (“Capture and retain heavy rainfalls in Jordan”; duration: June 2021–July 2024;) was funded by the German Federal Ministry of Research, Technology and Space (BMFTR).

The aim was to help improve current methods and tools for predicting flash floods and preventing of damage. Vulnerability analyses were carried out, data management tools for early warning were provided, measures to reduce the damage caused by flash floods through the use of nature based solutions were identified, and recommendations for urban planning and early warning systems were developed. Future scenarios were simulated for Amman and Wadi Musa to assess the impacts of climate change, urbanisation and how specific measures can help reduce vulnerability.

German project team: Institute for Social-Ecological Research (ISOE); Koblenz University of Applied Sciences; Hamburger Stadtentwässerung AöR; Potsdam Institute for Climate Impact Research (PIK); Institute for Technical and Scientific Hydrology (itwh); KISTERS AG

Jordanian research partners: Ministry of Water and Irrigation of Jordan (MWI); Ministry of Environment of Jordan (MoE); Jordan Meteorological Department (JMD); Royal Jordanian Geographic Center (RJGC); Greater Amman Municipality (GAM); National Agricultural Research Center (NARC); Petra Development and Tourism Region Authority (PDTRA)

www.captain-rain.de

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Images: AlGhad Newspaper (Cover Photo showing flooded Roman Theatre in Amman); ISOE (p. 6, figure 5)

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