Capture and retain heavy rainfalls in Jordan (CapTain Rain)

Progress report 2021

(June 2021 – December 2021)

Presented by the CapTain Rain project team

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Number and type of project partners

Partner from Germany (Abbreviation)	Type
Institute for Social-Ecological Research (ISOE)	Research Institute
Koblenz University of Applied Sciences (KU)	University
Potsdam Institute for Climate Impact Research (PIK)	Research Institute
HAMBURG WASSER (HW)	Company
KISTERS AG (KIS)	Company
Institute for Technical and Scientific Hydrology GmbH (ITWH)	Company
Partner from Jordan (Abbreviation)	
Ministry of Environment of Jordan (MoE)	Ministry
Ministry of Water and Irrigation of Jordan (MWI)	Ministry
National Agricultural Research Center (NARC)	Research Center
Greater Amman Municipality (GAM)	Administration
Petra Development and Tourism Region Authority (PDTRA)	Administration

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Zusammenfassung

Der Nahe Osten ist in besonderem Maße vom Klimawandel und extremen Klimaereignissen wie Dürren und starken Regenfällen betroffen. In Jordanien haben die wiederholten Starkregenereignisse der letzten Jahre zu Sturzfluten mit enormen Schäden geführt. Zugleich ist Jordanien eines der wasserärmsten Länder der Welt und verfügt nur über wenige erneuerbare Wasserressourcen. Die Minimierung solcher Schäden, aber auch die Maximierung des Nutzens von Starkregenereignissen durch verbesserte Wasserrückhaltung in einem der wasserärmsten Länder der Welt, ist das Forschungsthema von CapTain Rain ("Capture and retain heavy rainfalls in Jordan. Dazu werden die treibenden Faktoren von Sturzfluten in jordanischen Wadi-systemen analysiert und die komplexen Wechselwirkungen zwischen Klima- und Landnutzungsänderungen und wasserbaulichen Maßnahmen untersucht. Auf der Grundlage von Vulnerabilitätsanalysen und technischen Lösungen für die Wassersammlung und -ableitung bei Starkregenereignissen werden Maßnahmen zum Schutz der Bevölkerung identifiziert. Klimadienstleistungen (z.B. Sturzflutgefahrenkarten, Frühwarnsysteme, Empfehlungen zur Vorbeugung von Starkregenereignissen) werden in enger Zusammenarbeit mit jordanischen Akteuren und Praxispartnern unter Berücksichtigung wissenschaftlicher und lokaler praktischer Erkenntnisse entwickelt. Das Untersuchungsgebiet umfasst die Hauptstadt Amman mit ihren 4,3 Millionen Einwohnern in der Metropolregion und die eher ländlich geprägte Region um das UNESCO-Weltkulturerbe Petra. Beide Regionen waren in der Vergangenheit stark von Sturzflutereignissen betroffen.

Das Forschungsprojekt startete im Juni 2021. In den ersten Monaten von CapTain Rain wurde das Projektkonsortium gegründet, der Stakeholder Dialog und die transdisziplinäre Integration angestoßen und ein Projektkommunikationsplan erstellt. Eine englisch-arabische Internetplattform wurde erstellt und ist seit September 2021 online (www.captain-rain.de). Insgesamt wurden im Berichtszeitraum zwei Pressemitteilungen zum Projektstart erstellt. Um die inter- und transdisziplinäre Zusammenarbeit durch eine gemeinsame und transparente Datenbasis zu erleichtern, wurde eine cloudbasierte Lösung für das Forschungsdatenmanagement konzipiert und eingesetzt. Die verschiedenen Arbeitspakete des Projektkonsortiums begannen ihre Forschungsaktivitäten mit einer Literaturrecherche, der Datenerfassung und -verarbeitung sowie der Auswahl von Modellierungsansätzen. Diese Schritte umfassten auch eine Feinabstimmung der Aktivitäten und der entsprechenden wissenschaftlichen Produkte, um sie besser an die spezifischen Bedürfnisse der Stakeholder anzupassen. Um die kollaborative und transdisziplinäre Arbeit zu fördern, wurde der internen Kommunikation innerhalb des Projektverbundes besondere Aufmerksamkeit gewidmet. Dazu gehörten regelmäßige Telefonkonferenzen des CapTain Rain-Koordinierungsteams, monatliche Treffen und Video-konferenzen der verschiedenen Arbeitspaket-Teams sowie regelmäßige Projekttreffen. Insgesamt fanden im Berichtszeitraum drei große Projekttreffen mit den deutschen Partnern und zwei große Projekttreffen mit den deutschen und jordanischen Partnern statt.

Zu den Höhepunkten des Jahres 2021 zählten insbesondere die erfolgreiche Auftaktveranstaltung und der erste Stakeholder-Workshop in Amman mit mehr als 50 Teilnehmern. Neben der Förderung der transdisziplinären Zusammenarbeit, ermöglichte die Veranstaltung eine Feinabstimmung der Projektaktivitäten und -produkte an die Bedürfnisse der Stakeholder. Darüber hinaus war die Teilnahme an einem Internationalen Sturzflut Symposium eine großartige Gelegenheit zur wissenschaftlichen Vernetzung und zum Austausch von Erfahrungen und Wissen über das integrierte Management von Sturzfluten in Trockengebieten.

Summary

The Middle East is particularly affected by climate change and extreme climatic events such as droughts and heavy rainfall. In Jordan, repeated heavy rainfall events in recent years have led to flash floods with enormous damage. At the same time, Jordan is one of the most water-scarce countries in the world and has few renewable water resources. Minimising such damage while maximising the benefits of heavy rainfall through improved water retention is the research topic of CapTain Rain ("Capture and retain heavy rainfalls in Jordan (CapTain Rain)".Within the transdisciplinary research project CapTain Rain, the German and Jordanian project partners aim to help improve current methods and tools for flash flood prediction and prevention. For this purpose, the driving factors of flash floods in Jordan's wadi systems will be analyzed and the complex interactions between climate and land use changes and hydraulic engineering measures will be unravelled. Based on vulnerability analyses and engineering solutions for water collection and drainage during heavy rainfall events, measures to protect the population will be identified. Climate services (e.g., flash flood risk maps, early warning systems, recommendations for heavy rainfall risk prevention) will be developed in close collaboration with Jordanian stakeholders and practice partners, considering scientific as well as local practical knowledge. The study area includes the capital Amman with its 4.3 million inhabitants in the metropolitan region and the more rural region around the UNESCO World Heritage Site Petra. Both regions have been heavily affected by flash flood events in the past.

CapTain Rain started in June 2021. During the first months of CapTain Rain, the project consortium was established, the stakeholder dialogues and transdisciplinary integration started and a project communication plan was established. The English-Arabic Internet platform, which also provides an internal area for project communication, was designed, completed and published (www.captain-rain.de) and a project evaluation was conceptualized and carried out. In addition, a total of two press releases (on the start of the project) were produced by the Koblenz University of Applied Sciences and ISOE.

To facilitate inter- and transdisciplinary collaboration through a common and transparent data basis a cloud-based solution was designed and deployed for research data management. Furthermore, the different workpackages started their research activities with literature research, data acquisition and processing, and the choice of modelling approaches. These steps also comprised a fine-tuning of activities and corresponding scientific products to better adapt them to the specific stakeholder needs.

To foster collaborative and transdisciplinary work, special attention was paid to internal communication within the network. This included regular teleconferences of the CapTain Rain coordination team, monthly meetings and video conferences of the different workpackages' teams, and regular project meetings. In total, 3 major project meetings with the German partners (two online and one in presence) and two major project meetings with the German and Jordanian partners (one online and one in presence) took place during the reported period.

Highlights for the year 2021 included in particular the successful kick-off event and first stakeholder workshop in Amman with more than 50 participants fostering the transdisciplinary collaboration and allowed fine-tuning of project activities and products to the needs of stakeholders. Furthermore, the 6th International Symposium on Flash Floods in wadi systems was a great opportunity for scientific networking and to exchange experiences and share knowledge on integrated management of Wadi flash floods in arid regions.

Topics and objectives of the project

Background

The Middle East is particularly affected by climate change and extreme weather events. Over the past 50 years, heavy rainfall events in Jordan have caused many flash floods that lead to significant property damage and fatalities. At the same time, Jordan is one of the most water-scarce countries in the world and has few renewable water resources. Maximizing the benefits of heavy rain events in terms of water harvesting and minimizing flash flood damages is therefore one of the most important tasks when it comes to climate change adaptation in Jordan.

One prerequisite for minimizing disaster losses is the ability to accurately predict disaster events so that precautionary measures can be taken. Such “climate services” for risk prevention are a high political priority in Jordan, but have not yet been sufficiently put into practice. Despite recent scientific findings, there is a lack of basic hydrological and meteorological knowledge which is needed to better predict the occurrence and intensity of flash floods in Jordan’s wadi systems. A successful development and implementation of climate services also requires that it is done in cooperation with future users and decision makers. Here, transdisciplinary research methods enable a holistic analysis of flash flood hazards and hazard prevention and facilitate the transfer of scientific knowledge into practical measures for climate change adaptation.

Objectives

CapTain Rain aims to help improve current methods and tools for flash flood prediction and prevention in Jordan. For this purpose, the driving factors of flash floods in Jordan’s wadi systems are analysed and the complex interactions between climate and land use changes and hydraulic engineering measures are deciphered. Based on vulnerability analyses and engineering solutions for water collection and drainage during heavy rainfall events, measures to protect the population are identified.

Climate services (e.g. flash flood risk maps, early warning systems, recommendations for heavy rainfall risk prevention) are developed in close collaboration with Jordanian stakeholders and practice partners, considering scientific as well as local practical knowledge. The transdisciplinary research methods of CapTainRain enable a holistic analysis of flash flood hazards together with hazard prevention and facilitate the transfer of scientific knowledge into practical measures for climate change adaptation.

For this, CapTain Rain will:

(1) analyse the social-ecological drivers of flash floods in Jordan's wadi systems and entangle the complex interactions between climate and land use change to enable a better simulation and prognosis of flash flood events;

(2) assess the social-ecological risk of flash floods using an integrated vulnerability analysis, taking into account the spatial exposure of flash floods, sensitivity and adaptive capacity;

(3) develop climate services for flood-related decision making based on stakeholder dialogues and participatory approaches;

(4) and identify promising measures to improve the adaptive capacity of local communities, including methods and technologies to capture and retain water from heavy rainfall, but also to prevent damages.

The study area includes the capital Amman with its 4.3 million inhabitants in the metropolitan region and the more rural region around Wadi Musa, including the UNESCO World Heritage Site Petra (Figure 1). Both regions have been heavily affected by flash flood events in the past.

Both regions have been heavily affected by flash flood events in the past. In the past 10 years, Amman has experienced a total of six flash floods (Nov 14, Nov 15, Jan 18, Apr 18, Oct 18, Feb 19). The November 2014 flood was particularly severe, killing three people in Amman, as was the November 2015 flood, which killed four people and caused extensive property damage. Overall, the risk of flash flood events in Amman has increased dramatically due to rapid urbanization in recent decades.

In Petra, in particular, there was a very severe flash flood in 1963, when large parts of the UN-ESCO World Heritage Site were flooded and about 20 tourists died. In the 1991, 1995, and 1996 flash floods, several tourists had to be evacuated (Al-Weshah/El-Khoury 1999). The most recent severe flash flood in Petra occurred in November 2018 with a total of 12 fatalities, according to media reports.

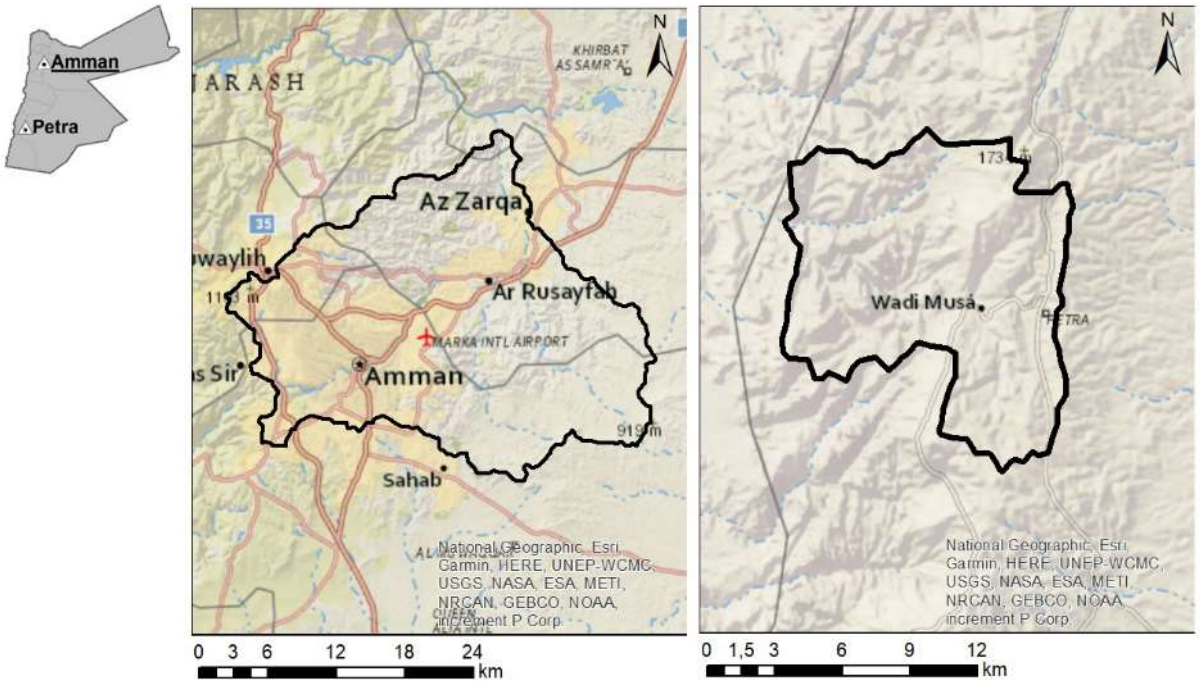

Figure 1. Overview of the selected study areas: The capital Amman as urban region (left) and the more rural region of Wadi Musa (right), Jordan (satellite image scene in the background: Sentinel-2B, April 2019).

Project structure

An integrated vulnerability analysis of flash floods is carried out in close collaboration with relevant stakeholders, which includes the analysis of the socio-ecological causes of flash floods and the identification, mapping and assessment of flash flood risks (exposure and sensitivity). In addition, risk perceptions are investigated from the perspective of the local population and strategies for adaptation to heavy rainfall events are developed. Model-based scenarios are used to develop and evaluate measures to improve risk preparedness, including technologies to divert and use water from heavy rain events. Climate services for the prevention of heavy rainfall risks are prepared and made available in a participatory manner.

Altogether, six work-packages (WP) with researchers from Germany and Jordan contribute to the analysis of flash floods including the integrated vulnerability analysis and provide a revision of the current methods for flash flood prediction and prevention. Each WP is subdivided in two sub-workpackages, expect of WP 3, which comprises three sub-workpackages (Figure 2).

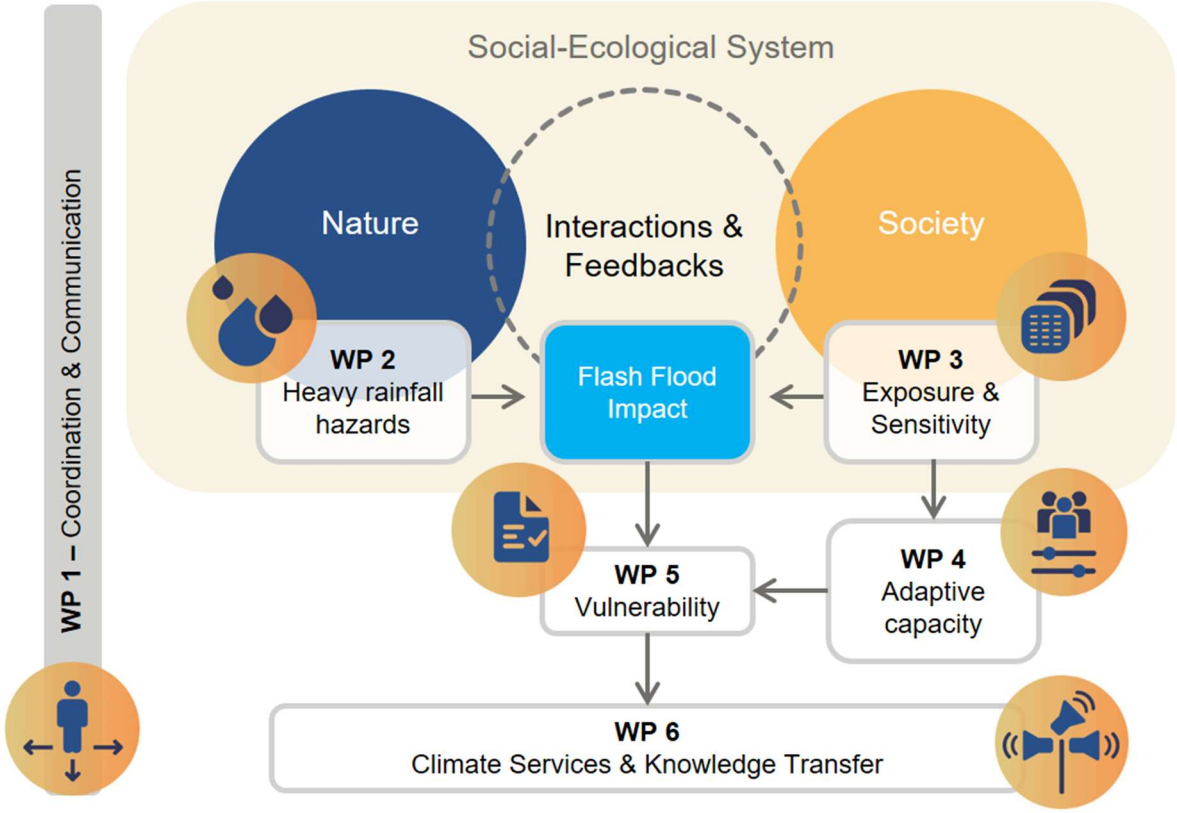

Figure 2. Conceptional framework of the integrated vulnerability analysis of flash floods and associated workpackages.

All WPs are closely linked to each other in a network that allows synergistic interactions. WP 1 “Coordination & Communication” encompasses the central project management including the scientific and technical coordination as well as the stakeholder integration and communication. WP 2 “Heavy rainfall hazard” focusses on an improved understanding of flash flood hazards in wadi-systems and investigates how heavy rainfall events have changed in the past and may continue to change in the future due to climate change effects. The spatial and temporal impacts of flash floods on people, infrastructure, and ecosystem services along an urban-rural gradient are analysed in WP 3 “Exposure & Sensitivity”. WP 4 “Adaptive Capacity” investigates the local knowledge of severe flash flooding and adaptation strategies, as well as potentials to improve methods and technologies to capture and retain heavy rainfall events through assessment of different water adaptation technologies. The results of WP 2-4 are synthesized to conduct an integrated vulnerability assessment and a scenario analysis of different adaptation strategies in WP 5 “Vulnerability”. WP 6 “Climate Services & Knowledge Transfer” focusses on the provision of climate services for climate and flood related decision-making and communication of flash flood risks and impacts.

Status quo of the project and achievements in comparison to the milestones set in the proposal

The interdisciplinary cooperation between the different workpackages is made possible in CapTain Rain through an overarching research design (Fig. 2). At the same time, a transdisciplinary approach is taken to ensure early stakeholder integration and the alignment of the project with the on-ground problem and need situation. The work of the individual WPs is closely interlinked and, in some cases, must be carried out in parallel, which is why one project partner is responsible for coordinating and combining the results for each WP. The tracking and follow-up of coordination and agreements is carried out along the SWP/topic responsibilities.

During the first months of CapTain Rain, the project consortium was established, the stakeholder dialogues and transdisciplinary integration started, a project communication plan, a project webpage was designed and published and a project evaluation was conceptualized and carried out. Furthermore, the different workpackages started their research activities with literature research, data acquisition and processing and the choice of modelling approaches. These steps also comprised a fine-tuning of activities and corresponding scientific products to better adapt them to the specific stakeholder needs. Numerous internal project events were carried out (online project meetings, meetings of workpackages' teams, etc.). From June to September, several online meetings took place with Jordanian partners to foster collaboration, clarify stakeholder needs and agree on a Memorandum of Understanding. Altogether, three kick-off events took place (two online events and one in-person event).

The Milestone (M1, Inventory completed) was successfully reached after the first 6 months. The milestone included an inventory of the data basis and related preliminary investigations in WP 2-6. Furthermore, relevant stakeholders have been identified and involved via a stakeholder analysis, communication plans have been drawn up and the first stakeholder workshop (SW 1) has been successfully held.

Overview of milestone status:

	Description of milestone	**Date of completion**	**Status**
M1	Planning-organizational milestone; Inventory completed	11/2021	fullfilled
M2	Scientific-technical milestone; Preliminary investigations carried out	11/2022	partly fullfilled
M3	Scientific-technical milestone; Models implemented and simulations completed	05/2023	pending
M4	Assessment-related milestone; Integrated scenario and vulnerability analysis conducted	11/2023	pending
M5	Utilization-related milestone; Dissemination of climate services successfully carried out	12/2024	pending

Highlights and difficulties

The beginning of the CapTain Rain project was unfortunately heavily overshadowed by the ongoing Covid-19 pandemic. Travel restrictions and the lack of local presence made the integration of and cooperation with Jordanian stakeholders difficult and hindered trust building among German and Jordanian partners. This led to delays in the provision of baseline data, especially for WP 2 and 3, as well as for the establishment of collaboration agreements among German and Jordanian Partners.

However, based on the experience already gained in other international projects in 2020, appropriate solutions were found to ensure project progress. The disciplinary work in 2021 was mainly based on freely available open-source data to test identified modelling approaches and simulate first results.

Numerous cross-association administrative and coordinative measures were carried out in the first months of the project to foster collaborative and transdisciplinary work. Special attention was paid to internal communication within the network. This included regular teleconferences of the CapTain Rain coordination team, monthly meetings and video conferences of the different workpackages' teams, and regular project meetings. Regular online meetings with the Jordanian partners should also be emphasized here, as they enabled good cooperation despite the lack of on-site visits. We experienced a good participation of Jordanian stakeholders in such online events

Highlights of the year 2021 included in particular the successful kick-off event and first stakeholder workshop in Amman with more than 50 participants fostering the transdisciplinary collaboration and allowed fine-tuning of project activities and products to the needs of stakeholders. Furthermore, the 6th International Symposium on Flash Floods in wadi systems was a great opportunity for scientific networking and to exchange experiences and share knowledge on integrated management of Wadi flash floods in arid regions. Several members of the CapTain Rain team participated in the conference and presented two conference contributions (one oral and one poster, see page 26). The symposium was one of a series of the annual International Symposium on Flash Floods in wadi systems, organized by the Inter-Islamic Network on Water Resources Development and Management (INWRDAM), Petra Development & Tourism Region Authority (PDTRA) and Kyoto University. This event also enabled an expansion of the stakeholder network and was a good opportunity to identify interview partners for the expert interviews as part of the stakeholder analysis.

Figure 3. Group photo of stakeholder workshop participants, October 2021, Amman.

Status quo of the workpackages

WP 1 „Coordination & Communication“

WP 1 "Coordination & Communication" encompasses the central project management including the scientific-technical coordination, the internal and external communication as well as the transdisciplinary integration. The sub-work package (SWP) 1.1 “**Stakeholder dialogue and transdisciplinary integration”** serves as an interface for external communication between science and society. As such, it includes a stakeholder analysis at the beginning of the project complemented by expert interviews in Jordan. The stakeholder dialogue aims to anchor and consider opinions, relevant practical knowledge and experience, and needs of societal (practical) actors in the project. The communication of knowledge and the active involvement in the findings and techniques for the prediction and prevention of flash flood risks takes place via annually coordinated stakeholder workshops. This will lay the foundation for the transfer of knowledge into practice in WP 6 and enables the early dissemination of the project results. The sub-work package 1.2 “**Scientific and internal project coordination”** coordinates the project activities of the consortium and is responsible for the scientific and internal communication in order to coordinate the different research activities during the project duration in a way that ensures the development of methods and tools (e.g. integrated vulnerability and scenario analysis). In addition to the project website, tools for web-based research data management are delivered to facilitate inter- and transdisciplinary collaboration through a common and transparent data basis. To ensure the involvement of the Jordanian partners and the utilization of the result, a steering committee is established.

Achievements in relation to milestones/work plan and intermediate scientific results

Public relation works in SWP 1.1 mainly included the preparation and finalization of public information material (project website, news, flyers): A project flyer was created and an English-Arabic Internet platform, which also provides an internal area for project communication, was designed and completed (www.captain-rain.de). In addition, a total of two press releases (on the project launch) were prepared by the Koblenz University of Applied Sciences and ISOE.

The kick-off event and first **stakeholder workshop** of the CapTain Rain project took place in Amman at the Geneva Hotel on October 3, 2021 with more than 50 participants. All collaborative partners participated in the stakeholder workshops as well as additional Jordanian stakeholders that have been identified based on recommendations of Jordanian partners, research of literature and reports, as well as previous experience (e.g. preparatory journey in the context of the application process). This first stakeholder workshops aimed to align knowledge levels and a joint fine-tuning of the research design, concretization of the target group-oriented dissemination strategy. After a general introduction and welcome notes of Jordanian project partners and the German funding agency, the CapTain Rain team presented some insights on the flash flood catastrophe of July 2021 in Germany and discussed with participants lessons learnt, that might also be transferable to Jordan. Subsequently, the research approach and preliminary results of the CapTain Rain project were presented and discussed. During a group work session, flash flood hot spots in Amman and Petra were jointly identified using a participatory mapping approach in Google Earth. Available studies on flash floods, knowledge gaps and need for actions were elaborated and compiled for each study sites. The workshop fostered the transdisciplinary collaboration and allowed fine-tuning of project activities and products to the needs of stakeholders. The results of the workshop were compiled in a document and shared with all workshop participants.

For the **stakeholder analysis**, expert interviews were conducted (n =15) and transcribed. Since the interview guideline was extended to include additional questions relevant for other work packages, the stakeholder analysis is still ongoing and data analysis will be completed soon.

A **first formative evaluation** of the work processes and quality control outcomes was carried out using an online survey format (Lime Survey) in December 2021. The purpose of the internal project evaluation is "assessing for learning" which means that the project is assessed by the project team (all German and Jordanian partners) in order to learn from it together. In this way, the internal evaluation provides feedback and guidance that aims to lead to identify opportunities for improvement and corresponding adjustments in project organizing, planning and implementation. The internal project evaluation is conducted by all partners individually once per year until the project end in May 2024. The internal project evaluation provides feedback and guidance that should lead to adjustments in the implementation of the project by helping to identify opportunities for improvement and serving as quality control for the project. The necessary tools (definition of quality criteria's, preparation of the questionnaire) for the first formal evaluation were developed. For the evaluation, the following criteria are used that include a short explanation and example questions for a) the current state and b) future challenges:

- Project organization (Quantity and quality of internal project communication among German and Jordanian partners, use of communication channels, level of information);
- Integration (transdisciplinary cooperation and integration of interdisciplinary work; assessment of the extent to which the work of the individual WPs leads to an integrated overall result);
- Innovation (methodological/conceptual innovative character of the scientific research and results);
- Relevance (effectiveness concerning the utilization of project results including usefulness or practical relevance);
- Resonance (target group-oriented communication of project results in practice and to the public; presence of the project in the public);
- Output (publications, policy briefs, training courses, etc.);
- Sustainability (possible or successful implementation by practice partners including potential links for applications and the further use of the results after end of the project).

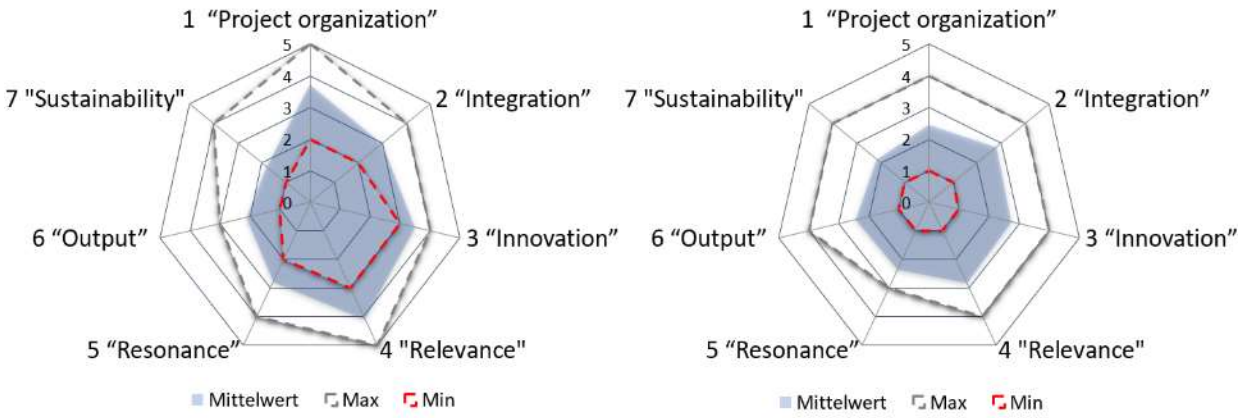

Figure 4. Evaluation results for 2021 with German partners. **Left:** evaluation of the current state based on own past project experience on a scale of 1 (very poor/not fullfilled) to 5 (excellent/ has been

completely fulfilled); **Right:** evaluation of possible future challenges in order to fulfil the corresponding criteria on a scale of 1 to 5 (1 = very challenging/ highly unsecure to fulfil; 5 = no challenge/ secure to fulfil); the mean value, minimum and maximum are shown (n = 11).

The results of the first evaluation were compiled with the help of a performance spider to allow an overall evaluation (Fig. 3). The results were disseminated within the project network and recommendations for improvements in specific field were jointly discussed and decided. From this internal evaluation, needs for adjustment were derived and a joint learning process was initiated.

To foster the internal communication a project communication plan has been established in SWP 1.2 (Fig. 5). Every WP-team meets approximately monthly. Further flexible communications via phone calls, online meetings, or in-person are organized by the partners. All German partners regularly meet online every three to four months, accompanied by in-person meetings every six months. These larger project meetings substitute the WP-meetings. Altogether, four large stakeholder workshops in Jordan are scheduled during the project timeframe. The kick-off workshop took place in 2021. Two workshops will follow-up in 2023 and a last workshop at the end of the project in 2024. Additionally, an internal project evaluation is carried out every year.

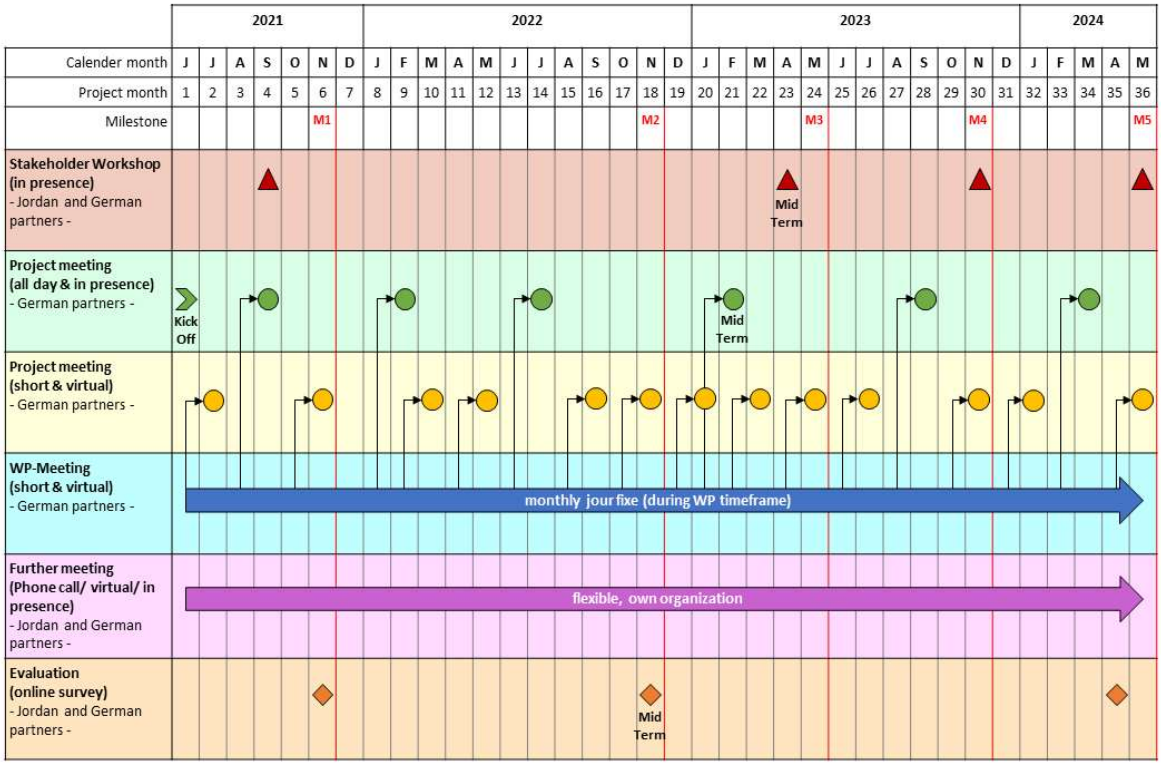

Figure 5. Communication plan of the CapTain Rain project.

To facilitate inter- and transdisciplinary collaboration through a common and transparent data basis a cloud-based solution was designed and deployed for research data management.

A first draft of a **steering committee** involving all Jordanian and German partners that are closely committed to the project´s objectives and results on the decision-making level was designed to ensure the involvement of the partners and the utilization of the results (Fig. 6). The commitment is formalized by a cooperation agreement and/or a Memorandum of Understanding. The tasks of the steering committee comprise:

- Monitor the progress of the project with regard to results and objectives
- Give directions to the project partners how to best achieve the results
- Support the success of the project including the dissemination of results within the means of each partner
- Support the mobilization of data and human and financial resources for the project´s success
- Decide on major changes with regard to the project´s work plan if required

Figure 6. Overview of the steering committee of CapTain Rain.

Inter- and transdisciplinary cooperation, highlights and difficulties

The overall coordination work of the joint project CapTain Rain is equally shared between ISOE and Koblenz University of Applied Sciences (KU). Internally, ISOE and KU coordinate the network in the form of a shared management. In consultation with the partners, they assume all coordination tasks between the network partners and share the content-related tasks according to their respective competences.

Based on the stakeholder analysis at the beginning of the project, as well as the implementation of regular stakeholder workshops, this work package provides the basis for stakeholder integration for all WPs and the transfer of knowledge into practice. The scientific coordination and internal communication ensures the coordination of all WP activities among each other to pave the way for the integrative vulnerability analysis in WP 5.

Future prospects/outlook 2022

The work of WP 1 will continue with regular online meetings to coordinate the CapTain Rain project. In 2022, the partner network will probably be expanded. The stakeholder analysis and mapping (analysis of interviews on stakeholder interests, overall challenges, knowledge on and experience with adaptation measures, ways of participation) will be finalized and the results published. Stakeholder dialogues and communication will continue on a regular basis. In spring 2022, the internal project evaluation is

conducted with the Jordanian partners. In spring and early summer 2022, a series of webinars will be organized; participating partners and stakeholders may obtain certificates. Furthermore, the WP1-team will continue with the organization of joint project meetings according to the established communication plan as well as with the planning and coordination of field trips to Jordan. Another task will be the regular maintenance of the project webpage and the cloud-based management of research data.

WP 2 „Heavy rainfall hazards"

The triggers of heavy rainfall events are critical circulation patterns in the atmosphere. Their forecast helps to identify resulting flash floods and serves as a basis for early warning and flood mitigation actions. Therefore, in WP 2 heavy rainfall events and the resulting flash floods are analysed in the context of their circulation patterns for the past and the future. The results will facilitate a better understanding of the relationship between the causes (e.g., circulation pattern) and the effects (e.g., rainfall patterns) of heavy rainfall events, as well as their climate sensitivity.

The aim of WP 2 is to develop the basis for an improved early warning of approaching rainfall events in Jordan in order to mitigate the impact of sudden flash floods, but also to collect draining water at the same time. The extent to which such risks are exacerbated by climate change should be derived from climatic evaluations of observed and simulated weather patterns. A dissemination of the results in climate services can help the local population in dealing with heavy rainfall events.

Achievements in relation to milestones/work plan and intermediate scientific results

SWP 2.1: Retrospective analysis of heavy rainfall events

Based on a homogeneous database (preferred re-analysis data) the linkage between large-scale drivers and local scale weather patterns (circulation and rainfall) were displayed and evaluated. Existing web services exploring climate data were used for a first plausibility check of data before downloading large datasets and developing software tools. The identified linkage between circulation patterns favouring heavy rainfall in Jordan is also used to evaluate weather forecasts and future climate projections. The derived diagnostics from the empirical study enable the local partners to objectively evaluate the performance of simulated weather conditions on different time scales. Climate monitoring services are developed in order to better compare current with past condition by overlaying seasonal cycles of daily rainfall data (absolute and cumulative). SWP 2.1 finalized the following tasks:

- Data acquisition and processing: Setup of a collection providing public available real-time weather and climate information for Jordan and Near-East: http://www.pik-potsdam.de/~peterh/s%c3%bcnoptik/jordan/; Evaluation of data availability (location, temporal resolution, variables, quality, real-time availability)
- Climate analysis and monitoring: Development of a first chart prototype for climate monitoring applications including retrospective analyses of heavy rainfall events in Jordan based on re-analysis data (Fig. 7).

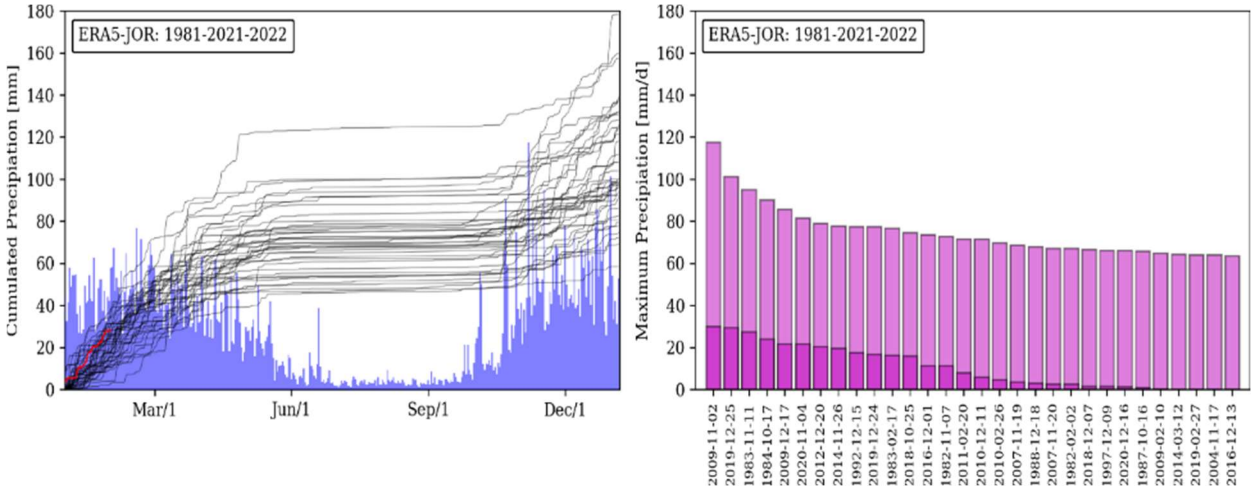

Figure 7. Chart for comparing the current conditions of daily rainfall in Jordan with other years in order to identify analogues for a better assessment (left). Ranking of extreme rainfall events in Jordan compared to the current year (right).

- Classification of circulation patterns: Based on global re-analysis data, weather maps for specific extreme events were generated to illustrate existing linkages between the atmosphere circulation (cause) and the rainfall patterns (effect). An objectively classification of recurring circulation patterns was developed using image recognition techniques. The retrospective diagnostic method aims to identify critical circulation conditions favoring heavy rainfall events in Jordan. Furthermore, the frequency, the persistence, and possible teleconnections of circulation patterns are quantified.

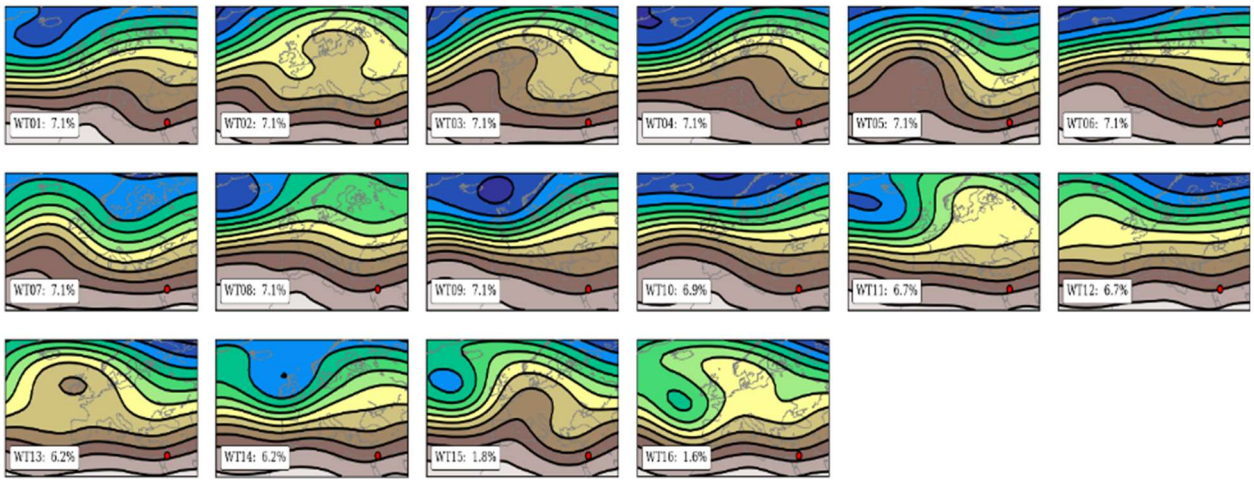

Figure 8. Recurring circulation patterns from 1981-2020 using NCEP/NCAR re-analysis data.

- Causal network analysis: A concept how to setup a causal network including potential drivers for heavy rainfall was developed. This categorize heavy rainfall events in Jordan by precondition and aims to train a decision tree for qualitative predictions and early warnings.
- Data products and integration: A list of useful open data and derived products for the integration in the early warning system demonstrator was compiled.

SWP 2.2: Modelling of heavy rainfall

Based on the retrospective analysis of heavy rainfall events in Jordan (SWP 2.1) future projections simulated by climate models are evaluated, how they perform heavy rainfall and quantify the climate sensitivity. Thereby we focus on the two main drivers: dynamical and thermodynamical.

Regarding long-term changes of seasonal mean precipitation in Jorden from December to February the two generations of global climate scenarios project a decreasing trend in Jordan depending on the warming level. Further climatic indicators will be analysed in the later phase of the project. SWP 2.2 finalized the following tasks:

- Predictors for heavy rainfall: Critical circulation patterns can trigger seasonally heavy rainfall events in Jordan. The analysis of long-term changes and climate sensitivity of the predictors started using large ensembles of global and regional climate scenarios (Fig. 9).

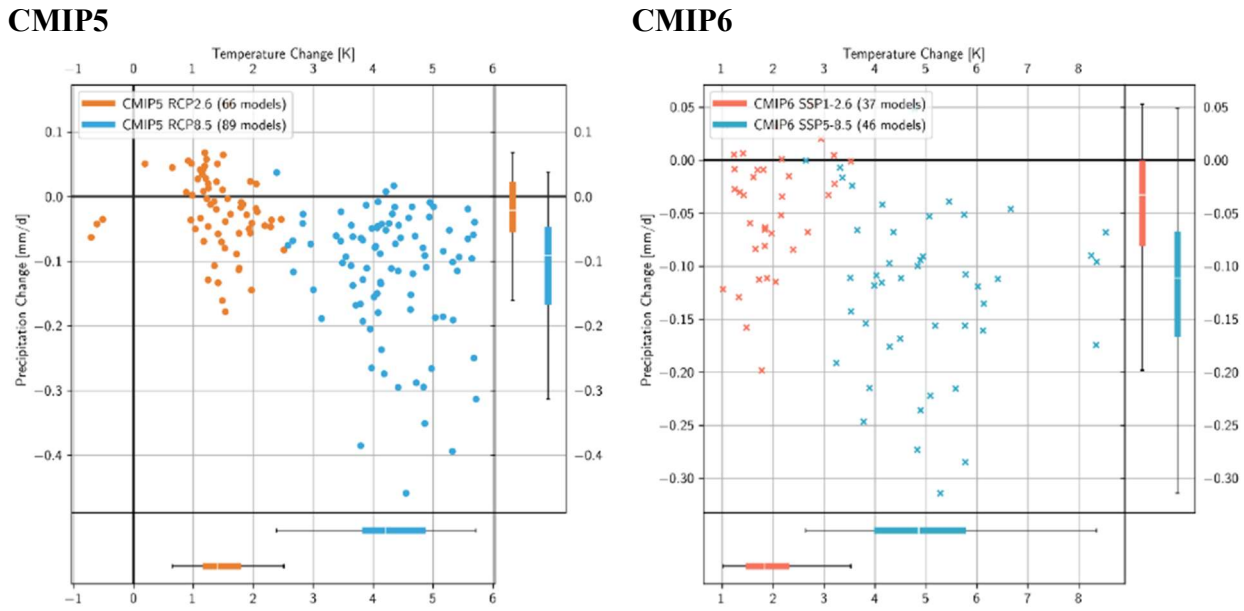

Figure 9. Comparison of the global climate model ensembles CMIP5 (AR5) and CMIP6 (AR6) for the seasonal mean precipitation changes over Jordan.

Inter- and transdisciplinary cooperation, highlights and difficulties

The available regional climate ensembles and precipitation events of WP 2 are used in WP 3 for the risk analysis of flash floods (SWP 3.1). The societal and climatological drivers of heavy rainfall risks will be determined and modeled in SWP 3.2 in the analysis of damage potentials and in SWP 3.3 in the risk assessment. All available climatological information is organized in a data management system for further processing. The data products and their processing used in SWP 2.1 flow directly into SWP 6.1 and provide the basis for the development of an EWS in the form of a demonstrator. Collaboration within the CapTain Rain project team (exchange on data and derived products on availability, quality,

processing, integration, accessibility and interpretation of results) was conducted during monthly meetings.

Future prospects/outlook 2022

Jan-Feb Setup and testing operational services for local climate monitoring and circulation pattern analysis focusing on Near-East and Jordan

Mar-Apr Hoffmann, P., Fallah, B., Menz, C., Wechsung, F., and Hattermann, F.: Kumulierte Wetterextreme durch anhaltende Strömungsmuster: Ein bislang unterschätztes Risiko?, DACH2022, Leipzig, Deutschland, 21–25 Mar 2022, DACH2022-6, https://doi.org/10.5194/dach2022-6, 2022.

May-Jun Quality control of local climate data, regional reanalyses and remote sensing rainfall products and mapping **Webinar:** Predictors for heavy rainfall in Jordan under Climate Change

Jul-Aug Setup a causal network analysis for classifying heavy rainfall events in Jordan depending on different drivers (SST, circulation)

Sep-Oct Workshop in Amman exchange with JMD on content

Nov-Dec Starting integration of derived data and analysis products in EWS demonstrator

WP 3 „Exposure & Sensitivity“

WP 3 analyses the spatial and temporal impacts of flash floods on humans, infrastructure, and ecosystem services. Exposure or spatial occurrence encompasses the hazard analysis due to flash floods. Sensitivity determines the potential for damage in areas affected by heavy rainfall. This WP is subdivided in three Sub-work packages. In SWP 3.1 “Hazard analysis (Exposition)”, the hazard analysis (spatial occurrence/exposure), GIS analyses, and hydrological and hydraulic modelling are performed. At the watershed level of the selected study regions (Amman and Petra), a GIS analysis of terrain low points and flow paths is conducted. For each study region a small catchment area is then selected together with the Jordanian partners to conduct a detailed, small-scale modelling. The analysis of damage potentials (sensitivity) in SWP 3.2 requires the mapping and economic assessment of infrastructure, land use and ecosystems, and possibly ecosystem services in the affected area. The latter is conducted in close collaboration with the Jordanian partners using quantitative and qualitative assessment approaches. The hazard analysis and the analysis of damage potentials are combined for the preparation of risk maps and assessments in SWP 3.3 “Identify and assess flash flood risk (Climate impact)”.

Achievements in relation to milestones/work plan and intermediate scientific results

In the SWP 3.1 the main focus areas, downtown Amman and Petra in Wadi Musa, have been selected based on the results of the first stakeholder workshop in Amman. With the GIS data and a digital terrain model (DTM) preparation we are in an iterative process. The DTM is checked and prepared with a resolution of around 12 m grid size, but a finer resolution would strongly improve results. Beside the DTM, other data sets like hydro-meteorological time series, street maps, culvert locations etc. are needed. Here the data acquisition and processing is in progress. Flow path and sink analysis are performed for Amman and Petra with the DTM of around 12 m grid resolution. Here again a finer DTM would further increase the accuracy. The selection and set up of hydraulic and hydrological models is

in progress, which is again an iterative process depending on the data availability and supply. First flooding simulations are therefore already done but still have potential for improvement.

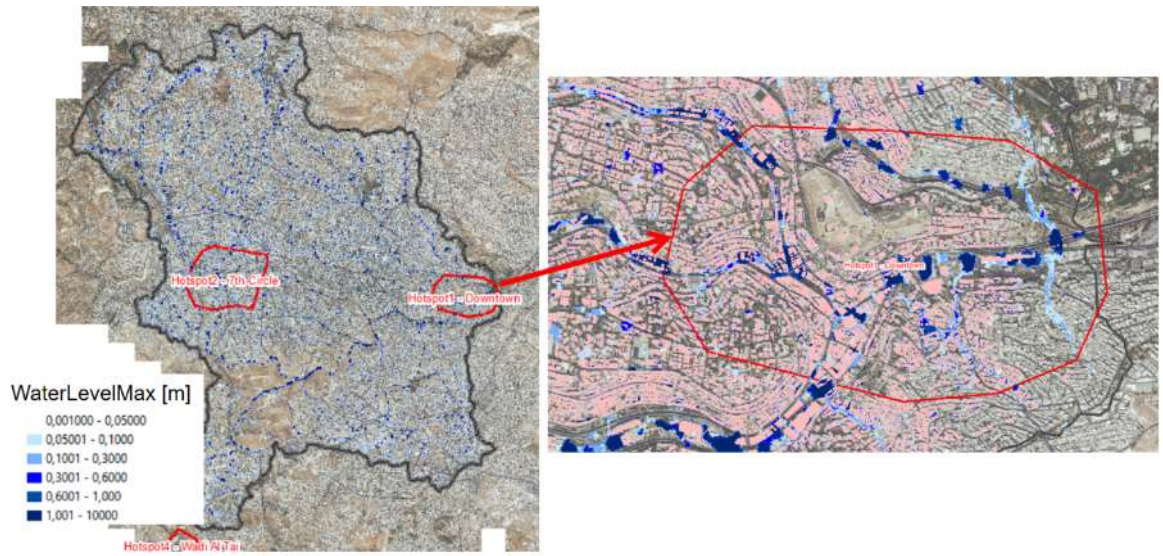

Figure 10. First preliminary results of a hydrodynamical 2D Simulation.

In the SWP 3.2 – Damage potential ("sensitivity") we started with the GIS data processing. A master thesis by Mr. Ahmad Awadon the analysis of the spatial-temporal dynamics of land-use changes and its interactions with flash flood risks started in autumn 2021 (supervised by ISOE). As part of this thesis, land use and land cover changes from 1968 to 2022 will be analysed based on high resolution satellite images using an object-based classification approach. Classifications for 2022 were already finalized (Fig. 11).

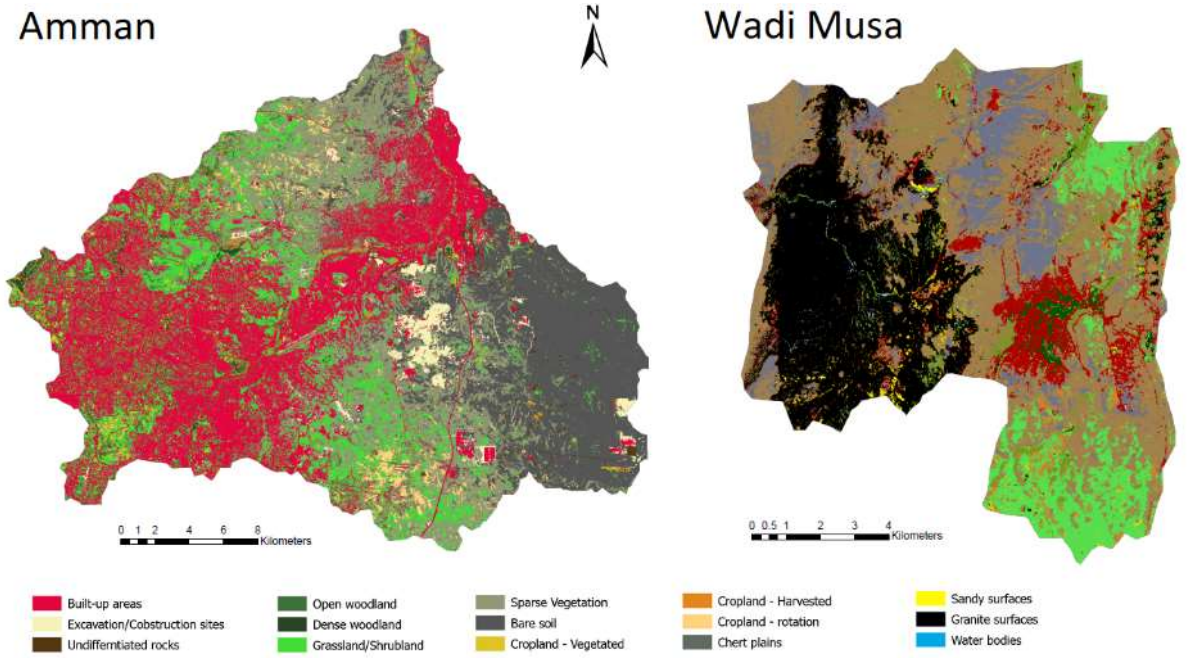

Figure 11. Preliminary results of the land use and land cover classification of the year 2021 for the two study regions.

Inter- and transdisciplinary cooperation, highlights and difficulties

WP 3 gives the basis for the scenario analysis in WP 5. The WP 3 is therefore in exchange with WP 2 and WP 4 to create a solid basis for WP 5 and WP 6.

The exchange with the Jordanian stakeholders especially with GAM, PDTRA and MWI started at the stakeholder workshop in October 2021 in Amman, Jordan. Also, the additional personal meetings at GAM in Amman in October and November 2021, including a personal city tour for flash floods hot spots, further strengthened the collaboration.

Future prospects/outlook

For further deepening of the collaborations with the different CapTain Rain partners travels to Jordan are planned for the beginning of May 2022 and in Autumn 2022. Beside personal meetings and exchange with the Jordanian partners field visits for Wadi Musa and Amman are planned. A bachelor thesis in the context of hydraulic modelling and flash floods in Amman is planned in cooperation between HK and ITWH for March 2022. The selection process of the hydrological model will be presented to the hydrological community with conference presentations at the “Tag der Hydrology” (Hohmann C., C. Maus, D. Ziegler, M. Brum and M. Thiemann (2022): Flash flood modelling and fore-casting in data scarce regions like Jordan – A first step of an adequate model selection) in March 2022 in Munich, Germany. As well as at the EGU General Assembly 2022 (Hohmann C., C. Maus, D. Ziegler, S. Kantoush, and Q. Abdelal (2022): Selection of flash flood models in data-scarce regions like Jordan) in May 2022 in Vienna, Austria.

Also, the integrative processes like the processing of the DTM, the data acquisition and preparation, the hydraulic and hydrological modelling will continue. A further focus will be on the “Sensitivity“ aspect, and further collaboration between the different work packages and Jordanian partners. For the latter two seminars from WP3 are planned during spring 2022: “Flood hazard analysis tools: Data needed, possible approaches” by ITWH as a webinar in March and “Overview of hydrological and hydraulic models for flash flood risk assessment” by HK as a hybrid seminar in May.

For the land use and land cover change analysis on-field surveys and expert interviews will be conducted in spring 2022. High resolution satellite images and aerial photographs will be acquired and used for a detailed classification.

WP 4 Adaptive capacity

WP 4 “Adaptive capacity” deals with the potential or capability of a system to adapt to the risk of flash floods. The perception and knowledge of the local population will be analyzed to identify knowledge gaps and recommend knowledge transfer. Appropriate and innovative measures to mitigate flash flood risks will be identified with the use of GIS-based participation methods. The measures and strategies of adaptive capacity of this project can be applied to other areas and therefore, with the help of technology, form an innovative foundation to reduce the risk of flash floods. The SWP 4.1 “**Local (practical) knowledge**” addresses the investigation and analysis of the perception of flash flood hazards by the residents as well as local (practical) knowledge including decision making for protective measures. Promising traditional adaptation measures of the past such as measures in the area of rainwater harvesting are identified and jointly assessed with local stakeholders. The aim is to identify existing practices and knowledge gaps, as well as recommendations for improved knowledge transfer to be incorporated in climate services (e.g. early warning systems). Innovative measures for the retention, safe discharge, storage and use of heavy rainfall are identified and evaluated in SWP 4.2 “**Prevention**

of (urban) flash flood damage". These measures can be related either to infrastructure, to the drainage system or to the catchment areas and they can be of technical, institutional or social nature. For areas with high land use pressure, the concept of multifunctional land use for heavy rainfall prevention serves as an interesting option. For the joint assessment of promising adaptation measures with local stakeholders and to provide tools for local decision-making, participatory GIS methods will be tested and implemented.

Achievements in relation to milestones/work plan and intermediate scientific results

Activities within the reporting period mainly focused on collecting information about possible measures for flash flood prevention or mitigation. In addition, the aim was to get a better understanding of the particular conditions in Jordan and learn about the results of previous projects carried out by third parties. During a short visit to Jordan, a rapid appraisal was carried out in the two project sites of Amman and Petra. Site visits provided insights into the specific conditions.

Regarding possible measures, a catalogue of different measures was set up. Several criteria to assess the suitability of the measures were defined. The main focus of the research activities was on systems and strategies to prevent flash floods and reduce hazards on the one hand and on the other hand, to strengthen the local water balance for providing e.g. water in the dry season. The literature research so far mainly included two aspects - traditional water harvesting methods in arid and semi-arid regions, and types and possibilities of the rainwater management in terms of WSUD (water sensitive urban design). The different types of measures are assigned to five main categories.

- Water harvesting
- Blue green infrastructure
- Object protection
- Structural measurements
- Non-structural measurements

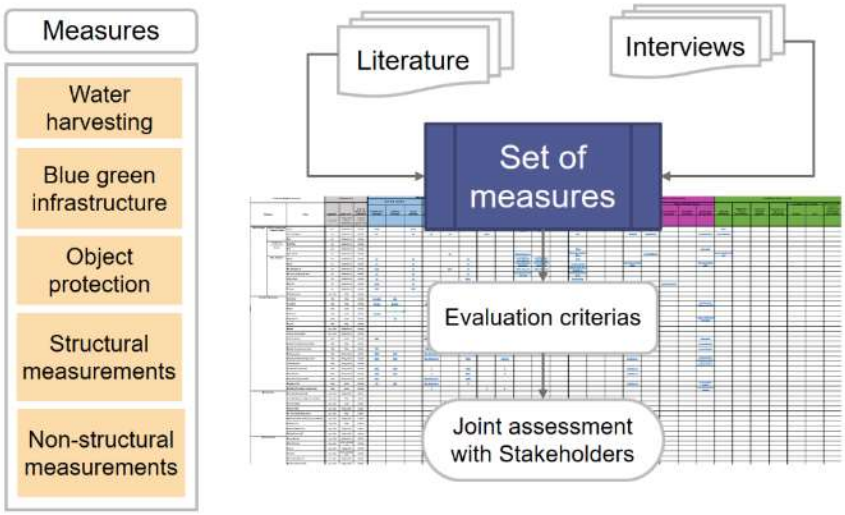

Figure 12. Overview of the methodological approach for the identification and evaluation of innovative measures for the retention, safe discharge, storage and use of heavy rainfall are identified and evaluated.

More than 50 different sub-types are summarised in the main categories, though the catalogue is still subject to further work. The catalogue is going to be used in further processes in terms of participative

research of implementation and developing guidelines and recommendations. Information was gathered mainly by literature review but also by the Interviews conducted in SWP 1.1.

Inter- and transdisciplinary cooperation, highlights and difficulties

With the help of the rainfall-runoff simulations and flash flood risk mapping prepared in WP 3, suitable locations for the implementation of possible adaptation measures will be identified and located together with the local actors in WP 4. Participatory GIS methods will be used, which also allows to better communicate and discuss the results of WPs 3-5 with local stakeholders. The plausible adaptation strategies identified in WP 4 will be evaluated in the scenario analysis in WP 5. The analysis on risk perception in SWP 4.1 provides the basis for establishing user-friendly early warning systems in SWP 6.2. On the Jordanian side, this WP is supported in particular by GAM and PDTRA, which contribute their knowledge and experience in dealing with (traditional) adaptation strategies.

Future prospects/outlook 2022

- Analysis of expert interview results (overall challenges, knowledge on and experience with adaptation measures) conducted in SWP 1.1 and incorporation of the results in the measures catalogue
- On-field survey and semi-structured interviews with residents in urban and rural areas and focus group discussions are used to gather information on traditional adaptation measures and determine how local people perceive, understand and respond to flash floods and flash flood warnings
- Discuss and sharpen the set of measures with the Jordanian partners
- Joint prioritization of adaptation measures with Jordanian Stakeholder
- Fine tuning of measures catalogue and in-depth literature survey on prioritized adaptation measures
- Implement the setup for the participative components. This also includes to compile software and hardware requirements for the usage of the multi-touch table in Jordan.
- Selection of adaptation measures, which will be used for the scenario and vulnerability assessment

WP 5 "Vulnerability"

WP 5 combines the results of the other work packages to perform an integrated vulnerability analysis for the selected study areas in Petra and Amman. Using a scenario analysis, promising adaptation strategies are simulated and assessed using indicators depicting the different social and ecological dimensions of vulnerability. Different options will be investigated with the aim of decreasing vulnerability. The resulting recommendations for action will be published as manuals, guidelines or policy briefs.

An integrated vulnerability analysis of flash floods is carried out in close collaboration with relevant stakeholders, which includes the analysis of the socio-ecological causes of flash floods and the identification, mapping and assessment of flash flood risks (exposure and sensitivity). In addition, risk perceptions are investigated from the perspective of the local population and strategies for adaptation to heavy rainfall events are developed. Model-based scenarios are used to develop and evaluate measures to improve risk preparedness, including technologies to divert and use water from heavy rain

events. Climate services for the prevention of heavy rainfall risks are prepared and made available in a participatory manner. The study area includes the capital Amman with its 4.3 million inhabitants in the metropolitan region and the more rural region around the UNESCO World Heritage Site Petra. Both regions have been heavily affected by flash flood events in the past.

The simulated scenarios are discussed and assessed with local stakeholders. Promising adaptation strategies (traditional and improved methods and technologies) that can contribute to increasing resilience to flash floods and climate impacts are identified jointly. This will lay the foundation to develop recommendations for action, which are compiled via manuals, guidelines or policy briefs.

Achievements in relation to milestones/work plan and intermediate scientific results

Since the results of the other work packages are required for the implementation of the integrated vulnerability analysis of flash floods in WP 5, the work on this will start in 2023 according to the original planning. However, preliminary conceptual work has already been carried out and was presented (oral) as part of a conference contribution at the 6th International Symposium on Flash Floods in Wadi Systems: Brinkmann K., Ziegler D., Maßmann S., Hohmann C. (2021): Integrated vulnerability analysis for flash flood risk management in Jordan, Oral presentation at the 6th International Symposium on Flash Floods in Wadi Systems (6th ISSF), Amman, Jordan.

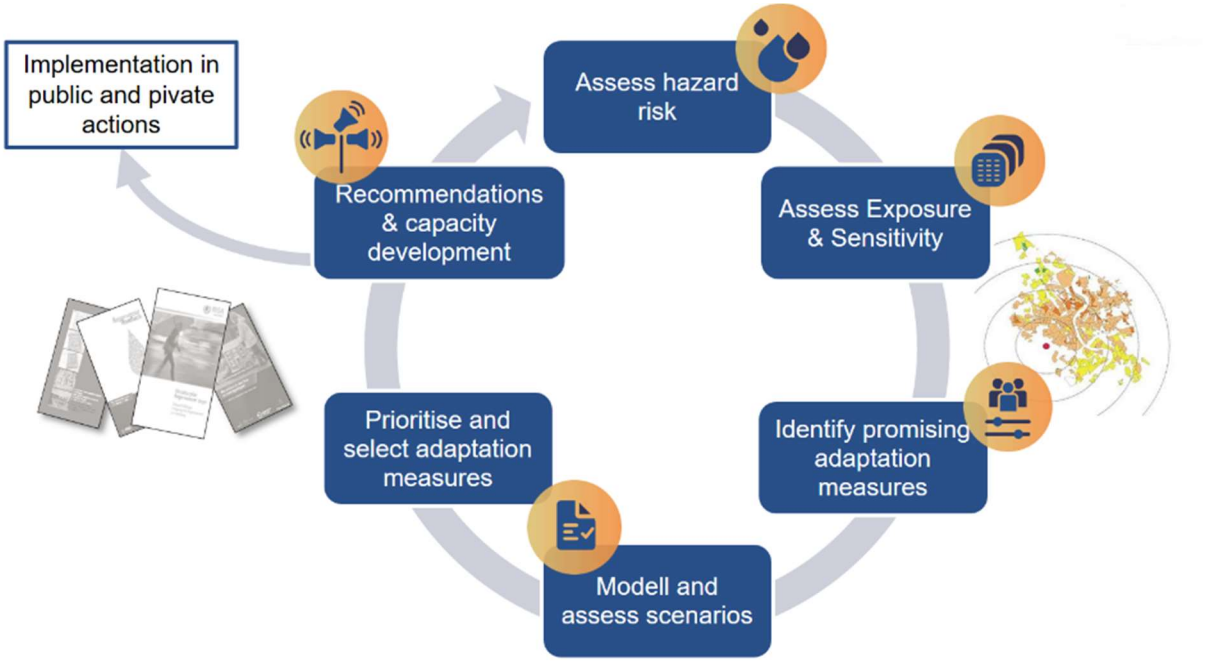

Figure 13. Overview of the integrated vulnerability assessment cycle.

Inter- and transdisciplinary cooperation, highlights and difficulties

The potentials of the promising adaptation strategies for urban and rural areas identified in WP 4 will be analysed in a scenario analysis in WP 5. The modelling tools required for this will be provided by WP 2 and WP 3. From the integrated assessment in WP 5, recommendations for action and measures will be derived and the results will be presented for integration into the dissemination strategy in WP 6.

In this WP, all partners are involved. In the framework of the planned stakeholder workshop "Validation and Scenario Development", the identification of promising adaptation strategies for the scenario analysis (scenario development) will take place jointly with Jordanian partners and stakeholders. The

presentation and discussion of the vulnerability and scenario analysis along with the related recommendations for action will take place in the subsequent stakeholder workshop "Assessment and Recommendations for Action".

Future prospects/outlook 2022

- Literature research and completion of the conceptual work
- Choice of modelling approaches and methods of model coupling
- Identification of possible scenarios for the integrated modelling within the project team

WP 6 “Climate Services & Knowledge Transfer”

WP 6 "Climate Services & Knowledge Transfer" focuses on providing recommendation for climate services (e.g. early warning systems) for climate and flash flood-related decision-making as well as the communication of risks and impacts of flash floods. The sub-work package 6.1 “Recommendations for early warning systems and demonstrator” analyses the weaknesses and strengths of existing early warning systems (EWS) including their underlying data sources, methodology and dissemination tools, and develops recommendations for an EWS adapted to the needs of the users. The user-friendliness of the existing early warning system in Petra is assessed and evaluated through expert interviews and focus group discussions with local stakeholders (What information should be included? What media channels should be used? Do warnings reach all people at risk? Are the risks and warnings understood? Are the warnings clear and usable?), in order to be able to work out recommendations for the development of early warning apps for the population. This will form the basis for the design and implementation of an appropriate service as a demonstrator. The transfer of scientific results and climate services into practice is conducted by means of target group-oriented dissemination strategies in Sub-work package 6.2 “Knowledge transfer into practice”. Comprehensibility and user-friendliness form the basis for well-prepared results, which are needed by the individual actors and decision-makers to facilitate decision-making processes and to be able to initiate climate-relevant changes. In this context, capacity development is crucial for fostering individual competencies that enable stakeholders to act in a way that is both responsible and self-dependent. Capacity development is carried out at different levels with formats specifically tailored to stakeholders and supports the training of local decision-makers and users in scientific and technical competencies to use the climate services established in CapTain Rain (e.g. EWS and risk maps).

Achievements in relation to milestones/work plan and intermediate scientific results

In SWP 6.1, an initial demonstrator of an Early Warning System for climate data management including an interface for the visualization, analysis and extraction of operational data was created for the project. The integration of several datasets in the demonstrator has already started and the datasets were made available to our partners via user accounts. Data products include:

- Operational Numerical Weather Predictions (NWPs) for Jordan, including surface and upper-level meteorological parameters and different time and spatial resolutions;
- Operational observations from geostationary satellites;
- Derived precipitation products from satellites;
- Historical observations from geostationary satellites and re-analysis products.

A selection of datasets for integration was completed, but is continuously being updated in close cooperation with other work packages and in accordance to stakeholder data needs. A first presentation

of the existing demonstrator features was carried out during a Stakeholder Workshop in Amman, Jordan, on the 3rd of October, including a preliminary discussion on how to integrate it within the existing business workflows in Jordan. This progress is well in advance regarding the original planning.

Marianne Brum (KISTERS AG) presented a poster on "real-time decision support for wadi systems - how similarities with the sponge city concept may inspire technological innovation" at the 6th International Symposium on Flash Floods in Wadi Systems in Amman, Jordan; 26-30.09.2021.

The aim of SWP 6.2 is to disseminate the project results by involving Jordanian stakeholders and developing target group-specific formats for decision-makers and practitioners. For this purpose, the first stakeholder workshop of more than 50 participants in Amman was carried it out together with the project coordination. The main objective of the first stakeholder workshop was to present the CapTain Rain research concept, discuss research approaches and results and identify further activities for cooperation. In preparation to the Workshop, a simplified product list was compiled. To gather information for the target group-oriented information and knowledge preparation and provision, a prioritization of these products was conducted during the workshop. Participants were asked to nominate the scientific products/outputs of CapTain Rain that are particularly important for them. Below you will find the summary of the evaluation/rating of the scientific products:

Table 1. Summary of the evaluation/rating of the scientific products of CapTain Rain by workshop participants during the stakeholder workshop 2021.

Product type		Stakeholder rating
A) Models & Software:		
	Climate model to simulate heavy rainfall events	9
	Hydrological and hydraulic models to simulate flash flood events	9
	Integrated model for vulnerability and scenario analysis	1
	Demonstrator of an early warning system (EWS)	3
B) Maps for spatial planning:		
	Flood risk and damage mapping	4
	Land use and land cover maps (1970-today)	3
	Site suitability maps for implementation of adaptation measures	2
C) Guidelines & Policy Briefs:		
	Recommendations for storm water management plan	3
	Handbook on EWS implementation	2
	Guideline/Policy Brief for integrated vulnerability analysis	0
D) Capacity development:		
	Trainings on early warning systems, modelling and mapping of flash floods	9
	Collaborative publications and research activities	3

Inter- and transdisciplinary cooperation, highlights and difficulties

Work on the integration of data in the demonstrator for with other project partners has started in relation with SWP 2.1. The dissemination of these data has already been started through the creation of accounts that allow our German and Jordanian partners to access visualize and extract it in order to integrate it with their own processes. A first presentation of the demonstrator and the existing data was carried out during the stakeholder workshop in Amman.

For the dissemination of the project results, all relevant CapTain Rain results are included and processed in a target group-oriented manner based on the results of the stakeholder analysis and stakeholder workshops in SWP 1.1. Contributions are made here by all project partners.

Future prospects/outlook

- Web (online) seminar on “Early Warning Systems for Flash Floods” for all Jordanian and German partners on 17.03.2022;
- In-person, hands-on workshops on the usage of the Early Warning System demonstrator in Jordan;
- In-person Python capacity building workshop in Jordan for specialists working with the system and the provided data.
- Inclusion of desired features in the demonstrator according to discussions with the other partners, e.g. comparison of model ensembles in the data viewer.

List of publications and conference contributions

- Brinkmann, K., Ziegler, D., Maßmann, S. and Hohmann, C., 2021: Integrated vulnerability analysis for flash flood risk management in Jordan. Oral presentation held at the 6th International Symposium on Flash Floods in Wadi Systems in Amman, Jordan; 26-30.09.2021.
- Brum, M., Schwanenberg, D. and Matouq, M., 2021: Real-time decision support for wadi systems - how similarities with the sponge city concept may inspire technological innovation. Poster presentation held at the 6th International Symposium on Flash Floods in Wadi Systems in Amman, Jordan; 26-30.09.2021.
- Hohmann, C., 2021: CapTain Rain – Capture and retain heavy rainfalls in Jordan. Oral presentation held at the Digital Meta-Conference “Ensuring Climate Resilience through Climate Action”, DAAD Regional Office in Cairo, Egypt, 29.11-30.11.2021
- Hoffmann, P., Lehmann, J., Fallah, B. et al. Atmosphere similarity patterns in boreal summer show an increase of persistent weather conditions connected to hydro-climatic risks. Sci Rep 11, 22893 (2021).
- Hoffmann, P.: Learning of weather-type transitions for risk assessment, EMS Annual Meeting 2021, online, 6–10 Sep 2021, EMS2021-382, https://doi.org/10.5194/ems2021-382, 2021.

List of project meetings and workshops

- 15.06.2021 Project meeting, German partners, online
- 30.06.2021 Project meeting, Jordanian & German partners, online
- 09.09.2021 Project meeting, German partners, Frankfurt + online
- 03.10.2021 Stakeholder Workshop, Jordanian & German partners & further stakeholders, Amman + online
- 24.11.2021 Project meeting, German partners, online

List of newspaper articles and press releases

- 23.07.2021, Rhein Zeitung Koblenz: „Hochschule Koblenz forscht zu Starkregen in Jordanien“
- 14.07.2021, RheinMoselCampus: “Transdisziplinäres Projekt CapTain Rain gestartet: Hochschule Koblenz forscht zu Starkregen in Jordanien“

- 04.10.2021, DLR Projektträger/VDI Technologiezentrum: „Deutsch-jordanisches Forschungsprojekt „CapTain Rain“ zum Schutz vor Starkregenereignissen startet in Jordaniens Hauptstadt Amman mit Stakeholder-Workshop“
- Press releases:
- 14.07.2021, Hochschule Koblenz - University of Applied Sciences, Sarah Stein: „Transdisziplinäres Projekt CapTain Rain gestartet: Hochschule Koblenz forscht zu Starkregen in Jordanien.
- 26.10.2021, ISOE - Institute for Social-Ecological Research, Melanie Neudert: “Deutsch-jordanisches Forschungsprojekt zu Katastrophenschutz bei Starkregen gestartet” / “Launch of German-Jordanian research project on disaster management during heavy rainfall”