Team 06 Presentation 3

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Work Summary

Online Stage and Week One Achievements:

- **Lumped model set up and calibration**
- **Began creating 2D catchment model**
- **Climate Change Factor Study**

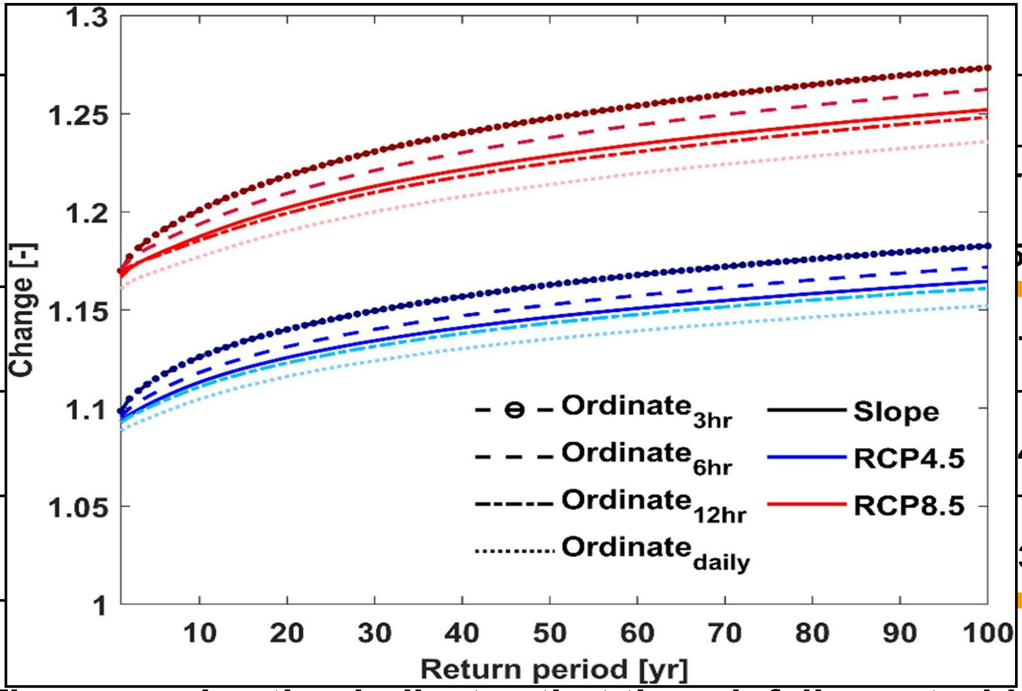
Week 2 Aims:

- **Scenario analysis using climate change factor**
- **Understand spatial distribution of rainfall in the catchment**
- **Development of 2D model**
- **Comparison of flood hydrograph and flood maps**
- **Potential interventions for the Ahr catchment**

Ahr Catchment

Effect of Climate Change on Rainfall

- RCP 8.5 Climate Change Factor (CCF) for a **50-year return period 6-hour and 12-hour durations of rainfall** respectively (Hosseinzadehtalaei, Tabari and Willems 2020): **1.23** and **1.21**.
- KOSTRA-DWD-2020 Dataset to fetch 50-year and 100-year return period rainfall (DWD: German Meteorological Service Agency).



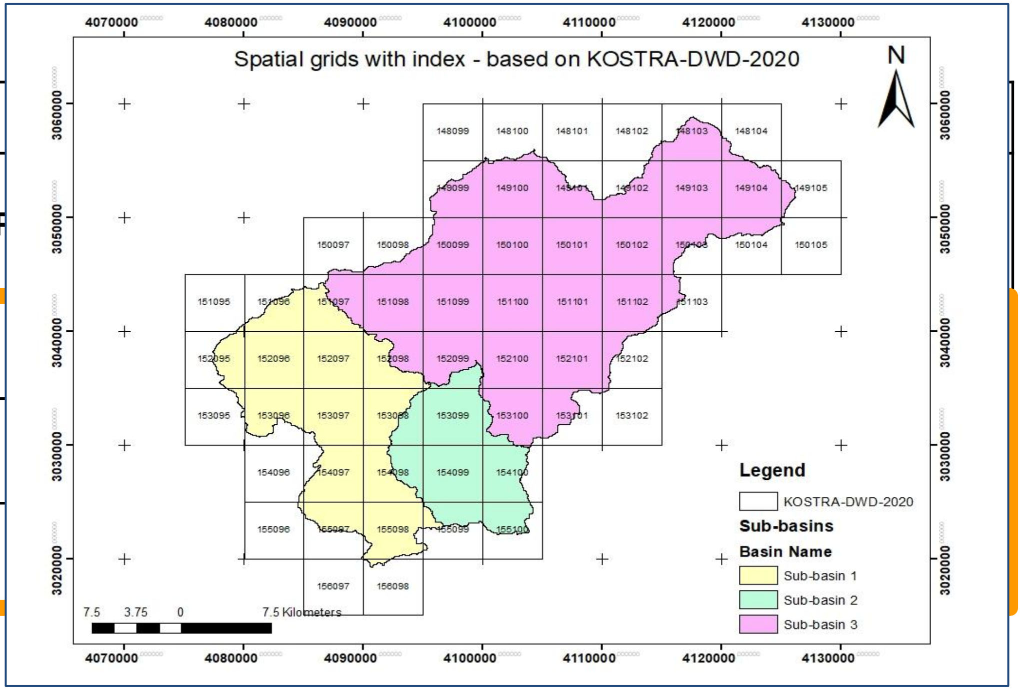
IDF curves for different durations, return periods and climate scenarios (RCP 4.5 and RCP 8.5) for the period of 2071-2100 (Hosseinzadehtalaei, Tabari and Willems, 2020)

Return
with RCP
CCF

7.17

4.91

3.32

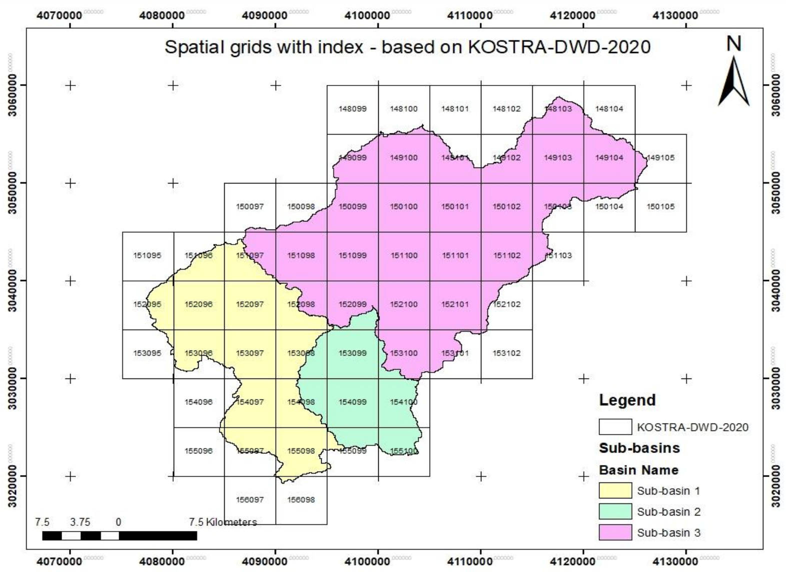


Sub-basins with Cells of KOSTRA-DWD-2020 Dataset

The approximation indicates that the rainfall event which is supposed to happen in every 100-year might happen in every 50-year due to the effects of climate change.

Ahr Catchment — Modelling Scenarios

- Distribution of 50-year return period rainfall in sub-basins 1, 2 & 3
- To understand the response of the sub-basins for 6-hour and 12-hour storm events
- To find out the basins which have the highest influence on peak flow

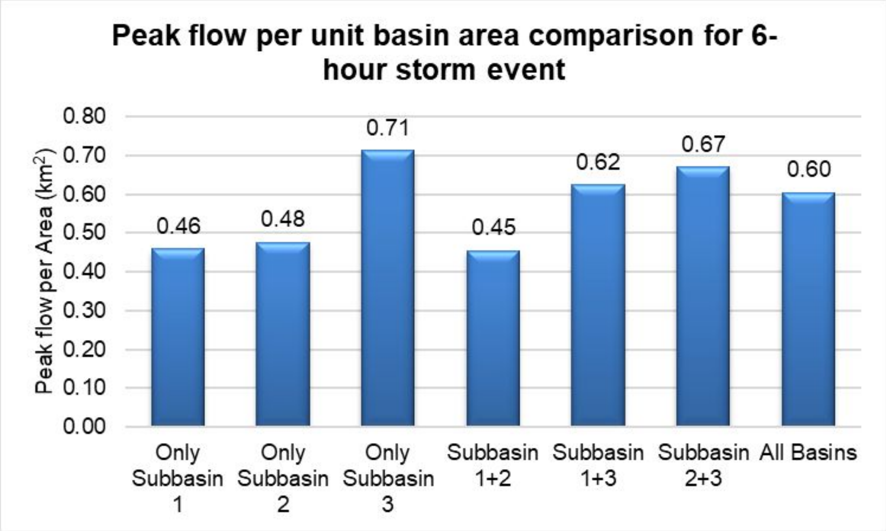


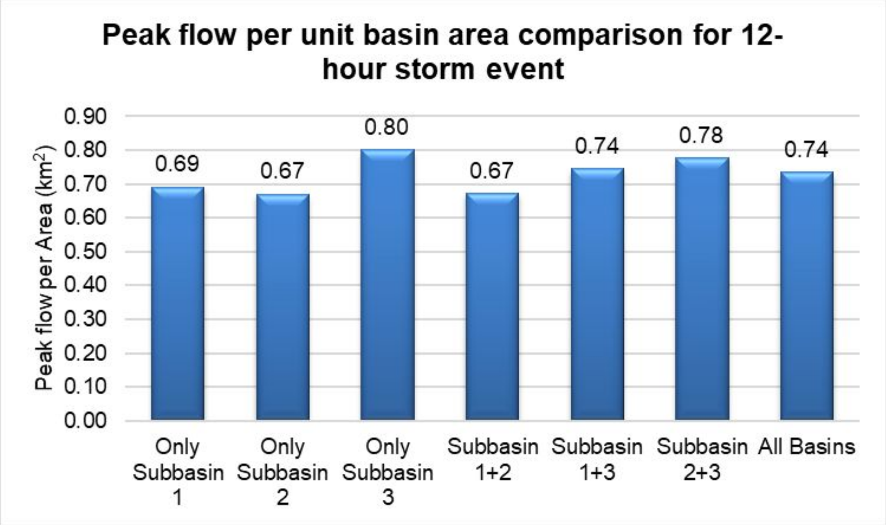
	6-hour Duration Rainfall (mm) 50-year Return Period with RCP 8.5 Climate Change Factor							12-hour Duration Rainfall (mm) 50-year Return Period with RCP 8.5 Climate Change Factor						
Sub-basins	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**
Sub-basin 1	✅	❌	❌	✅	✅	❌	✅	✅	❌	❌	✅	✅	❌	✅
Sub-basin 2	❌	✅	❌	✅	❌	✅	✅	❌	✅	❌	✅	❌	✅	✅
Sub-basin 3	❌	❌	✅	❌	✅	✅	✅	❌	❌	✅	❌	✅	✅	✅

*S = Scenario

Spatial Distribution

- Sub-basin 3 has the highest ratio of peak flow (m^3/s) per unit area of the sub-basin (km^2)
- Impact of sub-basin 3 is even higher than any combination
- The difference in the ratio of peak flow per unit sub-basin area amongst different sub-basins decreases as the duration of precipitation increases
- Sub-basin 3 is taken as the basin of highest importance for flood prevention measures and emergency response



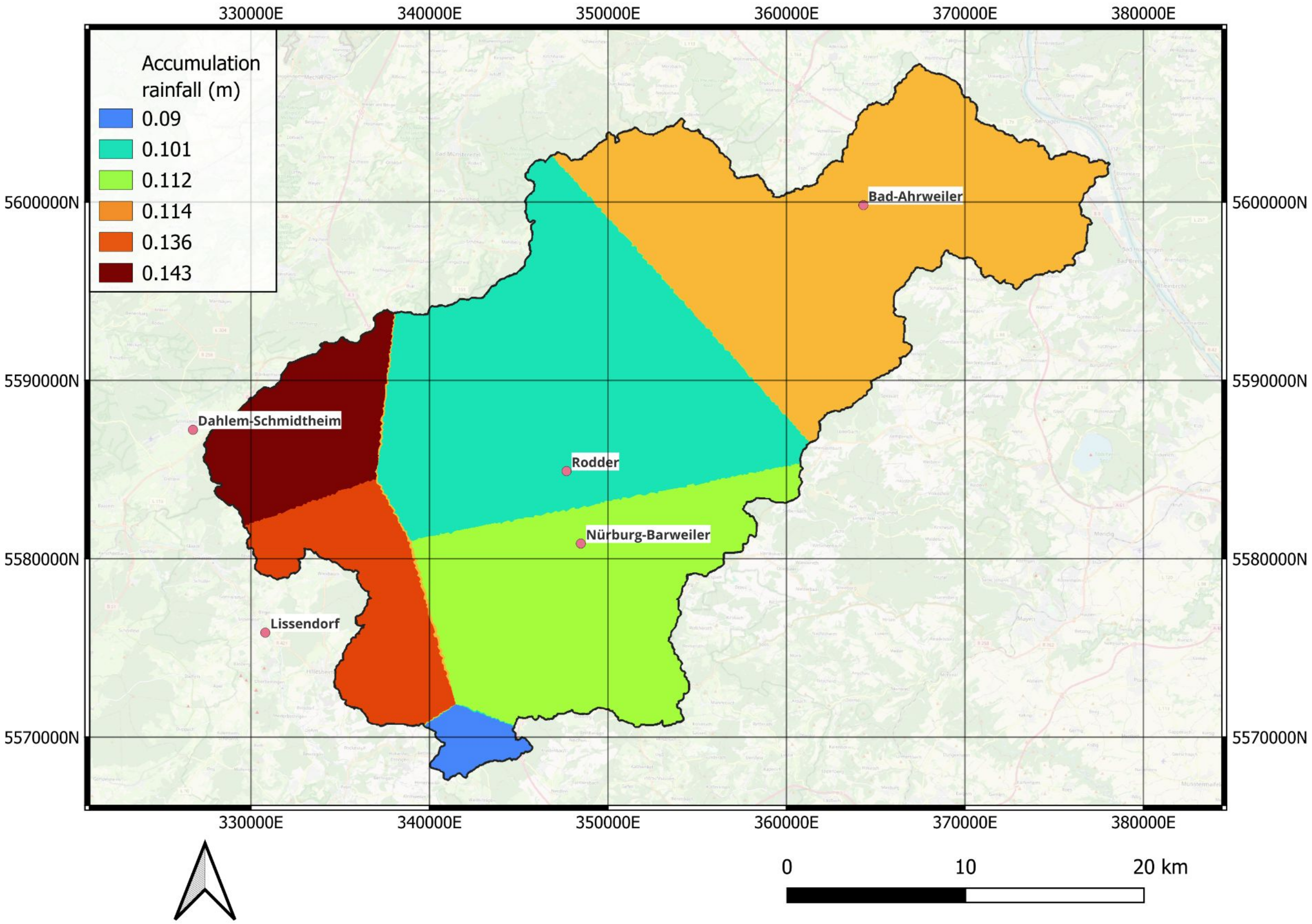


Development of 2D Model

Parameters

- Curve number uniform of 75
- Strickler coefficient uniform of 15
- Initially abstraction factor : λ = 0.2
- Duration of the simulation : 8 days
- Rainfall spatialized

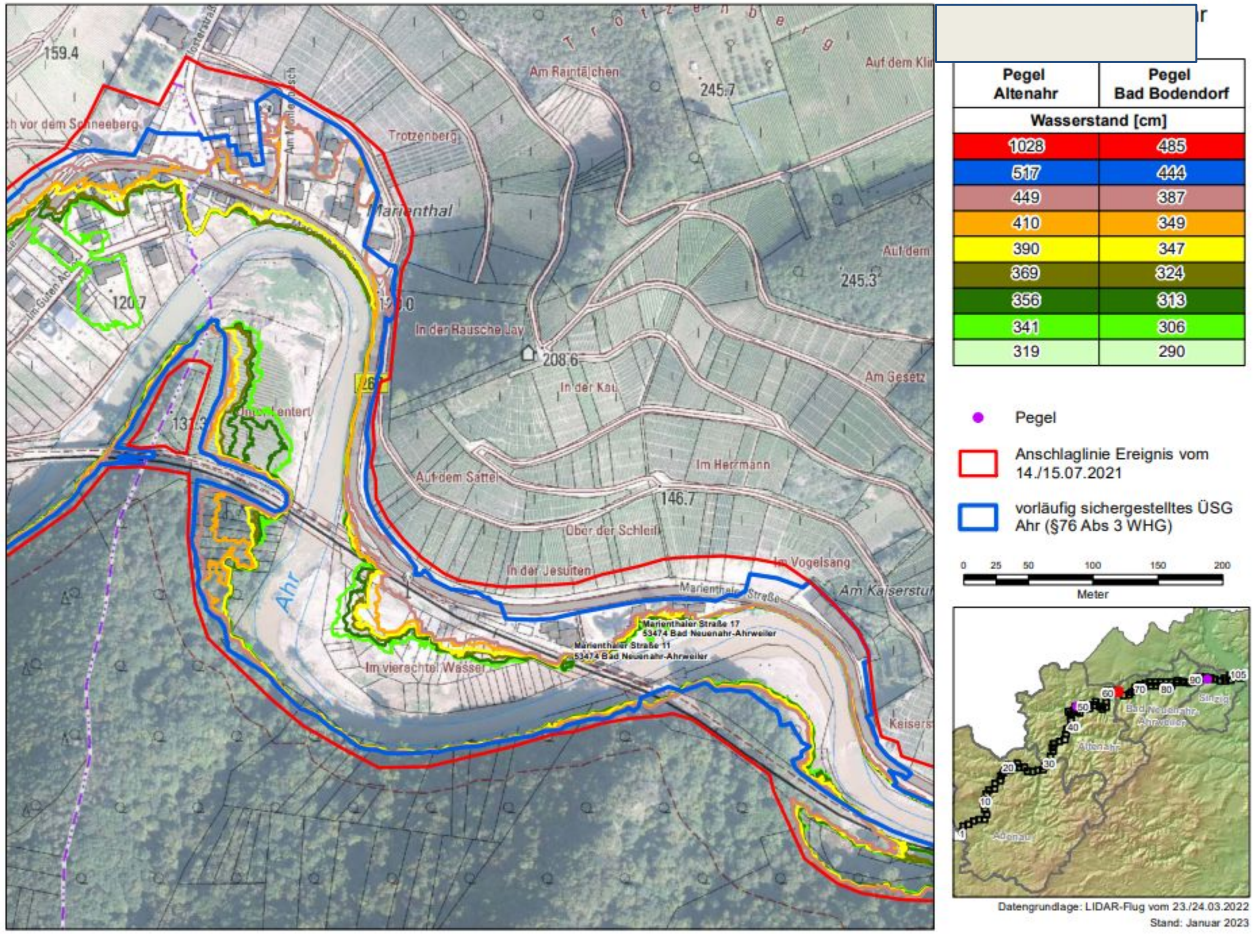
Accumulation of rainfall at the end of the simulation (20/07/2021)



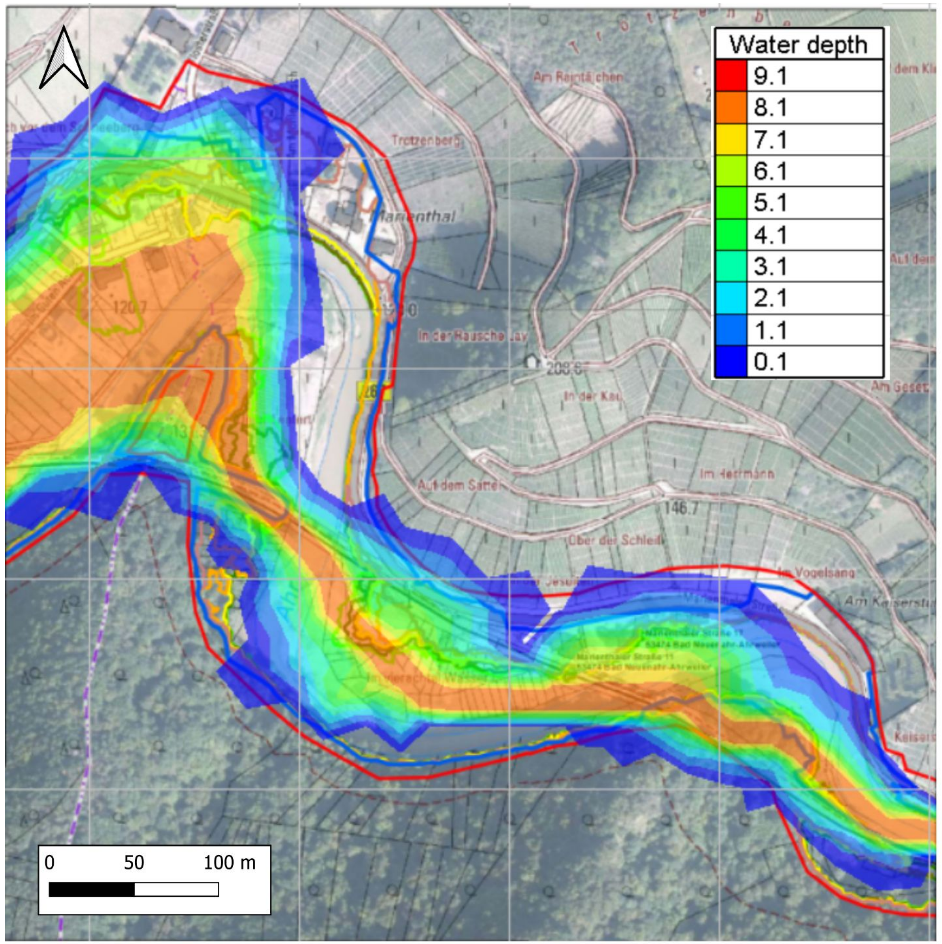
Ahr Catchment — Development of 2D Model

Ahr Catchment

Comparison of Flood Map at Marienthal (2021 event)

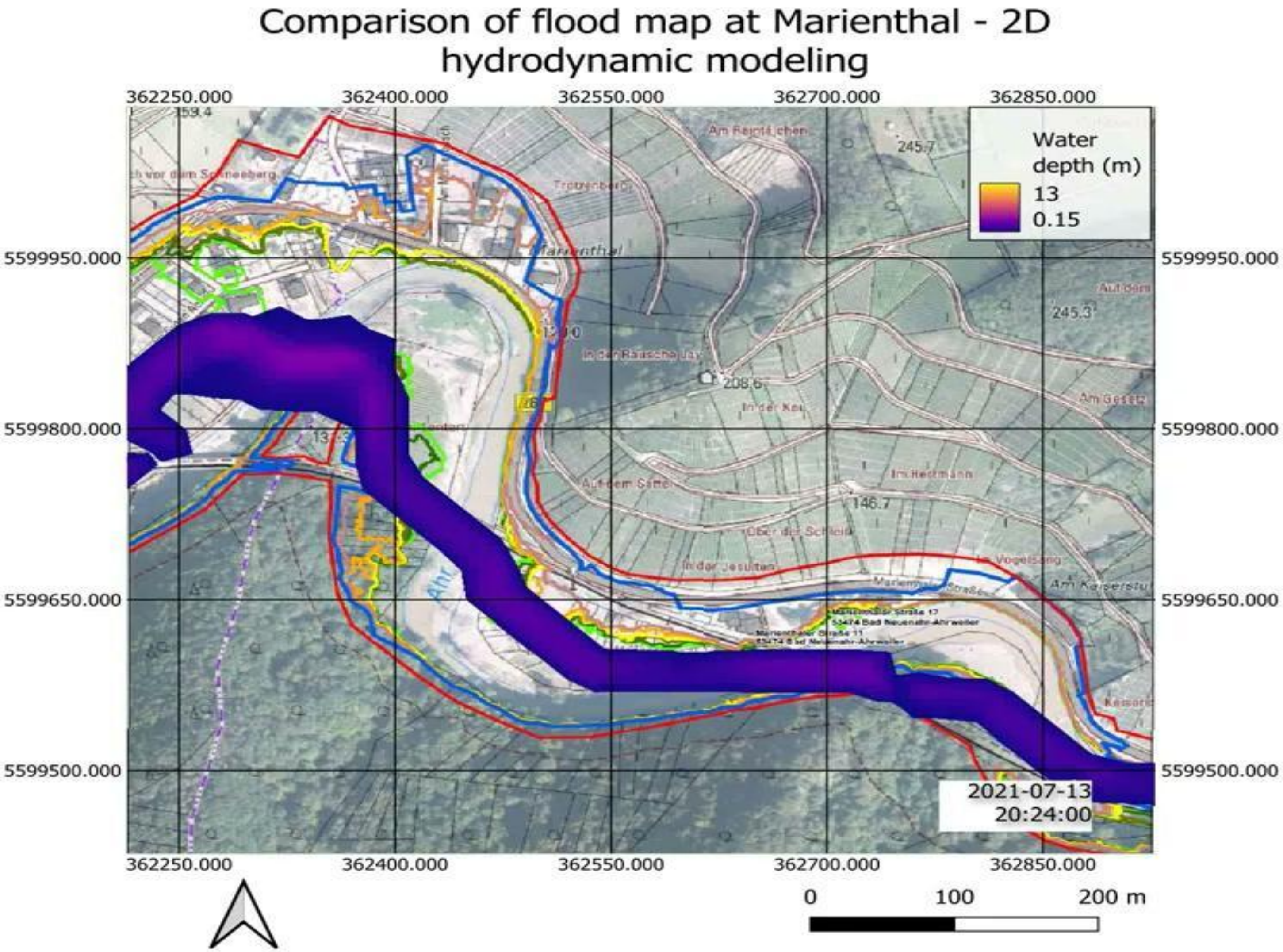


Water level markers for the flood of July 15th, 2021, at Marienthal (Flood Stop Lines. Structure and Approval Directorate North, 2023)



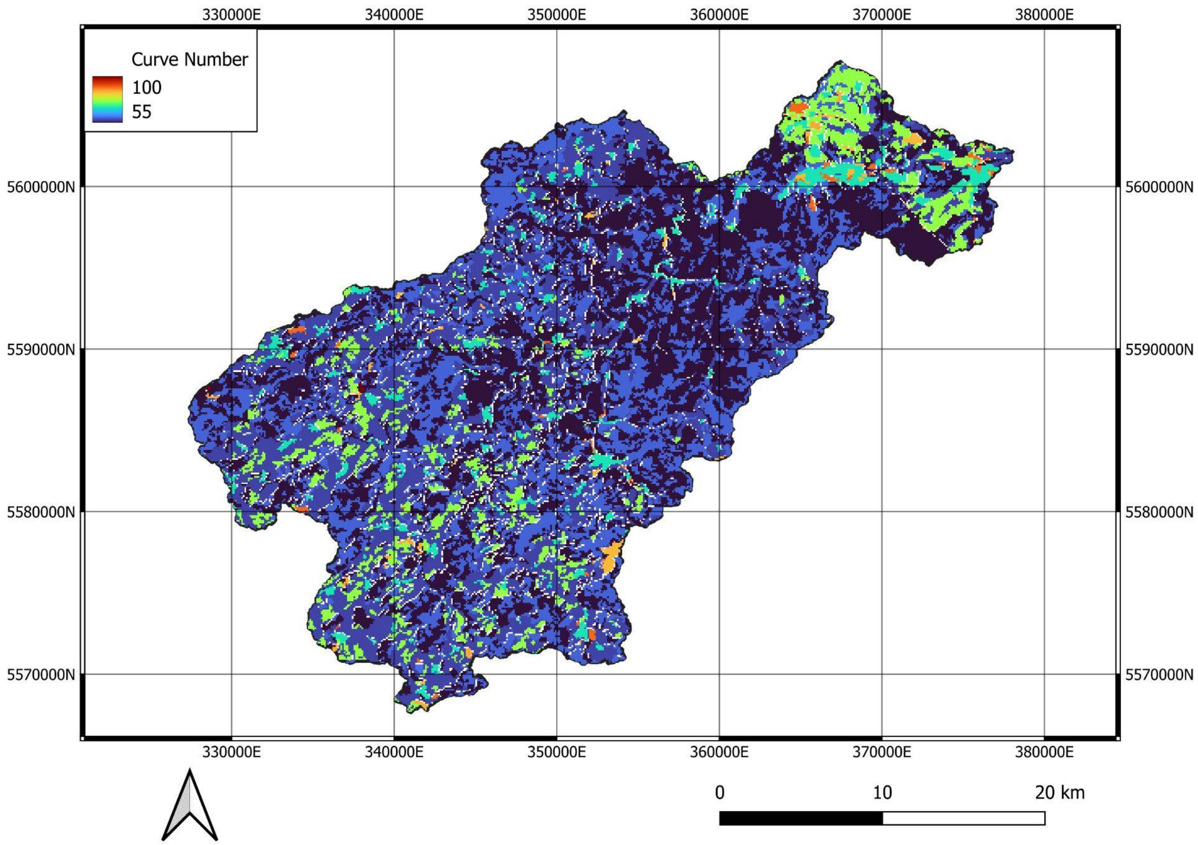
2D Hydrodynamic model for the location of Marienthal

Comparison of Flood Map at Marienthal (2021 event)

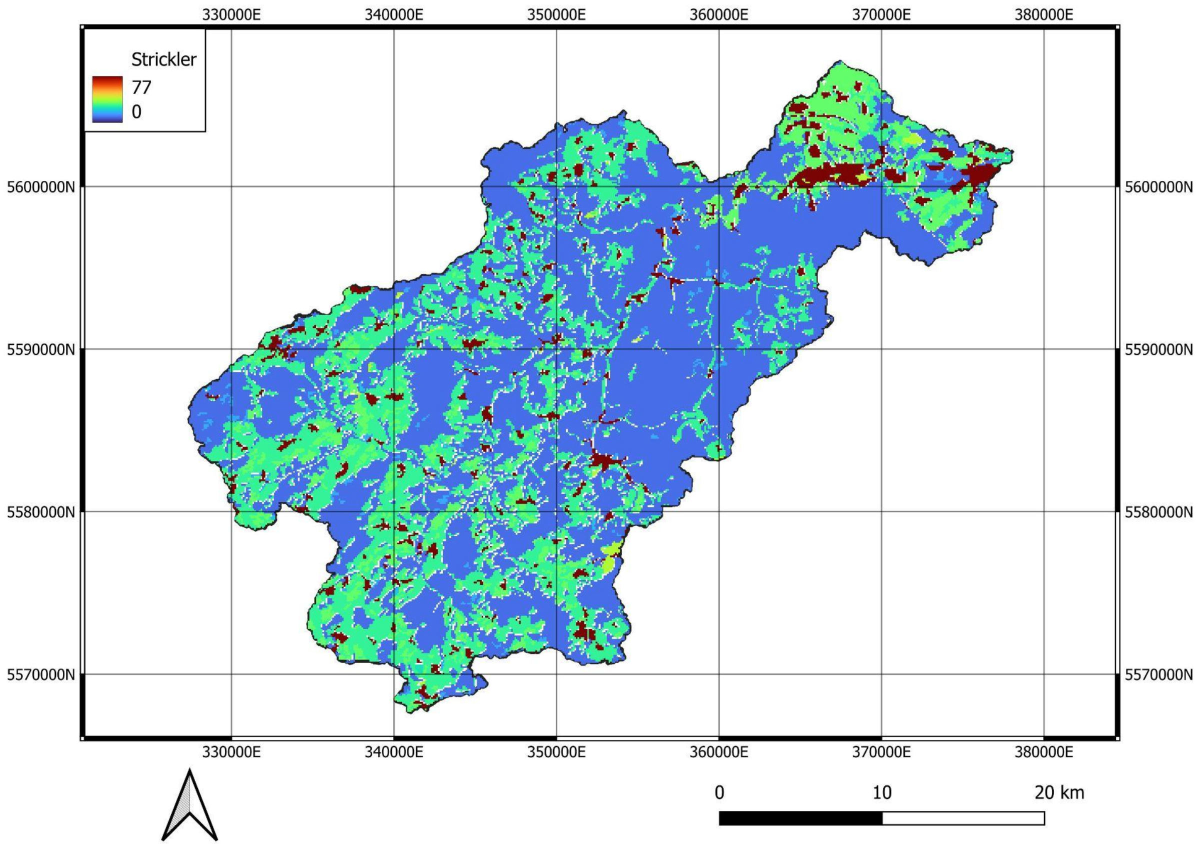


Improvement of 2D Model

Spatialization of Curve Number according to Corine Land Cover



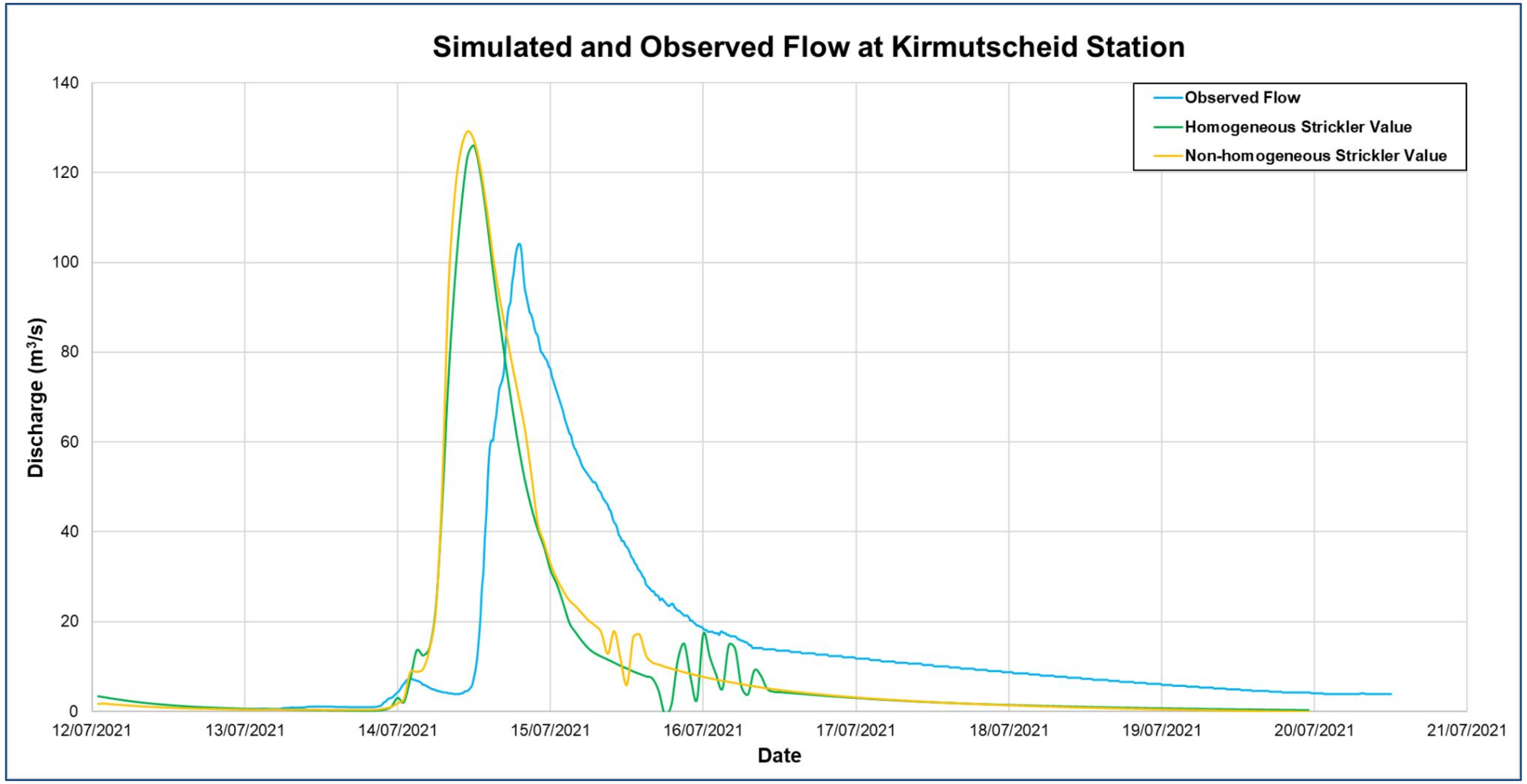
Spatialization of Strickler according to Corine Land Cover



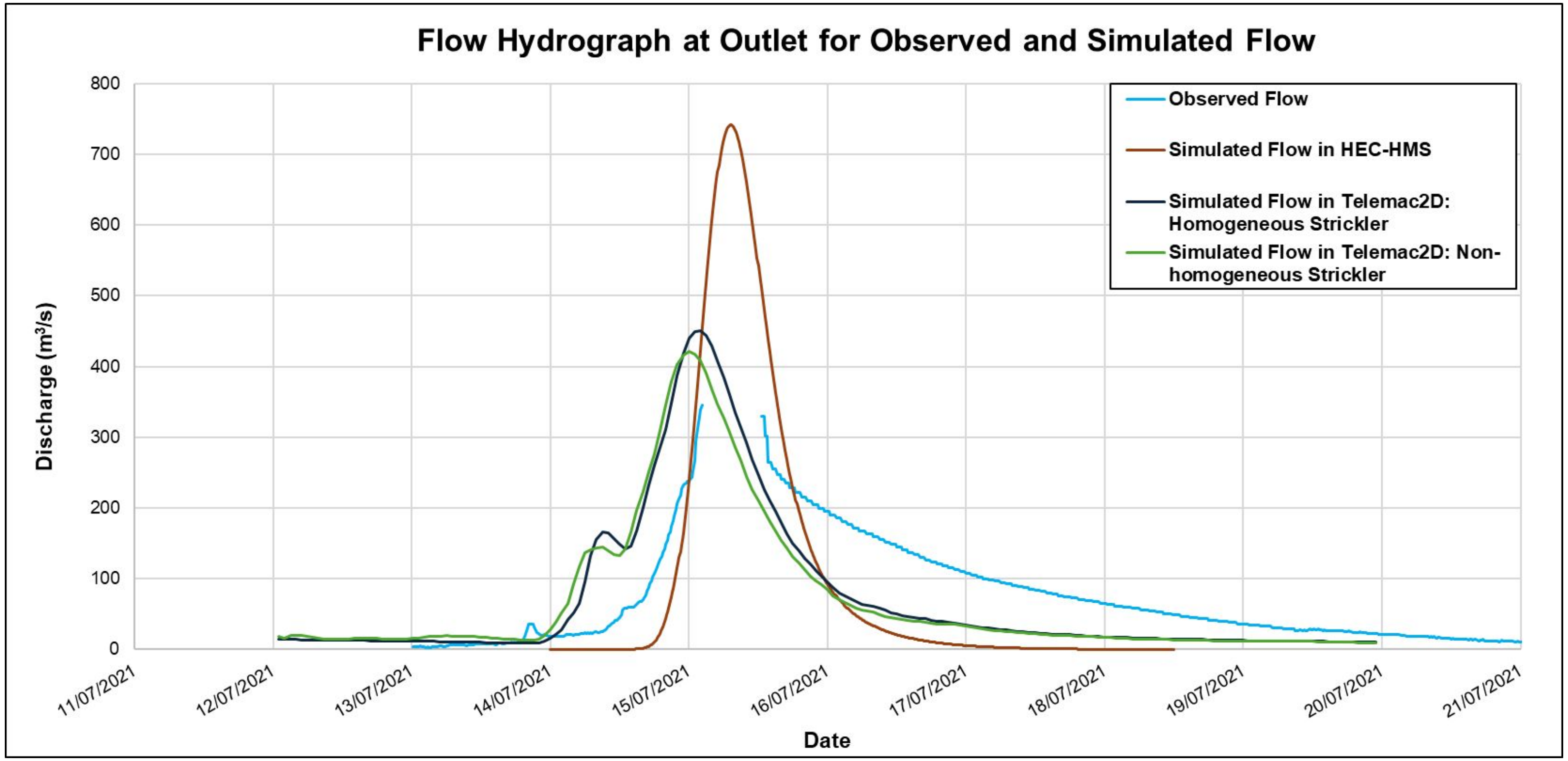
Comparison of Flow Hydrograph

Kirmutscheid control section

- **Control section** near Kirmutscheid gauge station
- **Overestimation** of peak flow
- Time of peak **earlier**
- **Local oscillations** due to numerical problems
- Simulated : **67.3 mm**
- Observed : **94.4 mm**



Ahr Catchment — Comparison of Flow Hydrograph



Control section at the outlet

- **Two peak discharges**
- **Different peak discharges** with HEC-HMS
- Time of peak **earlier**
- **No calibrated**
- **HMS : 48.5 mm**
- **Telemac2D : 55.4 mm**

Factors that intensified the 2021 flash flood

01	Sediment/Debris Transport	• Transportation of material causing blockages.
02	Soil Saturation	• Soil saturation from excess rainfall prior to flash flood = Reduced infiltration
03	Infrastructure built on flood plains	• Infrastructure, including residential, schools and emergency services, located in high probable flooding zones.
04	Topography/Runoff	• Steep topography across the catchment reduces infiltration and increases runoff.

Flood Defence

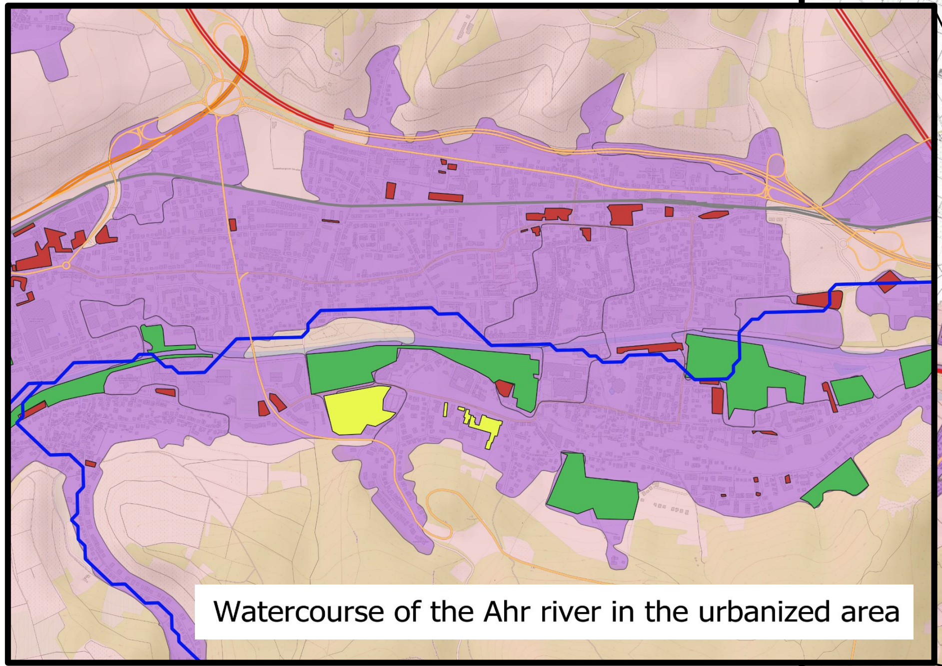
Strategy	Urban Subasin 3	Rural Subasin 3
Sustainable Drainages Systems e.g. Swales, permeable surfaces, rain gardens retention ponds etc.	✓	✗
River bank and slope stability: Gabion cages along banks and adjacent slopes riparian vegetation, sediment traps.	✓	✓
Reduce runoff/control flow upstream: Hill terracing for rural farms, Permeable long green dikes, weir installation	✗	✓
Policy change Limit new infrastructure on flood plains/new minimum standards	✓	✓
Flash Flood Emergency Response Evacuation procedures, temporary flood barriers/defence, education/Community Knowledge	✓	✓

Gabion Cages

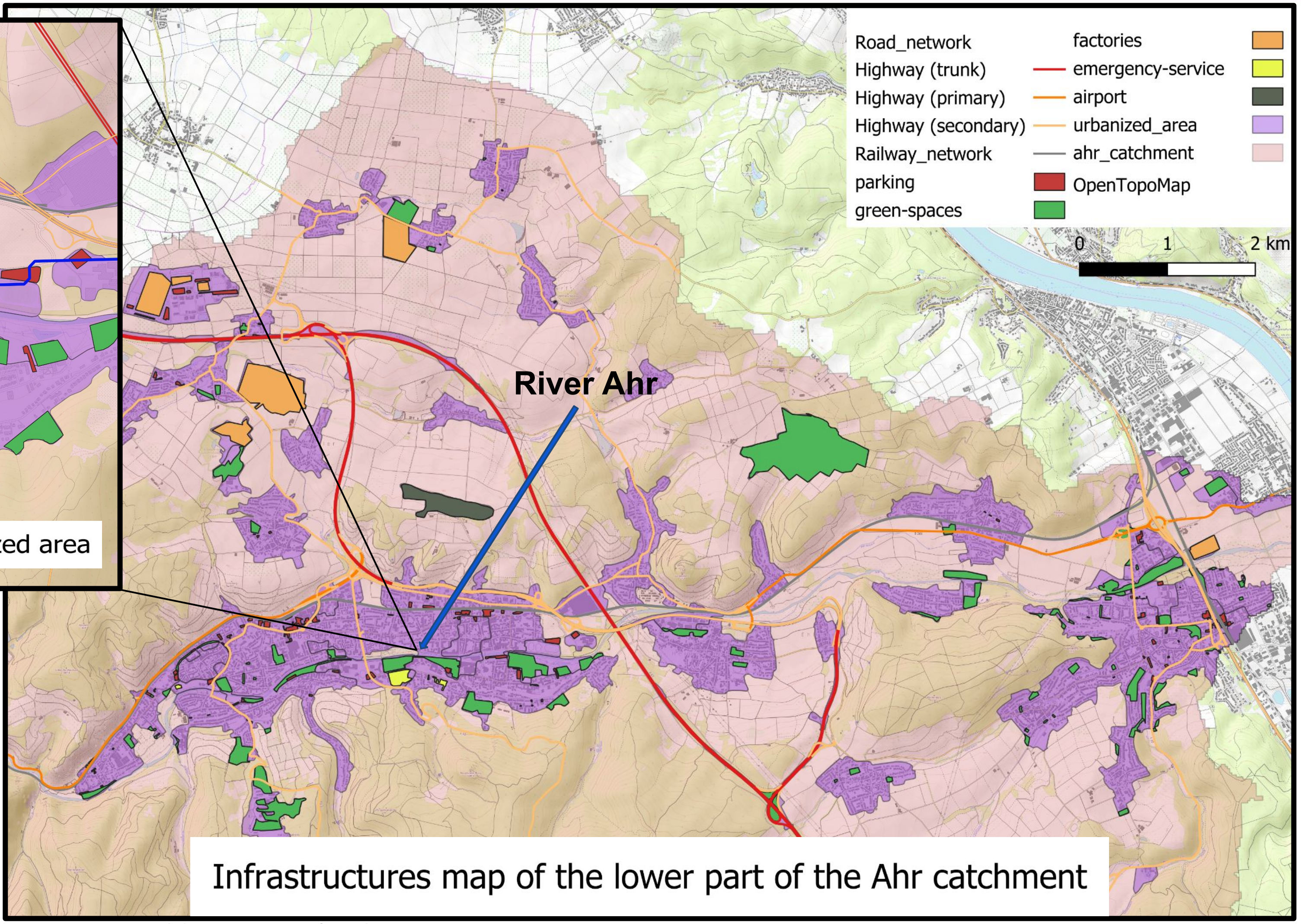
Hill Terracing

Ahr Catchment

Flood Vulnerability



Watercourse of the Ahr river in the urbanized area



Infrastructures map of the lower part of the Ahr catchment

- The river Ahr flows through the city of Bad Bodendorf
- Green spaces could be expanded to near the river.
- Green spaces could also be optimised to improve drainage and infiltration.
- Emergency services, educational buildings, Railway and Highways located within close proximity to the river.
- SUDs could be utilised around these areas.

Objectives

- ❑ To create a hydrological model representative of the catchment, to be employed for flood analysis.
- ❑ To understand and quantify how climate change influences the catchments response to flash flooding.
- ❑ To develop suggestions for flood mitigation and adaptation based on the finding of our results.

Limitations

- ❑ Complexity of the catchment characteristics.
- ❑ Data limitations - 25m DEM resolution, limited data to calibrate.
- ❑ Time constraints - limited time for the calibration of the 2D model.

Conclusion

Achievements

- Identified for a 6-hour storm event with a 50-year return period in 2070, will result in a peak flow of **528 m^3s^{-1}**.
- Identified for a 12-hour storm event with a 50-year return period in 2070, will result in a peak flow of **642 m^3s^{-1}**.
- Identified Sub-basin 3 as the most influential in terms of flow contributions.

Further Study

- The refinement of the 2D model, to further support the accuracy of our findings.
- Further analysis of different climatic scenarios, including, SSP and duration of the precipitation.
- Assess the temporal variation of rainfall across the catchment.
- Further study regarding the suitability of adaptation measures.

References

- Rhineland- Palatinate Water Management Administration. (2023). *Reference water levels of the Ahr*. https://sgdnord.rlp.de/themen/wiederaufbau-ahr/hochwasseranschlaglinien
- Hosseinzadehtalaei, P., Tabari, H. and Willems, P. (2020). Climate change impact on short-duration extreme precipitation and intensity–duration–frequency curves over Europe. *Journal of Hydrology*, 590, p.125249. doi:https://doi.org/10.1016/j.jhydrol.2020.125249.
- Wetter and Klima(n.d.) - *Deutscher Wetterdienst - Leistungen - KOSTRA-DWD*. [Online] [online]. Available from: ttps://www.dwd.de/DE/leistungen/kostra_dwd_rasterwerte/kostra_dwd_rasterwerte.html (Accessed 22 February 2024).

Thank You for Listening, Any Questions?

Rainfall Input

- 50-year return period 6-hr and 12-hr rainfall event with CCF.
- Rainfall distribution using Gamma distribution method.