Team 09: Report Week 2

HYDROEUROPE

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HydroEurope

WP2: Uncertainty in Advanced Hydrological and Hydraulic Modelling
WP3: Climate Change Impacts on Flash Floods
Case Study Tervuren Catchment (Country Belgium)

Team 9 - Report Exercise of Week 2: GIS Pre-Processing of Spatial Catchment Data

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1 Introduction

The goal of this week is to employ LISflood to simulate hydrological processes and flood dynamics with climate change impacts. Climate change stands as a paramount global concern, marked by the profound alterations in long-term weather patterns and temperature increases primarily linked to human activities, notably greenhouse gas emissions. These changes have extensive repercussions, notably impacting rainfall patterns, river discharges, and flood occurrences (Thomas, 2010). With escalating temperatures, regions witness shifts in precipitation, leading to variations in the timing, intensity, and distribution of rainfall. Some areas face heightened risks of more frequent and intense rainfall events, elevating river discharges and flood hazards. Conversely, other regions grapple with prolonged droughts, exacerbating water scarcity concerns. Such alterations not only challenge agriculture, water resource management, and ecosystems but also heighten the vulnerability of communities to flooding and its socio-economic ramifications. As climate change continues its course, it becomes increasingly crucial to address these challenges, mitigating adverse effects, and bolstering resilience in affected regions. The insights gleaned from the LISflood model offer valuable perspectives into the complex interplay of climate variables and hydrological dynamics, aiding in informed decision-making and proactive measures to confront the pressing challenges of climate change.

This report will provide a summary of the preparation of input data needed for the model, the model's simulation outputs employing various mitigation approaches.

1.1 Impact of Climate Change on Tervuren Catchment

The Tervuren catchment is experiencing notable impacts from climate change, particularly in precipitation patterns and hydrology. Shifts in precipitation dynamics are altering the timing, intensity, and distribution of rainfall in the region. This results in more frequent and intense rainfall events, leading to heightened flood risks and impacting water availability during dry spells. Concurrently, changes in hydrology are evident, with increased river discharges and more frequent runoff events affecting water quality, erosion, and sediment transport within the catchment. These climate-induced alterations necessitate adaptive water resource management strategies to mitigate risks and ensure the sustainability of the Tervuren catchment's natural and human systems.

1.2 Modelling with LISFLOOD-WP

In our climate change modelling efforts, we rely on LISFLOOD to understand the impacts of shifting climatic conditions on hydrological processes in river basins and catchment areas. By integrating climate change scenarios, we can assess alterations in precipitation patterns, river flow dynamics, and flood occurrence. This modelling approach allows us to anticipate changes in flood frequency, river discharge levels, and water availability under varying climate scenarios, aiding in the formulation of adaptive strategies for water resource management.

Through the use of LISFLOOD, we can evaluate the efficacy of adaptation and mitigation measures in addressing the challenges posed by climate change to hydrological systems. By simulating the impacts of interventions such as flood control infrastructure and water management practices, we facilitate informed decision-making to enhance the resilience of communities and ecosystems to changing climate conditions.

We will explore a few strategies on reducing the impact of an extreme flood event that may occur if a 500 year return period rainfall event were to take place.

2 Rainfall DataProcessing for Climate change

The following section summarises the calculation of rainfall data used in the model before it is run.

2.1 500 years return period precipitation

Data of the extreme weather event was collected from ISIMIP official website. We used data SSP585 precipitation (Figure 01) which is global daily rainfall data for the periods of 2041 - 2050 and 2091 - 2100. The daily rainfall data was extracted from the SSP585 scenario, the worst-case scenario where global dependence on fossil fuels is at its worst, in order to ensure the most extreme scenario is modelled.

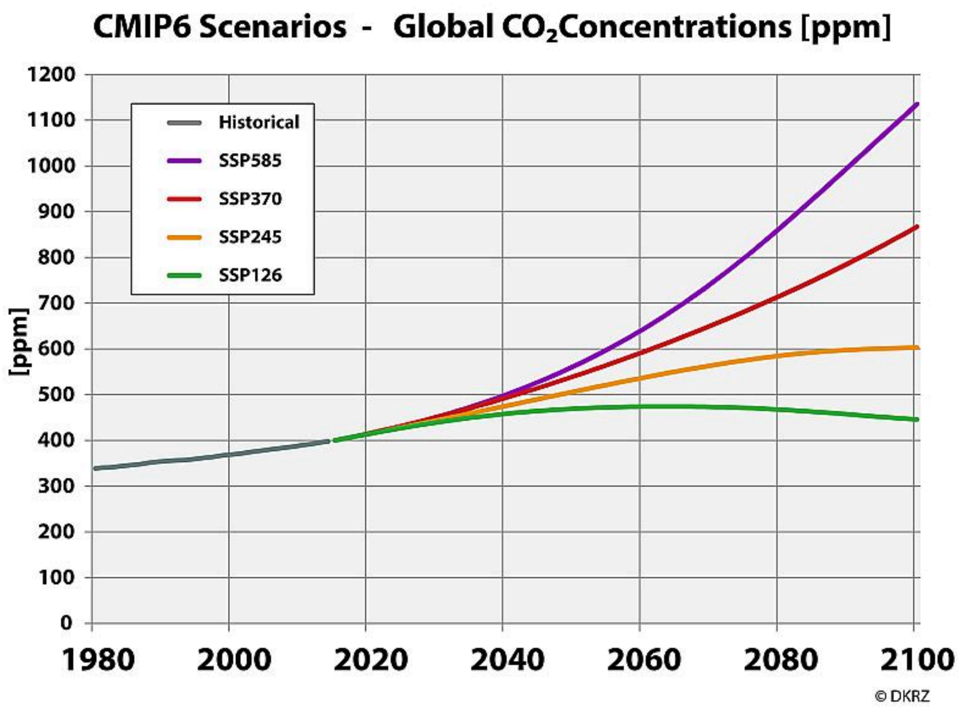


Figure 01. CMIP6 Scenarios - Global CO2 Concentration [ppm]

The rainfall input for the model, before climate change, was a symmetrical profile based on a corrected intensity-duration frequency curve. An increase factor was applied to this rainfall profile to model the climate change effects. These increase factors (for current, 2050 and 2100 scenarios) were obtained by first obtaining the peak over threshold (POT) values, which are the most extreme isolated peak rainfall values. These POT values are ranked in order to gain an exceedance probability. The POT rainfall values and exceedance probability were plotted against each other, to gain a relationship which could be used to extrapolate the return period data for the 500-year rainfall event required. An increase factor of 7.02 was obtained for the 2050 scenario and 3.65 for the 2100 scenario. As we are looking to model the most extreme case, the 7.02 factor was applied to the symmetrical rainfall input data.

3 Climate change Simulation

The input data files above were then utilised to run a simulation for climate change. Figure 02 shows the output. The flooded zone in the area is characterised by varying water depths, with distinct proportions of the total area affected. The region experiencing water depths ranging from 0.1 metres to 1 metre covers approximately 52.7 hectares, constituting 43% of the flooded zone. In comparison to the total area, this portion represents 1.6%. For water depths between 1 metre and 2 metres, the affected area is 16.2 hectares, accounting for 13% of the flooded zone and 0.5% relative to the total area. Finally, areas with water depths exceeding 2 metres encompass 53.7 hectares, comprising 44% of the flooded zone and 1.6% of the total area.

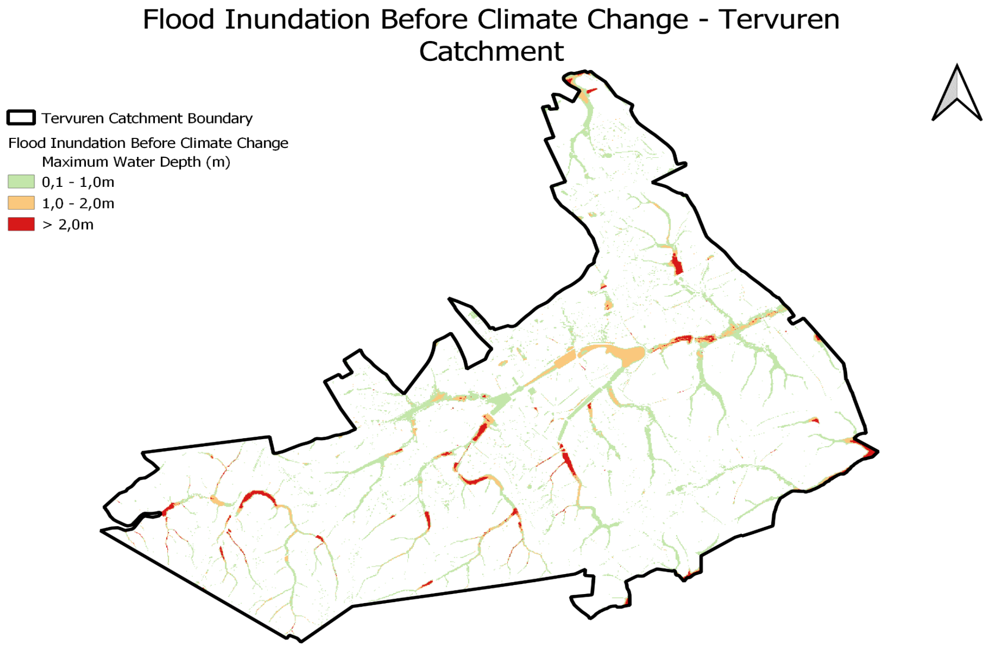


Figure 02. Output Flood model without climate change

The flooded zone within the area exhibits increased water depths with the climate change data. The water depth ranges from 0.1 metres to 1 metre, the flooded zone covers an area of 179 hectares, representing 34% of the total flooded area. Relative to the total zone, this section accounts for 5% of the affected area. For water depths between 1 metre and 2 metres, the flooded area spans 20.7 hectares, constituting 4% of the total flooded area and 1% of the entire zone. Furthermore, areas with water depths exceeding 2 metres encompass 322 hectares, comprising the majority at 62% of the total flooded area and representing 10% of the total zone. A very high increase was observed.

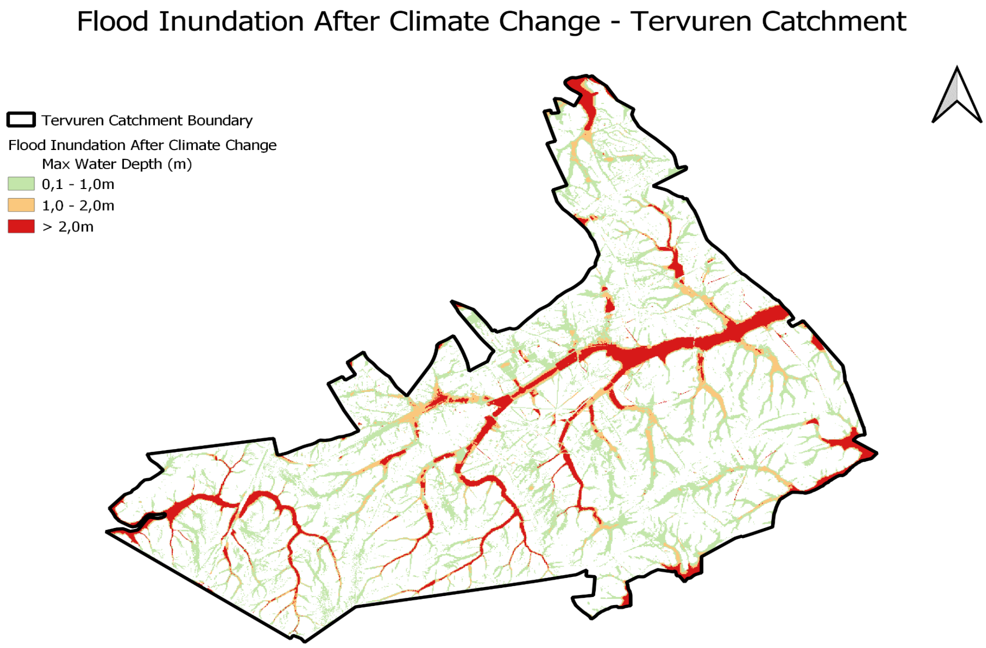


Figure 06. Output Flood model with climate change

We then explore a few management strategies. They will be described as scenarios below.

4 Scenario 01

The first scenario was focusing on reducing the flood that would affect a more densely populated area of the catchment. The scenario involved building a channel connecting two main rivers to conduct and force a discharge of the water in a constructed basin.

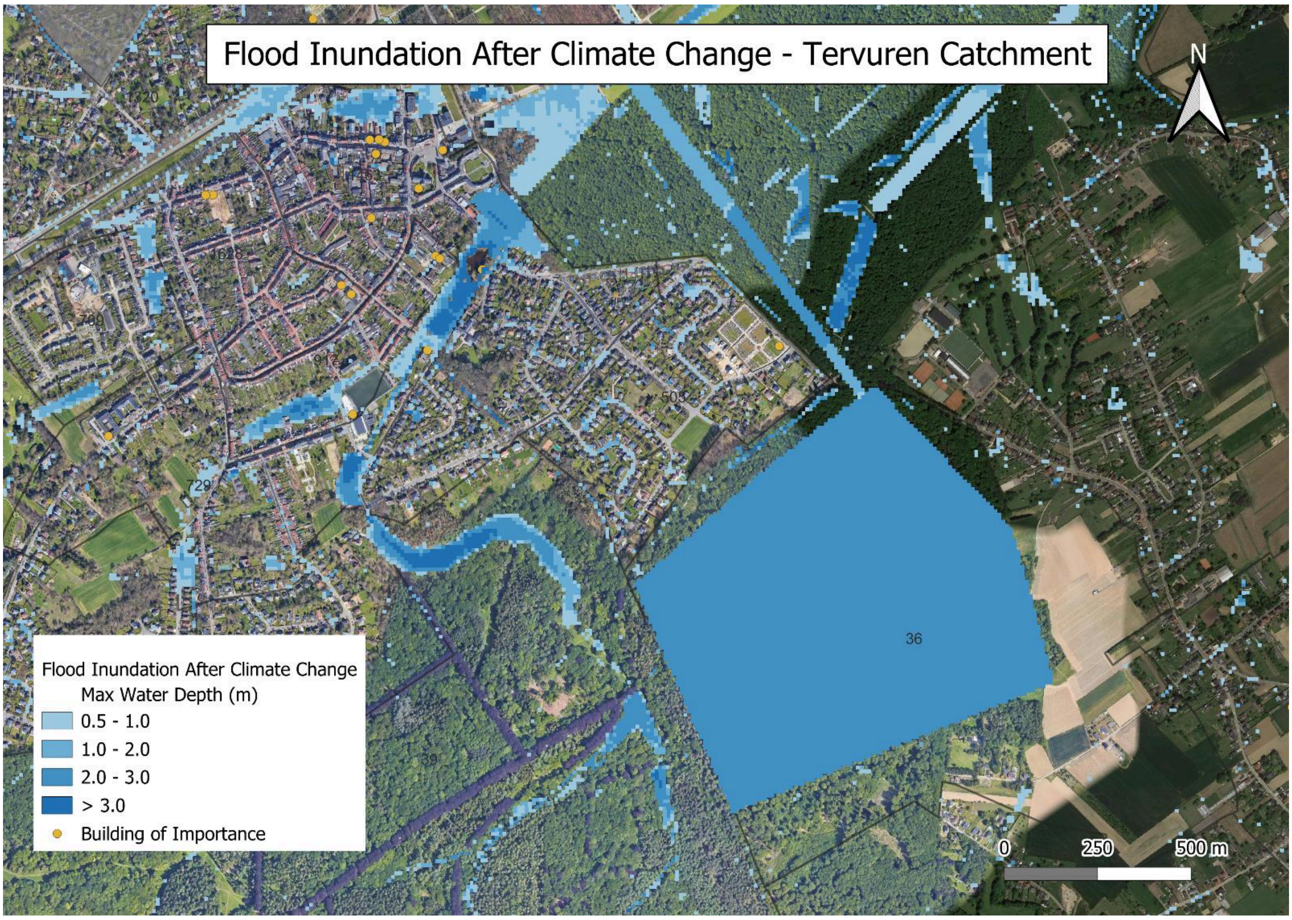


Figure 04. First scenario: building a channel to conduct the water to the basin.

5 Scenario 02

In this scenario we tried to increase the width and depth of the river around the region to help manage the flooding caused by this extreme weather event. This location holds about 800 people. If we employ this particular solution to this location it should help save this area from flooding. In the image below we observe a reduction in the water inundated areas after the implementation of this solution approach.

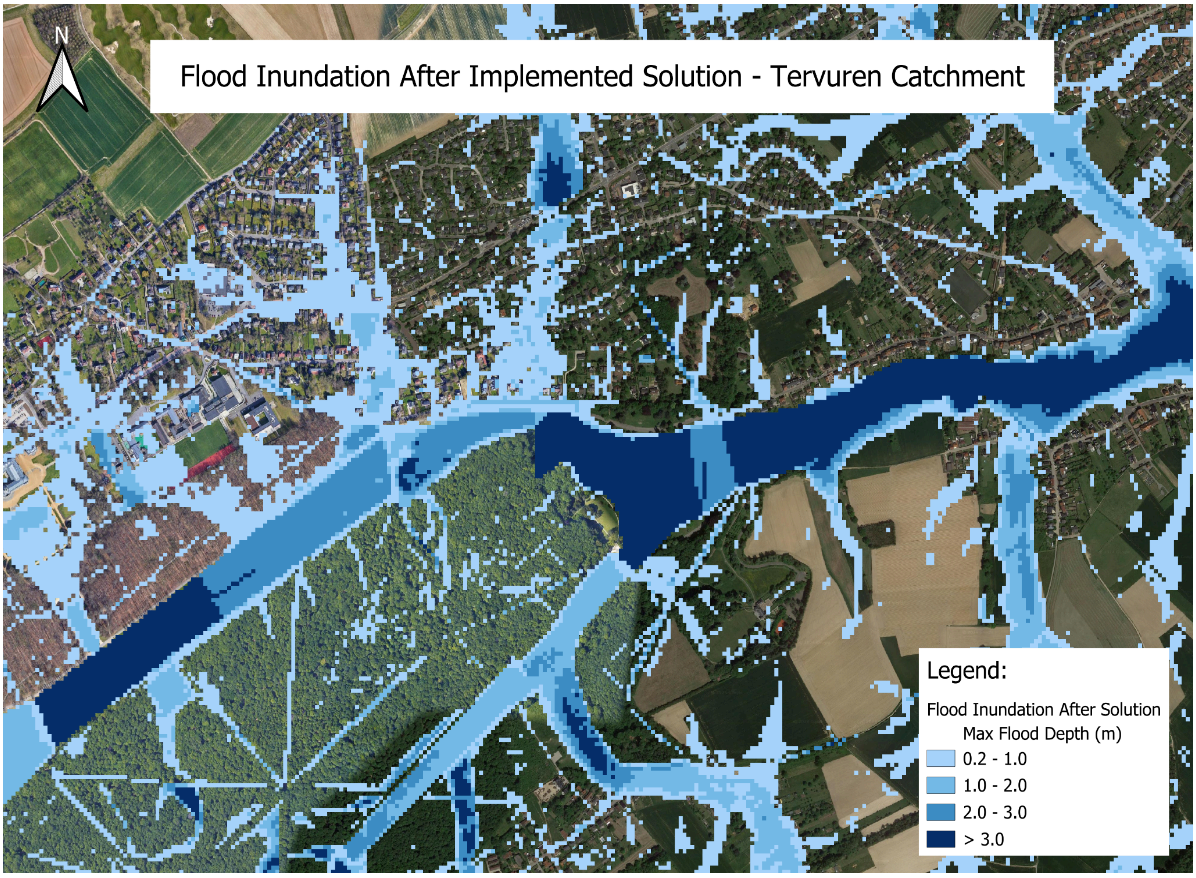
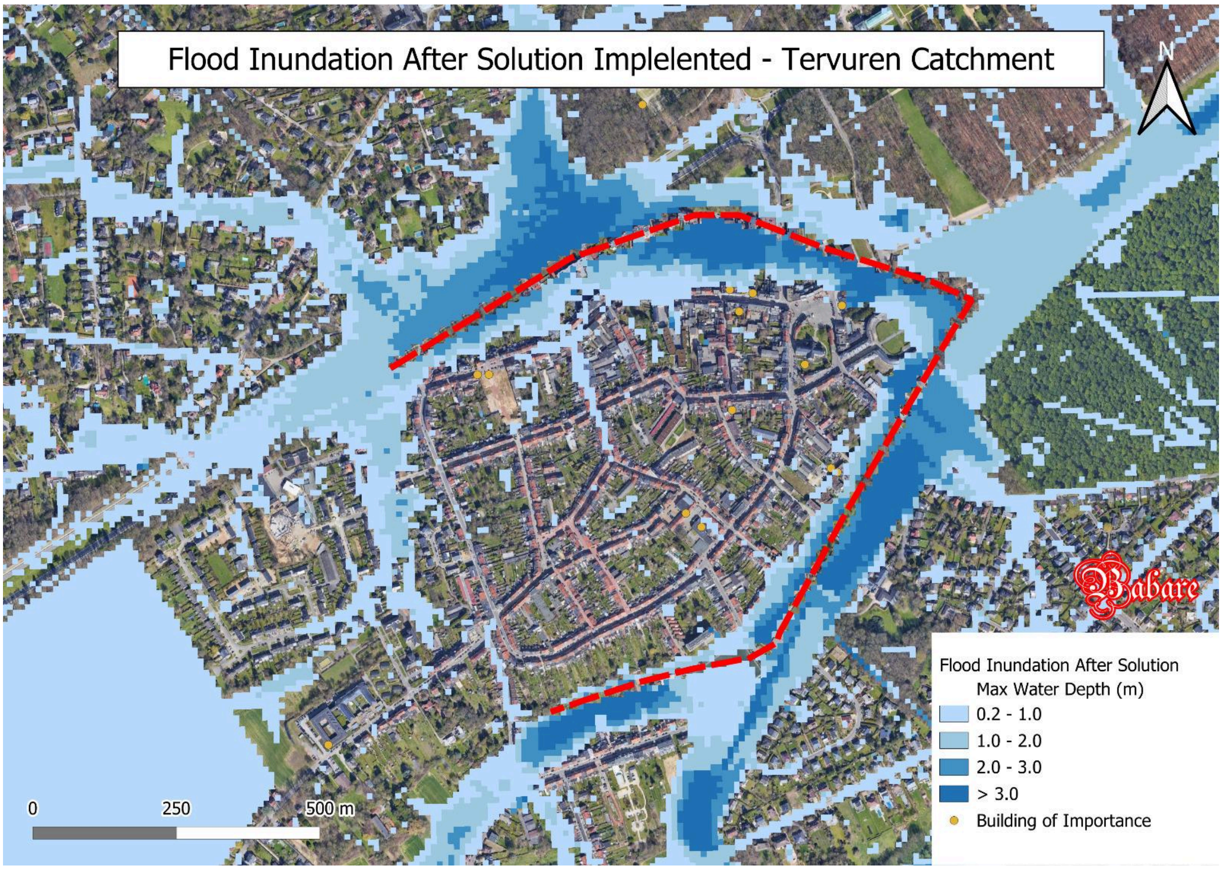


Figure 09. Flood inundation areas

6 Scenario 03

Climates Scenario 3 attempts to manage the flood inundation for a small area in the Tervuren catchment. But we see that it shows a negligible impact on the region. Because the precipitation is accumulated here and without a proper sewage/drainage system in place it does not help reduce flooding. Even an additional basin is not effective in this case. The need for a proper sewage/drainage system in urban areas is the appropriate adaptation strategy in this case. Which is outside the scope of our modelling project.



Dykes and basins are particularly helpful for managing fluvial flooding as our model is simulating heavy rainfall on this residential area. The best solution would be to employ adequate drainage.

7. Conclusion

Climate change models predict drastic levels of flooding for the Tervuren Catchment. Drastic solutions are also necessary to help manage such a catastrophe. Changing river width, creating large reservoirs and implementing proper drainage systems are some approaches that can be useful to reduce damage to human lives and properties.

References

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