Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

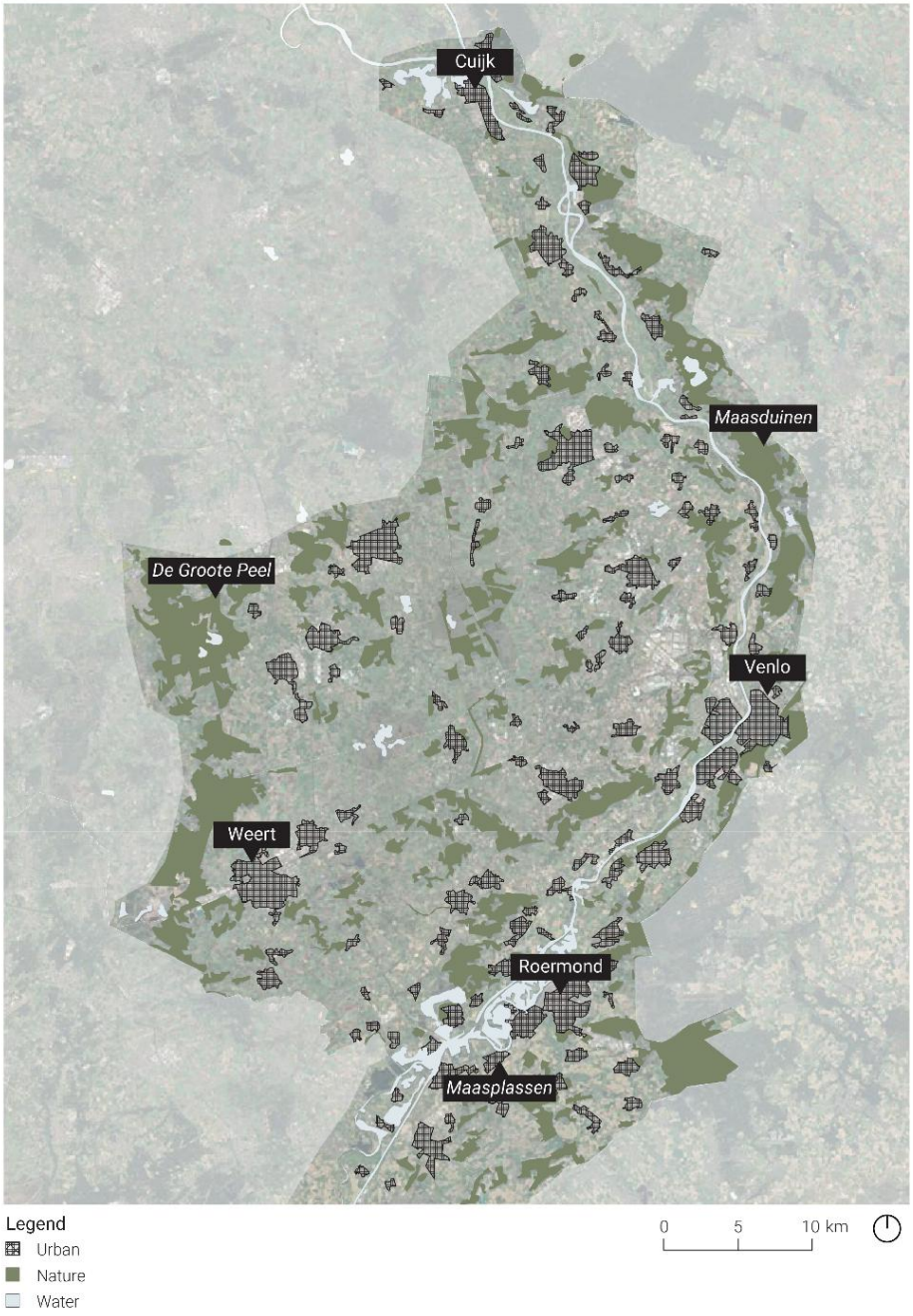
Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	**Esmee de Quant**
Student number	588472

Studio		
Name / Theme	Metropolitan Ecologies of Place (MEP)	
Main mentor	Kristel Aalbers	Environmental Technology & Design
Second mentor	Nico Tillie	Landscape Architecture
Argumentation of choice of the studio	MEP focuses on ecological and socio-economic transitions through critical and imaginative investigations of space and life. My project focuses on the renaturalisation of rivers as a flood resilience strategy, ensuring urban areas remain habitable. MEP would align with my research, as it redefines flood-prone urban landscapes, while considering the natural river morphology. It extends beyond human-scale interventions, addressing natural processes (river morphology) and ecological impacts. My research would fit within the subtopics of Water-based Climate Adaptation (WBC) and Urban Ecology and Biophilic Design (UEBD). It aligns with WBC by developing strategies for flood resilience in urban environments and with UEBD by placing nature, specifically the natural flow of the river, at the core of the design approach. MEP is the most fit studio for my project, as it emphasizes on both ecological restoration (renaturalising rivers) and socio-economic adaptation (new living strategies). In the end, I aim to develop multi-scalar strategies, which align with previous MEP master theses.	

Graduation project	
Title of the graduation project	Restoring Rivers: Integrating a renaturalised Maas river basin with the cultivated landscape to enhance climate resilience
Goal	
Project location	Noordelijke Maasvallei (Northern part of Limburg, from Roermond to Cuijk)



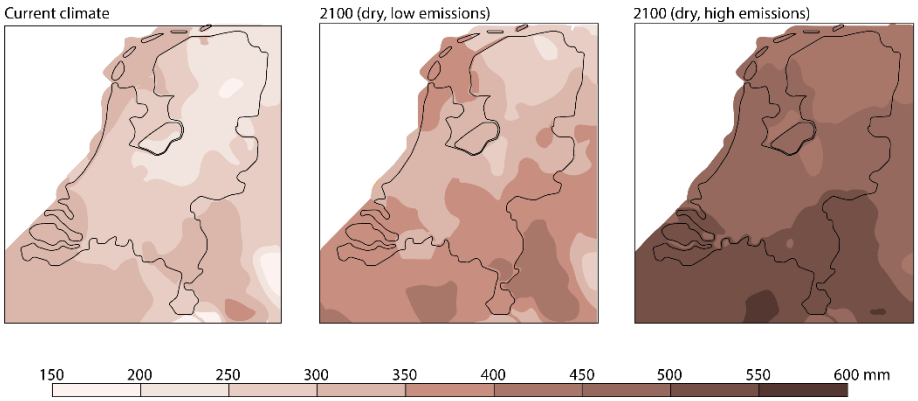
Problem statement	**Problem statement** The effects of climate change are becoming more visible every year. Precipitation patterns are shifting, with wetter winters and drier summers leading to more extreme droughts, while unpredictable summer rainstorms are becoming more frequent. Even if emissions were to drop, all these factors are expected to intensify over the next 75 years (KNMI, 2023). The Maas, a rain-fed river, is dependent on precipitation for its discharge, and these shifting patterns could become catastrophic, causing flooding due to wetter winters and summer storms, as well as growing water shortages in summer. These issues are not only shaped by conditions downstream, but are also heavily influenced by upstream discharge from France and Belgium. High water surges arrive downstream rapidly, while

during low discharge, water may be used upstream before reaching the Netherlands (IRM, 2023). As the problems continue to worsen, there is a growing need to store and accommodate water downstream.

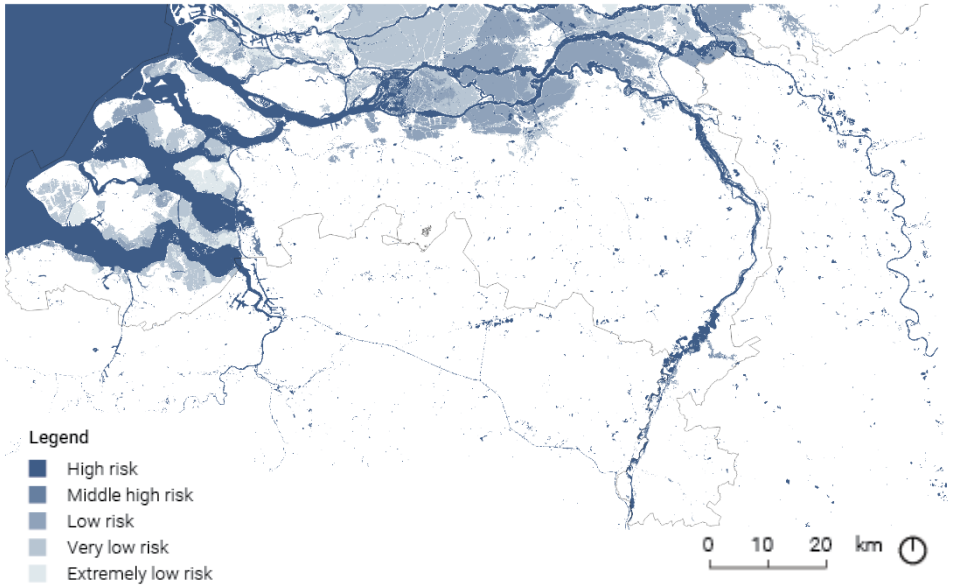
In addition, the Maas has been heavily altered over time to support human needs, and is now far from its natural state (Asselman et al., 2018). The entire downstream section is managed by weirs, with large parts canalised and dredged to accommodate shipping. This has resulted in a loss of space for the river, a decline in riverine nature, and a sinking, unstable riverbed (ibid). In the past, the river was able to adapt to changes in discharge, but without its natural processes, the Maas is no longer resilient to climate change in this way. A pathway to a more resilient basin could be through renaturalisation of the river morphology, restoring natural processes that allow room for excess water and create a landscape adaptive to drought (Baffert & Casey, 2024). However, the current landscape has been shaped around the engineered river, and renaturalising the basin would require a shift in land use. A transformation of the cultivated landscape, integrated with a more natural river flow, is therefore necessary to ensure climate resilience.

With current trends in climate change, there is a need for a change in land use, in which the river and the surrounding land will be able to cope with the unpredictability in weather and discharge from the entire Maas river basin.

Precipitation deficit (KNMI, 2023):

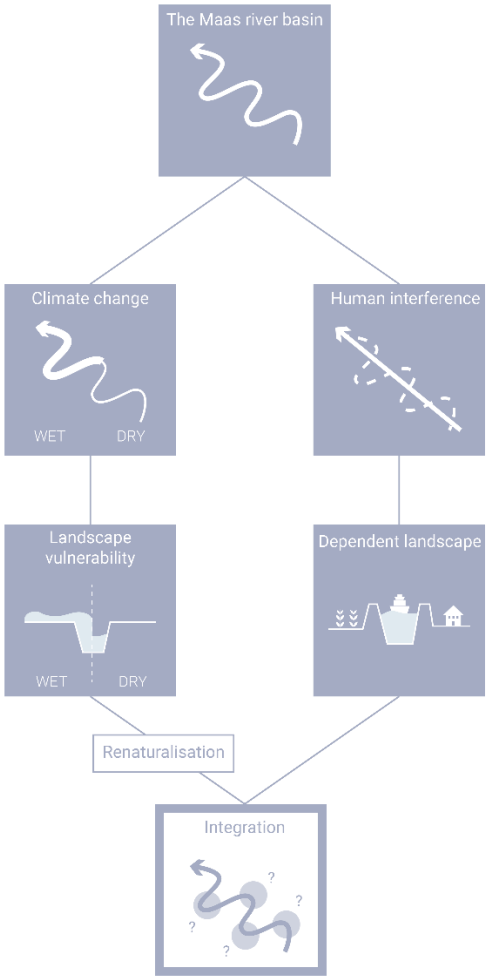


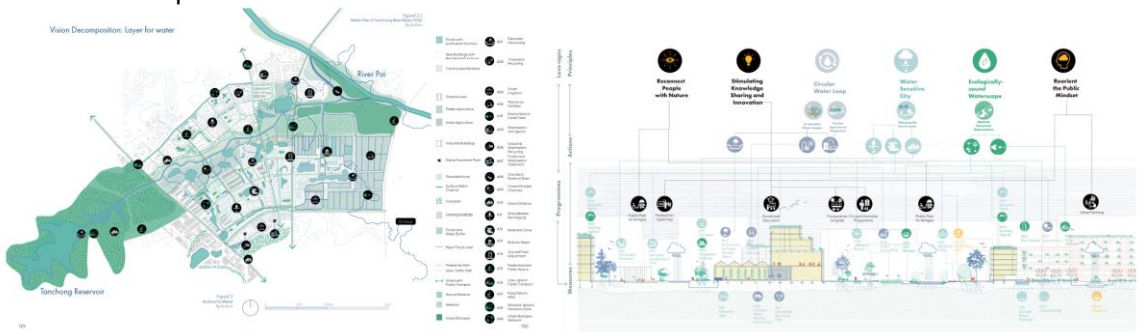
Flood risk 2021 (KNMI, 2023):

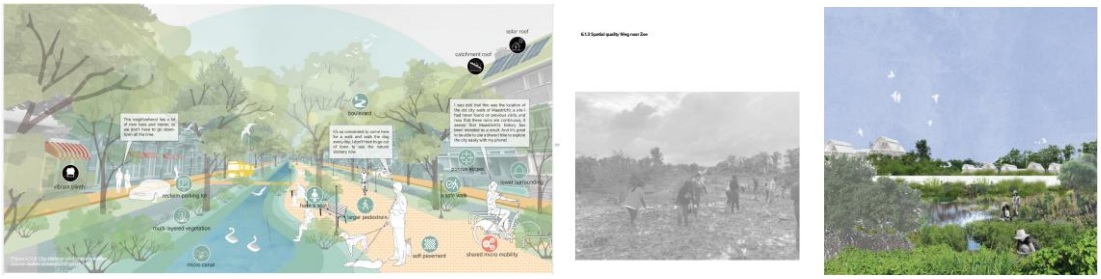


Research aim

The aim of this thesis is to investigate new opportunities for the landscape in the downstream Maas river basin to adapt to increasing extremes of drought and precipitation. Through the lens of renaturalisation, it investigates how a cultivated landscape can be integrated with a more natural river system to create a resilient and adaptive environment. The goal is to design a pathway towards 2100, presenting multiple nature-based solutions that are needed to create a resilient river basin in times of drought and rain. The Noordelijke Maasvallei will be used as a case study to test and show how these solutions can be spatially implemented.

	Problem framework: 
Research questions	**Main research question:** How will renaturalisation of the river Maas as a climate resilience strategy transform the Noordelijke Maasvallei under the most extreme dry and wet scenario by 2100, and how can the ecological, agricultural and urban landscape evolve with this transformation? **Sub research questions:** SQ1. How does the renaturalisation of rain-fed rivers enhance climate resilience? SQ2. How has the hydrology of the Maas changed over time and what role have human interventions played in this? SQ3. What are the current opportunities and threats for the Noordelijke Maasvallei spanning the ecological, agricultural and urban landscape, in relation to the river Maas? SQ4. How would the Noordelijke Maasvallei's landscape evolve under the given existing conditions by 2100? SQ5. What interventions are needed to renaturalise rain-fed river basins, and what interventions are required in the ecological, agricultural, and urban sectors to respond to this transformation and strengthen their climate resilience?

	SQ6. How will renaturalisation of the Maas river basin in the Noordelijke Maasvallei change the landscape under the extreme wet and dry scenario by 2100 and what are the spatial implications? SQ7. How can the cultivated landscape in the Noordelijke Maasvallei fit into a renaturalised Maas river basin under the extreme wet and dry scenario by 2100? The sub research questions belong to different phases of the thesis, as can be seen under ''method description'' in the methodological framework. SQ1 belongs to theory, SQ2-4 to analysis (past, present, future), SQ5 to pattern building, SQ6 to maximizing and SQ7 to design.
Design assignment in which these result	This thesis has multiple steps resulting in different designs. The outcomes of SQ5 will lead to a pattern language, consisting of tools and interventions that will be used in the following questions. Through investigation of literature and other case studies, different patterns will be created. They will be divided into a language focused on renaturalisation, and one focused on integration of the cultivated (ecological, agricultural and urban) landscape. These patterns are also intended to be transferable to other future projects relating to this topic. In SQ6, the patterns will be tested, and the research area will be maximized on renaturalisation. The outcomes of the analysis in SQ1 to 4 will be used in this phase as well. The historical analysis will show what the area looked like naturally in the past, being helpful to envisioning what this can look like in the future again. The SWOT and scenario analysis show the important areas of interest and what should change. In SQ7 this will be used to integrate the cultivated landscape with a natural river basin. From this phase, perspectives until 2100 following the wet and dry scenario will be designed to show the possibilities of using renaturalisation as a climate resilience tactic. The outcomes will be impressions for the future, and schematic sections and strategic maps showing possibilities on how the cultivated landscape can be designed in different ways, with the Noordelijke Maasvallei and zoom ins of this area as a case study.
References for possible outcomes:  *Vision map and section with incorporated interventions (MSc thesis J. Wang 2022).*	



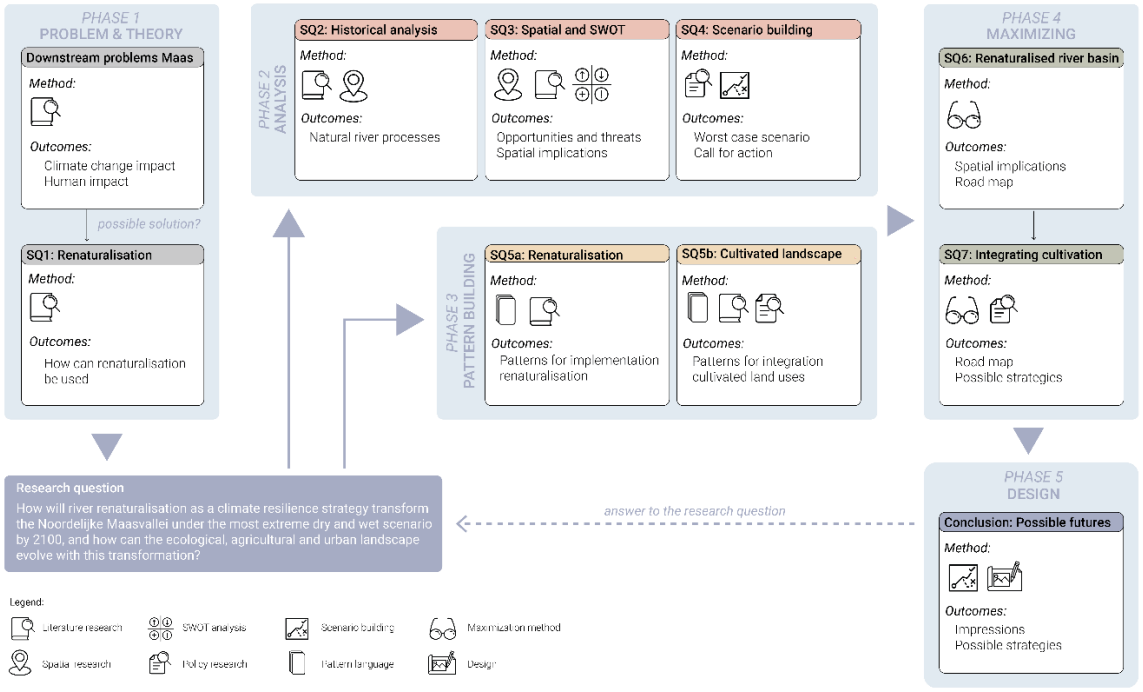
Impression of implementation of interventions (MSc thesis D. Xiang 2023; MSc thesis N. Chang 2023)

Process

Method description

The following shows the methodological framework of this thesis. It is divided into five phases. It starts with problem and theory, leading to the main research question. From there the two phases analysis and pattern building will work parallel to each other. After this, the maximizing phase starts, which leads to the final design phase. The sub-research questions are distributed across the phases, along with their corresponding methods and outcomes.

Methodological framework:



Literature and general practical references

This thesis will use different theories and concepts to answer the research question. Their description and relevance to this thesis will be explained in the following paragraphs.

Renaturalisation

Renaturalisation, or restoration, of rivers refers to the processes of restoring the natural hydrology of a river and limiting the amount of human interference (Baffert & Casey, 2024). In the past rivers have been altered to human needs, in the form of straightening, dredging, implementing dams and weirs causing some rivers to completely lose their natural flow. However, with the impacts of climate change increasing, continuing to rely on engineered solutions would only lead to more extreme interventions. However, before humans interfered with the river's hydrology, it was free to flow where it needed to go in case of extreme events such as floods or periods of drought (Kleinhans et al., 2013). Therefore, renaturalisation of rivers could be an outcome to the expected climate change.

The concept of renaturalisation will be at the core of this thesis, and is used as a guide for shaping a new landscape, in which the river is can flow naturally, and the cultivated land can respond accordingly.

Evolutionary resilience

The term resilience comes from the Latin word *resilire*, which means ''to spring back''. Therefore, resilience is often described as the capacity to bounce back to a stable state after a shock (Davoudi et al., 2013). However, Davoudi et al. (2013) defines a new form of resilience that will form the base of this thesis: evolutionary resilience. Evolutionary resilience rejects the idea that resilience is about returning to a "normal" stable state, but rather focuses on the ability of systems to change, transform, and adapt to disturbances. Evolutionary resilience is about embracing uncertainties rather than resisting it. The system should be able to learn from the change, and change with it.

Evolutionary resilience will form the basis of this thesis. There are many uncertainties for the river basin of the Maas regarding climate change. However, in the past a river was able to change with the landscape instead of returning to a former equilibrium. Currently, large parts of the Maas are engineered, and after disturbances, efforts are made to restore the river to its previous state. However, maintaining this equilibrium requires continuous intervention, which will only grow over time. Therefore, the river should be able to change and transform after disturbances, in which preparedness plays a crucial role. The goal is to create a river system that is resilient and able to transform, adapt, change and learn from coming future challenges.

Adaptive planning

Evolutionary resilience goes hand in hand with adaptive planning. The adaptive planning process is a proactive approach that reduces uncertainty by continually assessing the feasibility and effectiveness of planning decisions (Kato & Ahern, 2008). Adaptive planning is based on the adaptive cycle with four distinct phases: growth, conservation, release and reorganisation (Davoudi, 2021). It shows that if systems grow, their resilience decreases, and they become more susceptible to disturbances. When the release happens, however, the system can transform and innovate creating high resilience again. The moment of the highest uncertainty becomes the greatest window for opportunity in a crisis.

The way of thinking in adaptive planning will be used to plan for a future in which the Maas river basin can change with the uncertainties that are coming. The river is not just an absolute in the landscape, it is a moving force which relates to other forces in space. Knowing this and using this to plan for the future will be important to create a resilient system. This thesis will have a time frame until 2100, and focus on going through one adaptive cycle in which the resilience of the river Maas will be reorganised through renaturalisation. After 2100 the system will change again in which a new cycle might start.

However, the focus of this thesis is to show the possibilities of adapting for evolutionary resilience by using this cycle.

Water and soil led planning

Water and soil led planning ("water en bodem sturend") is a concept developed in Dutch spatial planning and water management. As the name suggests, it means allowing water and soil to guide spatial decisions (College van Rijksadviseurs, 2023). Water and soil systems provide essential resources such as drinking water, agricultural land, nature, and clean air and must remain healthy to adapt to climate change and support human use. Therefore, water and soil led planning starts with the needs and limits of these systems, recognising that without a healthy water and soil system, the pressure on society will keep increasing. Instead of shaping nature to human desires, it looks at what nature already offers, starting with the water and soil system (Wageningen University and Research, n.d.). This takes the system's carrying capacity into account, offering interesting opportunities. The methods used in this thesis will come from a water and soil leading perspective, which relates to the main lens of renaturalisation.

Nature-based solutions

Nature-based solutions (NBS) is a concept that puts the ecosystem at the core of designing solutions. There are different definitions of the concept, but this thesis uses the one from International Union for Conservation of Nature (IUCN):

> ''actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits''
> (Cohen-Shacham et al., 2016).

There will be a focus on the ecosystems first, before integrating the cultivated landscape. However, there is an interaction between the social system and the ecosystem, as implementing NBS could provide ecosystem services to the social layer, therefore also improving the cultivated landscape (Albert et al., 2019). Furthermore, NBS can focus on using an existing ecosystem, restoring one or creating a new one (Cohen-Shacham et al., 2016) This thesis will focus on restoring ecosystems, as the river was once a naturally flowing system that has been altered over the years. The goal of this thesis is to restore the natural ecosystem to create a more climate resilient environment with the use of nature-based solutions.

Ecosystem services

Ecosystem services are services that ecosystems provide to humankind (MA, 2005). This thesis will start by looking at the natural processes of the river and landscape to require resilience against climate change, for both the natural environment and the human landscape. Therefore, this thesis is not about just finding ecosystem services to serve us. It stands from the notion that an ecosystem should be healthy first before being able to provide services to humankind. From this, new ecosystem services can be found through the integration of the cultivated landscape in a renaturalised river basin.

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Reflection

1. **What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?**

My graduation thesis deals with issues of floods and droughts from the river Maas and how this impacts its surrounding landscape in the Noordelijke Maasvallei. It looks at how a more natural form of the river can be integrated with the cultivated landscape (including the built environment, agriculture and other land uses) to strengthen climate resilience. Through spatial planning and design, this thesis aims to develop new spatial perspectives and solutions, as is taught during the MSc programme AUBS. Moreover, the project connects different disciplines, showing new opportunities and motivating actors to look at the future in a different way, which reflects the approach taken in Urbanism. It is a multi-scalar project, focusing on analysing and finding solutions on different scales to get a full picture. Finally, my project aligns with the graduation studio Metropolitan Ecologies of Place, as it emphasises on both ecological restoration (renaturalising rivers) and socio-economic adaptation (new living strategies).

2. **What is the relevance of your graduation work in the larger social, professional and scientific framework**.

Scientific relevance
My thesis aims to create a better understanding of how renaturalisation of rain-fed rivers can enhance climate resilience and how the urban, human-altered environment can adapt to this transformation. Although it is known that projects like room for the river work, as of now areas need to be de-urbanised. Therefore, there is still a knowledge gap on how human-altered land uses can be integrated into a more natural river landscape, while also shaping a more adaptive cultivated landscape. As the climate scenarios are becoming more pressing, scientific research and design is needed to tackle this problem. Therefore, I aim to address this gap through an urbanist, multi-scalar approach and show new possibilities and solutions for climate resilience of rain-fed river basins and the land uses related to this.

Societal relevance
With increasing extreme weather events and high water unpredictability, and long periods of droughts of rain-fed rivers, there is an urgent need for a change in water management along the river Maas. This thesis does not only look at protection from the water, but investigates integration of cultivated functions that can be used by the stakeholders in the area. Moreover, the developed strategies will provide insights for policymakers, urban planners, and communities on how to integrate natural river dynamics into spatial planning. The aim is to contribute to a more resilient living environment for the stakeholders in the research area, and possibly create a guideline for areas with similar problems.