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	Malavika Gopalakrishnan
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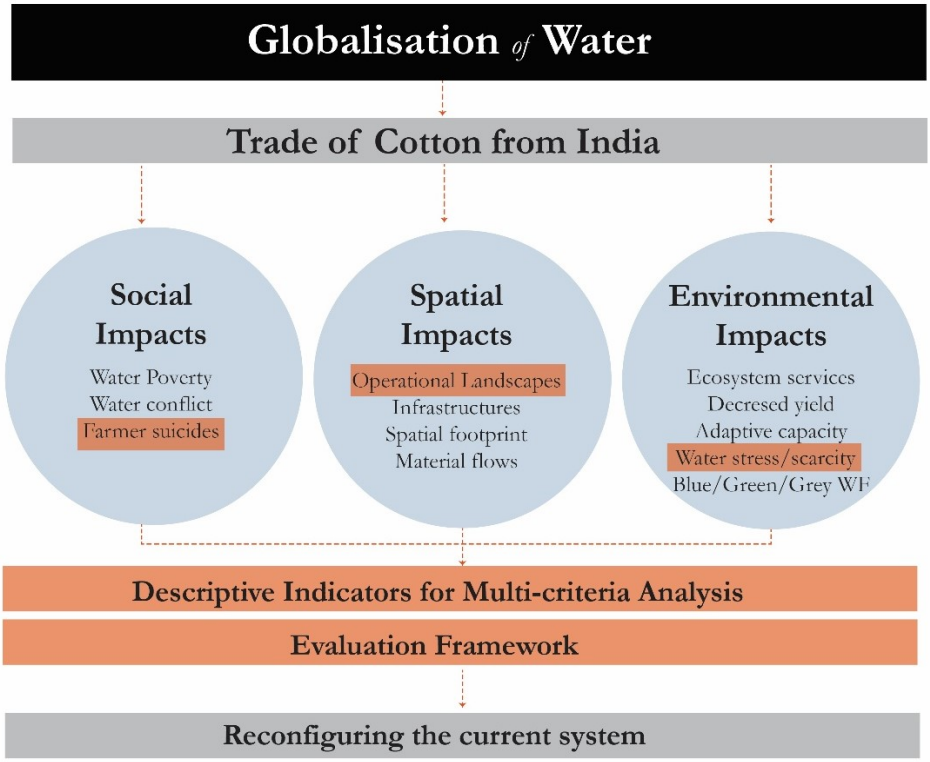
Studio		
Name / Theme	Urban Metabolism	
Main mentor	Alexander Wandl	Urban Metabolism
Second mentor	A Dr. Diego Sepulveda Carmona	Transitional Territories/ Planning Complex cities
Argumentation of choice of the studio	This project is part of the larger studio group 'Urban Metabolism' which is concerned with understanding the metabolism of urban environments and its relationship to landscape systems theory. I have a keen interest in understanding the synergies between social, ecological and infrastructure flows and how they influence the resources and their metabolic processes, especially related to water. This studio is the perfect place for me to research upon my topic as my key interest areas and the approach aligns very much with the research being done under this group. Through my project, I hope to have a clear overview of the globalisation of water through the production of cotton from India and the relationship between ecological, natural and human entities and its effects on a local scale (farming communities in Marathwada, India). This I hope to analyse from a concrete theoretical underpinning of socio-ecological systems theory and telecoupling framework, a complex adaptive system in which human and non-human entities interact. So, it involves looking at the interrelations between humans and nature and natural phenomenon, understanding the current and possible future flows, and looking at the system comprising of everchanging, complex, dynamic processes,	

	but which are interconnected. Under the urban metabolism studio, I am able to pursue my interests in a much more comprehensive manner through different scales and using various analytical methods of modelling and scenario planning, which I am keen to learn more about. Hence, I strongly believe that urban metabolism is the best studio to develop my research project to the best way possible.

Graduation project	
Title of the graduation project	Graduation Thesis project titled, 'Appropriation of Water: Exploring the impacts of global supply chain of Cotton virtual water in Central India (Marathwada)
Goal	
Location:	Multiscalar analysis – Global, India, Marathwada, Maharashtra, India (regional scale), Beed, Aurangabad (Village scale)
The posed problem,	India is facing acute water stress and water scarcity in more than half of the country. It is also one of the largest exporters of virtual water through agricultural products and the largest exporter of scarce water. The globalisation of water and the virtual water trade within and outside of India has significant effects on water scarcity and stress in the country. These lead a multitude of spatial, socioeconomic and environmental issues related to water which are interlinked and related to the supply chain of products and commodities from India such as cotton. However, the spatial impacts of Globalisation of water, more specifically the change in land use related to the consumption elsewhere and how that effects the socio-economic structure is not yet fully researched upon. There is a clear correlation between the large-scale agriculture production for export markets and their resultant impacts on water scarcity and socio-economic crisis in rural regions like that of Marathwada, India. This region has experienced extreme drought and water scarcity leading to a staggering number of farmer suicides. Therefore, the problem lies in understanding the relationship between the negative externalities of cotton production and the subsequent trade of virtual water due to globalisation of water.

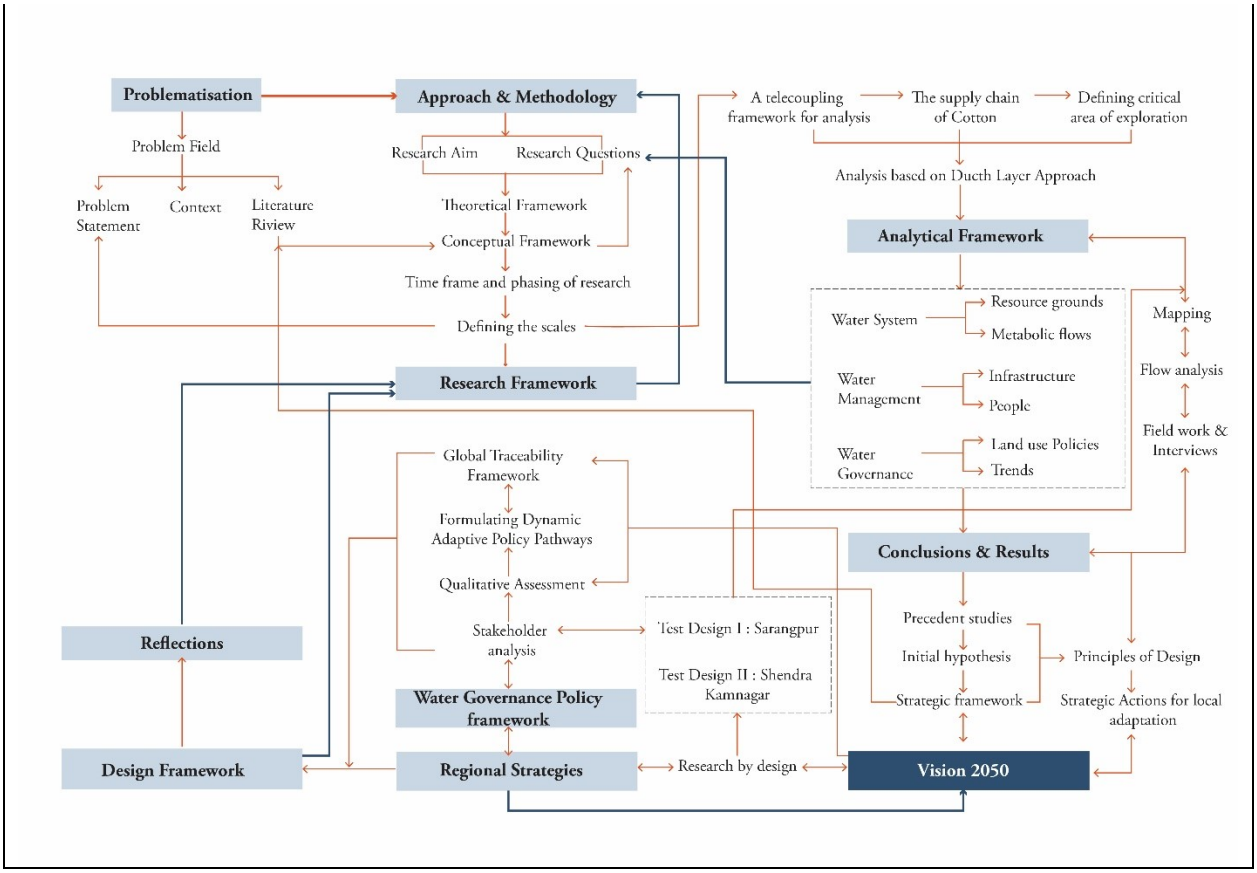
	
research questions and	To what extent can the impacts of Globalisation of water be minimized in order to achieve a more sustainable water footprint in cotton supply chains? (socio-economic, environmental and spatial) Sub questions: 1. What is the link between virtual water trade and water scarcity in India? 2. What are the various spatial, socio-economic and environmental impacts of the virtual water trade in India? 3. Why is the current system of cotton production in India (Marathwada) unsustainable and unjust? 4. How can an improved system be developed in a more just way that there is fewer negative externalities of virtual water trade and create more spatially just system? 5. How can a design of a new system contribute to water resilience and empowering local communities? 6. How can a sustainable supply chain of cotton be developed that integrates multiple scales? 7. How can futures scenarios be envisioned that can guide policy makers to make effective choices?
design assignment in which these result.	Through this graduation project, the consequences of large-scale export oriented agro-industrial landscapes as part of the urbanisation and globalisation and the severe impacts they have on

	the society will be researched upon. The main aim of this research is to clearly understand this relationship and analyse the current networks that form the system of virtual water trade using the trade of cotton from India to the EU as an exemplary project. Further, the issue of water depletion and scarcity is always seen at the local level in India. So, it is important to look at this issue at the scale where it is most visible and this will be done through the extensive field work in the upper Godavari river basin and the cotton producing and manufacturing villages in Marathwada region, in the state of Maharashtra, India. The possible outcomes of the research will be to analyse the spatial, socio-economic and environmental impacts of this virtual water flows and the possible solutions land use planning and social policy framework to re-organise the current system by providing impact pathways to achieve a more sustainable water footprint for cotton production in India. By using the example chain of cotton to provide a clear framework for analysis of such similar chains and to clearly define the elements of system of globalisation of water.

[This should be formulated in such a way that the graduation project can answer these questions.
The definition of the problem has to be significant to a clearly defined area of research and design.]

Process

Method description



Literature and general practical preference

Literature

Arnell, N. W. (1999). Climate change and global water resources. In Global Environmental Change (Vol. 9).

Bohensky, E. L., Reyers, B., & Van Jaarsveld, A. S. (2006). Future ecosystem services in a Southern African river basin: A scenario planning approach to uncertainty. Conservation Biology, 20(4), 1051–1061. https://doi.org/10.1111/j.1523-1739.2006.00475.x

Brenner, N., & Schmid, C. (2015). Towards a new epistemology of the urban? City, 19(2–3), 151–182. https://doi.org/10.1080/13604813.2015.1014712

Darrel Jenerette, G., & Larsen, L. (2006). A global perspective on changing sustainable urban water supplies. Global and Planetary Change, 50(3–4), 202–211. https://doi.org/10.1016/j.gloplacha.2006.01.004

Gómez-Baggethun, E., & Barton, D. N. (2013). Classifying and valuing ecosystem services for urban planning. Ecological Economics, 86, 235–245. https://doi.org/10.1016/j.ecolecon.2012.08.019

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain

world. Global Environmental Change, 23(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Hoekstra, A. Y., & Hung, P. Q. (2005). Globalisation of water resources: International virtual water flows in relation to crop trade. Global Environmental Change, 15(1), 45–56. https://doi.org/10.1016/j.gloenvcha.2004.06.004

Hoekstra, Arjen Y., & Mekonnen, M. M. (2012). The water footprint of humanity. Proceedings of the National Academy of Sciences of the United States of America, 109(9), 3232–3237. https://doi.org/10.1073/pnas.1109936109

Kennedy, C., Pincetl, S., & Bunje, P. (2011). The study of urban metabolism and its applications to urban planning and design. Environmental Pollution, 159(8–9), 1965–1973. https://doi.org/10.1016/j.envpol.2010.10.022

Kwakkel, J. H., Haasnoot, M., & Walker, W. E. (2015). Developing dynamic adaptive policy pathways: a computer-assisted approach for developing adaptive strategies for a deeply uncertain world. Climatic Change, 132(3), 373–386. https://doi.org/10.1007/s10584-014-1210-4

Lenzen, M., Moran, D., Bhaduri, A., Kanemoto, K., Bekchanov, M., Geschke, A., & Foran, B. (2013). International trade of scarce water. Ecological Economics, 94, 78–85. https://doi.org/10.1016/j.ecolecon.2013.06.018

Liu, J., Hull, V., Batistella, M., deFries, R., Dietz, T., Fu, F., … Zhu, C. (2013). Framing sustainability in a telecoupled world. Ecology and Society, 18(2). https://doi.org/10.5751/ES-05873-180226

Paul, J. H. (1995). WK4_SR_MOD001074_Schoemaker_1995.pdf. 36, 25–40.

Postel, S. L., Daily, G. C., & Ehrlich, P. R. (1996). Human appropriation of renewable fresh water. Science, 271(5250), 785–788. https://doi.org/10.1126/science.271.5250.785

Ramaswami, A., Weible, C., Main, D., Heikkila, T., Siddiki, S., Duvall, A., … Bernard, M. (2012). A Social-Ecological-Infrastructural Systems Framework for Interdisciplinary Study of Sustainable City Systems: An Integrative Curriculum Across Seven Major Disciplines. Journal of Industrial Ecology, 16(6), 801–813. https://doi.org/10.1111/j.1530-9290.2012.00566.x

Ridoutt, B. G., & Pfister, S. (2010). Reducing humanity ' s water footprint. 44(16), 6019–6021.

Sohn, J., Vega, G. C., & Birkved, M. (2018). A Methodology Concept for Territorial Metabolism - Life Cycle Assessment: Challenges and Opportunities in Scaling from Urban to Territorial Assessment. Procedia CIRP, 69(May), 89–93. https://doi.org/10.1016/j.procir.2017.10.005

General Practical preference

GIS Analysis using evidence-based research, Fieldwork and case study, Interview

with experts and stakeholders

Reflection

Relationship between project and studio and Urbanism track

The Urbanism track combines urban design, landscape architecture, spatial planning and engineering. It is an integrated approach of social, cultural, economic and political perspectives with the natural and man-made conditions of the site in order to shape and plan for more sustainable development. Urban Metabolism is one of the graduation studios within urbanism which investigates the performance of infrastructures, environmental technology and systems in relation to spatial quality, environmental sustainability, livability and the social wellbeing of future cities.

Through this graduation project, I hope to understand the spatial, socio-economic and environmental impacts of this virtual water flows and the possible solutions to re-organise the current system to achieve a more sustainable water footprint in India. The application of the concept of urban metabolism is essential to look at the problem from a spatial perspective. The urban metabolism study looks at the sum total of all the socio-economic and technical process that happen in a city associated with growth, production of energy and elimination of waste (Kennedy, Pincetl, & Bunje, 2011). The concept of planetary urbanization challenges the idea of city and how the broader landscapes of urbanization extends beyond the realm of what is conventionally called urban. These extended landscapes are part of the urbanization which can no longer be differentiated as 'rural' and 'urban' and how this impacts the city and vice versa. To understand the Globalisation of water and the spatial impacts related to it, it is important to look at it from a more territorial scale. Here, territory is not the conventional geo-political boundaries but rather the 'production territory' or the extent to which the supply chains of products cross over (Sohn, Vega, & Birkved, 2018).

Therefore, this graduation project builds upon the theories of urban planning and urban metabolism as an extension of spatial planning concepts which are the underlaying themes of the urbanism track.

Scientific Relevance

It can be understood that there is a clear correlation between virtual water trade and water scarcity. This leads to various spatial, socio-economic and environmental impacts. However, the extent of Globalisation of water and the interdependencies between these impacts is not fully researched upon. There is a need to study about how the production of water intensive crops from a water scarce region of India, such as cotton, has impacts on the global water efficiency and resulting in the local water depletion. It is important to understand the link between water scarcity of

these regions in association to virtual water trade and as a result leading to spatial impacts, such as infrastructure, the operational landscapes, the land use policies and planning. How has these landscapes impacted in the continued ground water depletion and as a result a reduced crop yield and pollution of major fresh water sources? The links between these in the increased number of farmer suicides and how can they be tackled? This requires looking at the problem and the rippled effects of globalised water on achieving spatial justice locally. To formulate a framework for understanding the metabolic processes related to virtual water flows, the theories related to the concept of urban metabolism and their evolution need to be assessed. Further it is essential to look for a framework to be able to analyse these metabolic processes to understand the problematisation and give it a spatial dimension. Therefore, the sceintific relevance of the thesis is addressed in three ways, (a)by understanding the problem, (b)the theories to frame the problem precisely and (c)a possible approach to analyse the problem.

Societal Relevance

Several countries have externalised their water footprints significantly by importing water intensive products. This brings the need to look at the issue of water scarcity in a more global context due to the external water dependencies of several countries often from water scarce regions due to an increased global virtual water trade. There are various social impacts associated with the Globalisation of water and extracting water from water scarce countries. For example, the extreme effects of such a phenomenon is the depletion of Aral Sea in Uzbekistan. The Aral Sea is a devastating example of a complete ecosystem collapse. As the sea dried up over the years due to continued drenching of water from the sea to irrigate the countries cotton production and export. This also led to socio-economic issues as the collapse of the fishing as well as extreme pollution leading to cancerous diseases among the population from the toxic dust from pesticides such as DDT used in cotton production (Article in national geographic online magazine, 2015).

In India, too such extreme socio-economic impacts can be seen related to to local water resource depletion. In the region of Vidarbha in central India, the latest statistics show over 7,700 farmers committed suicides in the last years, with a staggering average of over 6 farmers committing suicides per day. These suicides are attributed to debts caused by poor yield as a result of unavailability of enough rain, extreme drought, ground water depletion and water stress. Vidarbha is one of the biggest producers of cotton in India with almost 50% of the state of Maharashtra's cotton being produced here (Cotton Association of India, 2017).

Ethical Consideration

There are several ethical considerations to be considered while looking at the problem. The main ethical consideration is to understand the intricacies of culture and people in providing voice towards analysis and planning. For years, cotton farming has been the livelihood of several small holder farmers in India. To radically analyses or reduce the

production would mean a significant change in the lifestyle and sources of income for these farmers. This brings a serious ethical dilemma if such a measure is to be taken, will the society be able to cope with it. But at the same time, without doing any changes would only mean that the lives of the farmers will continue to suffer and will soon reach a point of no return.

Subsequently, while considering the ecosystem services as main drivers for the project, there is a possibility that economic stability is affected and hence could have impact on the society. There is also dilemma regarding the ways in which environmental factors play a role, such as the rich biodiversity and the subsequent use of that as a means to address human needs. The non-consideration of flora and fauna while analysing the impacts and effects. The proposal of various infrastructure projects also has serious environmental as well as human rights consideration, as often these projects are in places of informal settlements and require rehabilitation efforts, which always brings the question of who does the land ultimately belong to? Who has the right and who decides?