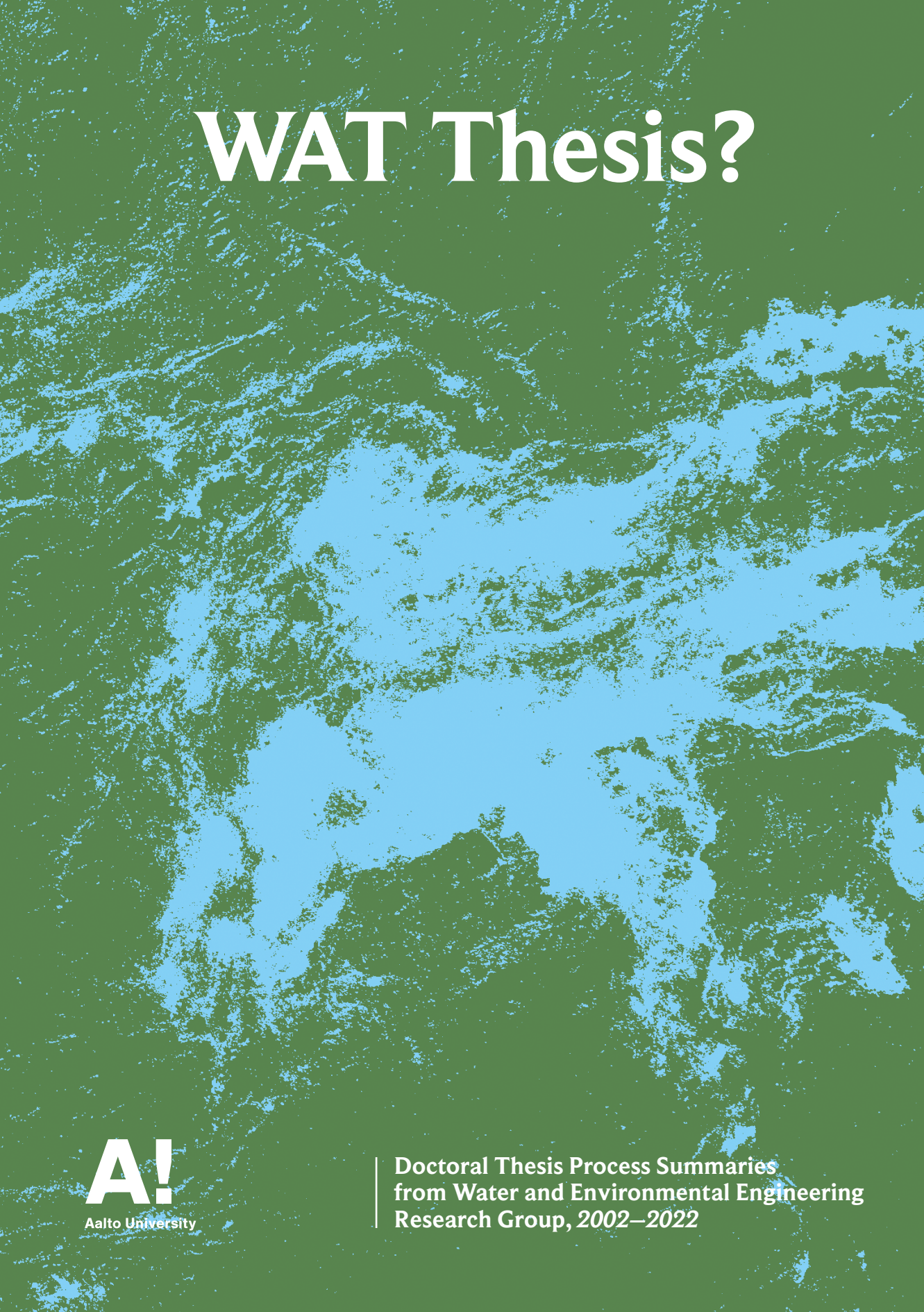
WAT Thesis?



Aalto University

Doctoral Thesis Process Summaries from Water and Environmental Engineering Research Group, *2002–2022*

WAT Thesis?

Aalto University

Doctoral Thesis Process Summaries
from Water and Environmental Engineering
Research Group, *2002–2022*

Marko Keskinen, Maija Taka & Heidi Salo (2023). WAT Thesis? Doctoral Thesis Process Summaries from Water and Environmental Engineering Research Group, 2002–2022. Aalto University, Finland

Layout: Tuuli Ollikainen

Aalto University publication series
SCIENCE + TECHNOLOGY 1/2023

ISBN 978-952-64-1103-3
ISBN 978-952-64-1104-0 (pdf)
ISSN 1799-4896
ISSN 1799-490X (electronic)

Contents

Foreword

Olli Varis

"Like herding cats." This was a comment from my professor colleague, as we once chatted on supervision of doctoral candidates. Officially, doctoral studies are about learning the scientific method, to produce relevant new knowledge with it, and demonstrate related capabilities in communication and ethics. Those all are burningly and growingly important in today's extremely open, information intensive working life. While learning the scientific method is quite demanding as such, a doctoral candidate needs to go through the process of learning also many other capabilities that often are even more demanding and fuzzy for talents at that stage. Learning to plan own work, set goals, and to commit on them. Take account on funding, often raising funds, and organizing work accordingly. Learning to cope with freedom and especially with the flip side of it, namely responsibility – matching those two is not trivial at that stage. Learning to keep the own package in shape and focus intact, while learning to respect others and work equitably with peers. Sharing work, plans, ups, downs, a major growth process altogether, with fellow students and supervising colleagues. Respect the capabilities and limits of all those individuals.

Each story that we have in this volume is different. This is obvious, of course. Nevertheless, one of the big, ever-astounding features when working decades with doctoral candidates is that every student is so profoundly different from anybody encountered before. This is one of the lures and excitements of this work, while it often takes plenty of effort. It also underscores the importance of enabling the student to find the own way for working and doing research, and at the same time trying to keep the student's focus and ambition level appropriate for the degree under study. Occasionally we see students that try to bargain the bar lower, but way more common is the opposite; the bar is raised higher and higher, and almost nothing seems to be enough for reaching the stage at which the work is ready for putting into covers — nobody being then competent enough to provide the needed support for that.

Why engineering students want to learn research skills? Why a large share of professors' effort is being allocated to the supervision of doctoral candidates? Why a soaring number of young scholars use some of their best professional years for completing a doctoral degree? Reasons are many and they vary. The demand-side baseline, though, is clear: societies are increasingly knowledge intensive, with a continuing acceleration. Doctoral studies are apt for that as they target on enhanced learning skills, mastering complex entities with analytic, scientific tools, and communicating and arguing rigorously and ethically. All these skills are genuinely demanding. In fact, doctoral degree has already become the basic requirement for many mid- and upper-level leadership positions in international organizations and is rapidly becoming such in many businesses, too. Without a doctoral degree, the possibilities to lead own professional endeavors is far less easy.

Cats are just great, most of the time.

Introduction:
the varied ways of getting there

This book both celebrates and makes visible the diverse processes that lead to a Doctoral Thesis.

We did this by inviting the authors to write so-called “Process Summaries” i.e. short descriptions of the process that ultimately led to their Doctoral Thesis. While writing those summaries, we advised the authors to reflect the most rewarding and challenging parts of the process and to consider what kind of twists and turns the journey entailed. We also asked the authors to think what kind of advice they would like to give now to themselves when they were just starting their thesis work.

The result is this collection of Process Summaries and related official Thesis Abstracts. Together, the summaries indicate that completing a Doctoral Thesis is not just one process, but several processes brought together — often along a long and winding road with unforeseen uphills and downhills. Despite this, the Thesis itself describes mainly its scientific contribution, and the related learning and collaborative processes are usually referred to only in a concise and declaratory manner. While this is understandable, it also partly misses the point: as the Process Summaries remind us, the Doctoral Thesis is very much about the diverse ways of “getting there”.

By making visible these diverse journeys we feel that this book makes three important contributions. First, the Process Summaries remind us about the importance of collaboration, collegial support, and peer learning — a recurring theme throughout this book. Second, the summaries show very clearly that there is no one “correct” way of carrying out doctoral research, but each path is unique. Thirdly, we hope that the stories documented in this book provide insights and even inspiration for those currently planning or being on the journey of getting there. In that journey, the authors’ encourage us to be active, curious, and brave, to explore and enjoy and, ultimately, to trust in the process and trust in yourself.

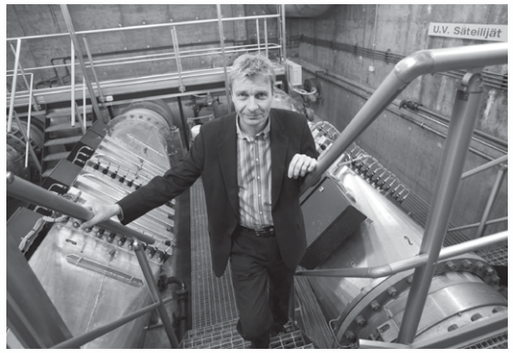
This book includes a selection of Doctoral Theses that have been completed in the field of water and environmental engineering at Aalto University and its predecessor Helsinki University of Technology from year 2002 until 2022. This, way, the book also celebrates the 20th Anniversary of our Water Building, located at Tietotie 1E in Otaniemi.

Thank you to all the contributors!

Marko, Maija and Heidi

Riku Vahala

Two step granular activated carbon filtration in drinking water treatment *(2002)*



Finnish economy was in a long economic depression. I had been working for some years in Pentti Murole's company, LT Consultants, and finally received my Master´s degree in 1994. I was totally fed up with being a dog slave and working literally around-the-clock in chaotic Libyan infrastructure projects. I started looking for a new job. At that time, my professor Risto Laukkanen asked me to come back to TKK for LicSc (Tech) degree project. The topic was related to my MSc thesis and to an upcoming major investment in Helsinki Water's drinking water treatment process. Although, I was not convinced that this investment in two-step activated carbon filtration was an ideal decision, I had no other option than to accept the offer.

After two years of hard working, I gave my licentiate thesis to my supervisor to get feedback. His comment was: "A nice report. When will you submit your thesis?". As a result, I made a right decision to skip LicSc and continue my research a couple of years more. Finally, I published five journal articles and four conference papers almost during the same year 1998 — more than the total number of all other publications from water laboratory. Luckily, my temporary supervisor professor Jukka Rintala (Risto went back to consultancy for some time) was of great help and gave a lot of detailed mostly linguistic comments on my manuscripts. A fun part of the work was to travel to various scientific conferences and get many of these papers published in journals.

Practically, I did all my experimental work and publications during the time I spent in TKK (1995–1998). The synthesis remained unwritten and finally in summer 2001, I took off from my work at Finnish Water Works Association to write the summary — one page per day. Next summer, I did all the corrections that the pre-examiners required. I spent both summers at Helsinki Water's Pitkäkoski water treatment plant, where I had my own office room.

According to what I had discussed with my supervising professor, I had an impression that my numerous conference presentations would be enough to compensate the remaining study credits needed. However, Department Council decided that I need to study additional 10 weeks (15 ECTS) of minor in the field, where I have already competence from my MSc studies. Thus, I lost my motivation again and it was not before in 2006, when I took off from the work again. With the help of cognitive psychotherapy, I was able to write the required essays to Helsinki University's Institute of Development Studies and finally received my DSc degree in 2006.

For the first two years in TKK my grant came directly from the MVTT. Practically, the compensation was so small for a man with two children and wife at home, that I had to work in parallel as a part-time lecturer at Helsinki Polytechnic. As a results, I did not have much time to spend with my family during those four years and my wife had to take all the responsibility on raising our kids. I did not repeat this mistake with my third child — thanks to Covid-19, I have had a plenty of good time with him.

Your advice now to yourself then?

Be active in finding a competent and motivated scientific instructor for your work.

Abstract

In the treatment of Finnish surface waters, the main objective is to reduce natural organic matter (NOM) before the water is disinfected. In many treatment plants, granular activated carbon (GAC) filtration is applied for the enhanced removal of NOM after conventional treatment. The aim of this study was to assess the performance of two-step GAC filtration in NOM removal and to determine its effects on the water quality in the distribution system. Furthermore, the optimal operation conditions of the existing process scheme at Helsinki Water's treatment plant after installing two-step GAC filtration and UV disinfection was evaluated.

The study revealed that the major factors influencing the effective NOM removal in GAC filtration are the choice of GAC type and the frequency of regeneration. Other factors, such as empty bed contact time and biological degradation rate, were of minor importance. However, even the fully exhausted "old" GAC effectively decreased the assimilable organic carbon (AOC) and the regrowth of heterotrophic bacteria in the distribution system. The most interesting finding of the study was that introducing GAC filtration and UV disinfection increased the nitrification in the chloraminated distribution system.

Introducing GAC filtration is a challenge for the more efficient use of the existing treatment process. Although optimal ozonation probably provided the highest biological activity in the following exhausted GAC filters, alone it does not justify the use of ozone. After installing GAC filtration and UV disinfection, the role of ozone is rather to provide an additional barrier against unexpected changes in the source water quality.

Harri Koivusalo

Process-oriented investigation of snow accumulation, snowmelt and runoff generation in forested sites in Finland *(2002)*

The time dedicated to doctoral dissertation was a special period offering many ways to learn and create networks in the research field. I started the doctoral study work from scratch after completing the licentiate thesis, when Pertti Vakkilainen hired me in a project at Lab of Water Resources and provided an opportunity to focus on a new field site in Siuntio. Making lots of ground snow and micrometeorological measurements was time consuming, but fun along with diverse discussions and shared time during field works with Matti Keto. Then I met Martti Heikinheimo from FMI at EGU meeting in Vienna and he ended up giving me a very interesting snow dataset with turbulent flux observations from Sodankylä. Visiting the northern site and having an unofficial permission to climb in a weather mast glued our joint efforts. Collaboration with FMI gave me valuable experience about cold region land-surface processes and provided a natural-science view on snow hydrology.

Another direction of collaboration was SYKE, where Ahti Lepistö joined the efforts of hydrological modelling in Siuntio. A cornerstone in the model development was the Pascal programming supported by my advisor and ingenious code-writer Tuomo Karvonen. The most important connection was created at the home lab, where I started to work closely with Teemu Kokkonen. He became to be a prime colleague to reflect ideas and together publish the Siuntio data and model results.

My supervisor Pertti and Tuomo both supported our collaboration, which proved to be fruitful for our thesis works. In fact, I have been working with Teemu for years sharing research and education challenges. In this way, the shadow of a doctoral thesis can reach far. The biggest surprise for me was in the end of the process. I was expecting the thesis book to be piled at the bottom cellars, but then a team of researchers from METLA visited us and told about their plans to develop a forest hydrological model FEMMA. My thesis work was a perfect match to their project, and sometime later I joined the project.

The post-doctoral celebration, karonkka, was held in the basement of Vanha Poli. It was the first time when I played French horn duets with Pertti, and the play with speeches was afterwards repeated in many post-doctoral parties, Teemu's karonkka having the next show.

Your advice now to yourself then?

Be yourself.

Abstract

This thesis summarises development and application of a hydrological model for simulating forest canopy processes, snow accumulation and melt, soil and ground water interactions, and streamflow routing. A motivation behind the model development is to outline a methodology for predicting the influence of land use changes on catchment hydrological processes. In addition, the development aims at providing linkages from the hydrological model to atmospheric models through implementation of surface energy balance and to water quality models through quantification of runoff components.

The work started with comparison of two existing snow energy balance models using meteorological and snow data from Northern Finland. Based on the comparison the more simple of the tested snow parameterisations was modified to improve its performance in terms of snow heat balance simulation. The modified snow model was then coupled with a canopy scheme to account for the influence of forest on snow processes. The combined model was applied to clear-cut and coniferous forest sites in Southern Finland to identify the differences in snow mass and energy fluxes between open and forest. Finally, runoff generation in a forested catchment (Rudbäck, 0.18 km^2) was studied by using two different parameterisations. First, the catchment was parameterised as a three-dimensional domain, and secondly, as a vertical two-dimensional hillslope.

The models produced similar results in terms of fit against measured daily streamflow, but the computed runoff components were different. Independent calibration of hydrological submodels yielded a more realistic partition of runoff into surface and subsurface components than did calibration merely against streamflow data. It is proposed that the hillslope model can be used to simulate runoff generation in each possibly non-contiguous area that is similar in terms of its land-use. A system where a set of such models is combined together can be used to quantify runoff contributions from pre-classified areas of different land-use, and constitutes a tool for studying hydrological impacts of land use changes.

Teemu Kokkonen

Rainfall-runoff modelling - comparison of modelling strategies with a focus on ungauged predictions and model integration *(2003)*

I glided into doctoral studies; I do not recall having made a conscious decision to start to work on a doctoral dissertation. During my MSc thesis work I got intrigued by mathematical modelling of environmental processes, and as I simultaneously had a strong feeling that I had not learned 'enough' in my MSc studies, I gladly took the opportunity to work in a project addressing the quality of groundwater in the Pakri peninsula, Estonia. After wrapping the results from this project in a form of a licentiate's thesis, the road was paved for continuing to doctoral studies.

I wanted to travel abroad for my doctoral studies. So why not go all the way pretty much as far away as you can. At that time, in 1998, our senior researchers in the field of water resources management had already established a connection to scientists at the Australian National University (ANU). Benefitting from this connection I managed to arrange myself a dissertation topic and an instructor from ANU, and after receiving a scholarship from the Finnish Cultural Foundation I booked a Garuda Indonesia flight to Sydney over Dubai and Bali.

In Australia I learned a lot. In addition to extending my knowledge about hydrological modelling I learned that:

- you should never wear socks with sandals
- hearing rattle in the middle of the night probably comes from opossums running on a tin roof
- fans of AFL clubs Carlton and Collingwood hate each other
- unless you take caution, you might end up sharing a morning shower with a redback spider
- Canberra is known to be a nice place as it is so convenient to get out of there
- if you had a banana in a rucksack, even if you had dumped it before the customs, you might find a beagle sitting in front of you and your baggage being inspected by airport quarantine officers
- sulphur-crested cockatoos look nice but sound terrible

After having returned to Finland there still was a long way before I eventually graduated with my doctoral degree. Apart from hard work, this time period also included some memorable celebrations. Two of those stand out and I still have vivid recollections of 1) my doctoral party, and 2) responding to reviewer comments together with Harri on the Finnish Independence Day with two candles at the office windowsill.

Your advice now to yourself then?

While being pedantic, know when is the time to move on.

Abstract

This work is an integrative study of methods for rainfall-runoff simulation. The thesis addresses process description considerations, problems associated with ungauged predictions, and tools for sharing data and computational procedures over the Internet.

Simple runoff model structures can be preferred as they facilitate systematic uncertainty assessments and can fit streamflow data as well as more complex structures. A more complex model structure can be invoked when assessing hydrological problems involving water quality considerations, which often necessitates explicit representation of runoff generation mechanisms and different flow pathways. Models that have more ambitious objectives than merely to reproduce streamflow should also be validated against other measured data than just flow records. It is demonstrated that two different model parameterisations can yield both good quality fits to observed streamflow data, but generate drastically different evapotranspiration time series. This thesis also presents a case study where a physics-based hydrological model is calibrated and validated using groundwater levels and isotope tracer results.

Runoff predictions for a catchment lacking streamflow records can be based on establishing relationships between physical catchment attributes and runoff model parameters using flow data from other catchments belonging to the same region. Results of this thesis suggest that consideration of correlation among runoff model parameters can improve performance of such a regionalisation exercise. Ideally, one would wish to exploit available information on catchment properties in a more physics-based way where observed values of physical catchment properties are incorporated into the model structure and parameters directly. Although physics-based models still face problems which are not readily solvable, results of this study show some promise in predicting streamflow in a physically more consistent way with a minimum amount of parameter calibration.

The final part of this thesis explores tools for distribution of environmental data sets and simulation models over the Internet. The idea is to promote openness in environmental simulation studies by providing means for data and model integration from resources published by different parties.

Juha Järvelä

Flow resistance in environmental channels: Focus on vegetation *(2004)*

I was thrown in the deep end. I did not have prior knowledge about the topic, nor did my supervisor. Working independently and learning by doing describes the process of completing my thesis. The "memoirs" presented here are based on detailed notes I made regularly from the beginning to the end (2000–2004). I found reading the notes somewhat disturbing after ~20 years, as I realized that my way of working was merely a collection of unprofessional practices rather than being any good example for others. If you were asked to take "my way or highway", I would advise the latter.

This story began in winter 2000, when I started at TKK as a lecturing researcher. Things were unorganized right from the beginning — or positively seen: I had all the freedom one could ask for. Fortunately, at that time I did not know about any other ways of doing doctoral studies. The coming years brought up everything between frustration, lost motivation, and success. First weeks were busy with preparing an EU project proposal that later failed. The first meeting on the thesis planning was after several weeks and the second ½ year later.

Any type of formal research plan was never written. It was simply agreed that I will focus on experimental work in a flume (that rusty infrastructure from 1970 does not exist anymore). Lab experimentation was to be complemented by field investigations together with another doctoral student. Eventually the project grew too big and overambitious. The field investigations could have been completely cut out. Teaching took a lot of time besides completing a one-year pedagogical training program. I was responsible teacher for two advanced courses, taking care of everything between course planning, lecturing, preparing assignments and evaluating exams. Major problem in the fast-moving train was that I did not have enough time despite working long days and skipping some holidays.

I had no idea that experiments with living vegetation are very challenging, even if one would have years of experience. I did not have any. Mistakes were made. Discouraging accidents happened many times: water circulation pumps and valves broke down, plants dried, vegetation boxes went mouldy, ADV instrument was damaged etc. The notes show that after the first year I raised serious self-criticism, including a question about what, if anything, I can contribute worthy of publishing in a journal. One month later I was visiting University of Karlsruhe and soon presenting at a EGU conference. International networking helped a lot and resulted in research stays abroad. I was traveling alone but luckily managed to establish connections that exist even today.

Things started to roll, and I submitted the first paper after 1½ years of work to Journal of Hydrology. One revision and a lot of patience was needed: final acceptance came 2½ years after I had started my studies. Surprisingly, after 20 years this first paper still is my most cited scientific output, even though in the beginning I had no experience on how to publish a paper in an international journal. As I did not have co-authors, my guide was Robert Day's classic book "How to write & publish a scientific paper" besides some helpful discussions. The following three papers were single authored as well, while the last two papers about the field investigations were co-authored.

Important scientific advances were gained because there was no one to advise (or limit) me how to conduct the experiments. This risky setting led to some novel ideas — or thinking outside the box, as I later realised. If I had been working in some well-established group abroad, someone would have stopped the experimental stupidity, but the novelty now gained would not have been materialized.Later on, the most challenging phase was the development of a new generalized computational procedure based on the experimental data and observations of the flow phenomena. I was racking my brain for months trying to develop a mathematical formulation of the complex interconnected processes suited for implementation in different hydraulic models. The outcome I now consider as the most important contribution of my whole professional career.

Writing the synthesis was a very intensive process. In the darkness of January, I packed two laptops, piles of articles and books, a bright light panel, and loads of frozen pizzas, and drove off to our summer cabin. There was no internet, but all the time and quietness required for focused writing. Upon arrival I had an empty template but returned after eight days with the synthesis almost ready. It was crazy writing from morning to past midnight besides taking care of firewood for heating (it was -20˚C outside). The conclusion section I wrote in one day when back in the city, and couple of weeks later the thesis was ready for final polishing.

Positive remarks in my notes are few and far apart. Eventually everything worked out nicely so that the doctoral defence was in slightly less than 4½ years from the start. A key paper for the thesis had to be replaced by a preceding peer-reviewed conference paper, as the review process was tiresome again (submitted manuscripts were not allowed). The final paper was accepted in Journal of Hydrology ½ year after my defence and still is the second most cited in my career. During the process I was insecure about the quality of the thesis but afterwards was glad to receive the Vilamo Foundation doctoral dissertation award and the Alexander von Humboldt fellowship for post-doc in Germany.

To avoid any misinterpretation of the above, I am indebted to my supervisor for his support and trust with my research and my tutor for his invaluable help and advice. No hard feelings really — it is simply that the system was different in those days.

Your advice now to yourself then?

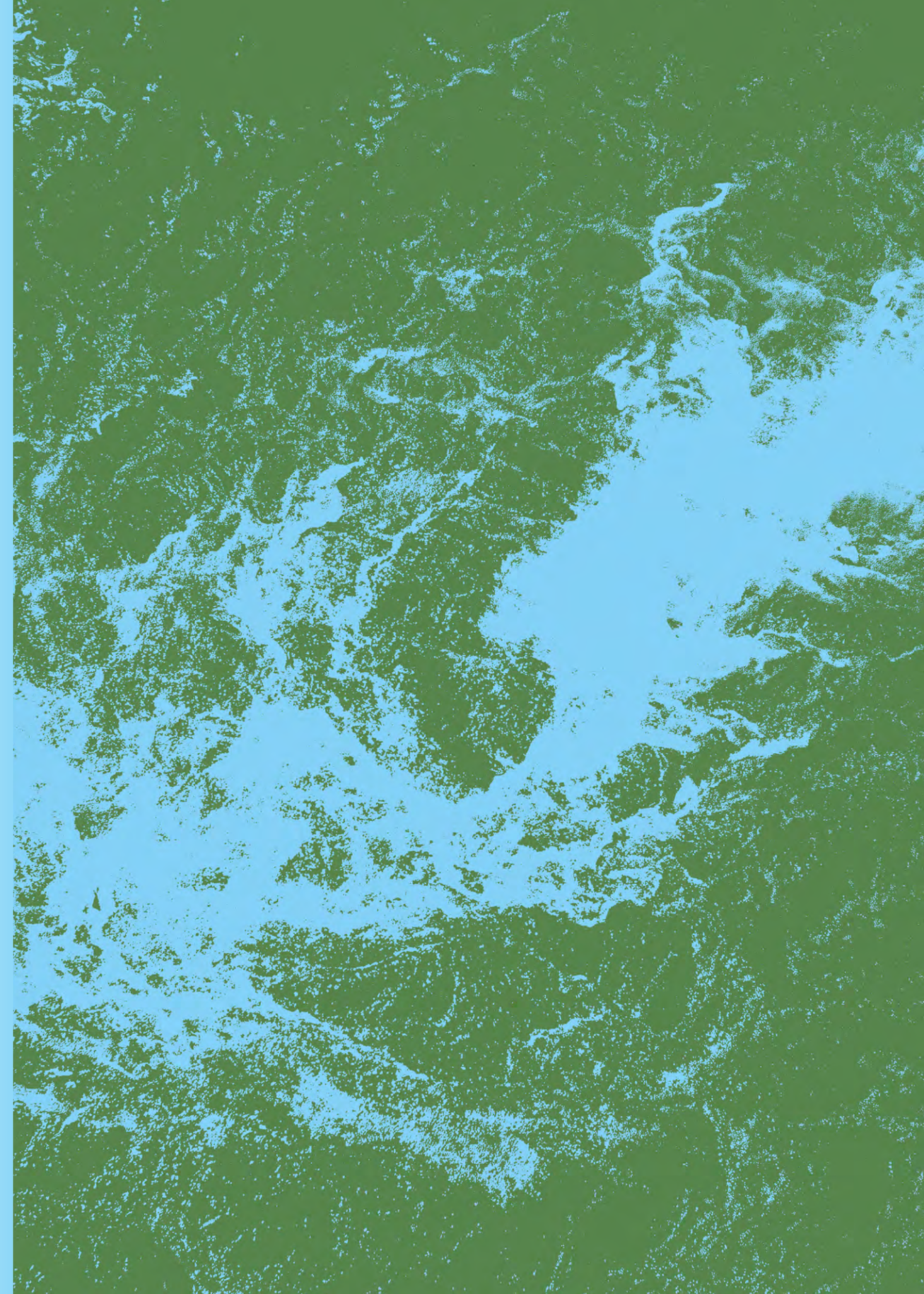
Later it was easy to see that I should have read much more before jumping in the experimentation. Do your homework: read and digest your reading.

Abstract

This thesis aims to improve the reliability of the determination of flow resistance in environmentally acceptable channels and floodplains. Special emphasis was placed on addressing the hydraulic effects of vegetation. For this reason, laboratory flume studies with living vegetation were employed. The most notable finding was that, when compared to leafless conditions, the presence of leaves increased the friction factor up to seven-fold. This was strongly dependent on the flow velocity. In addition, the linkage between flow resistance, channel properties, and physical habitat was investigated. For this purpose, field studies were conducted in degraded, restored, and natural channel reaches.

To determine friction factor f or Manning's n for non-submerged woody vegetation, a new procedure based on the measurable characteristics of vegetation and flow was developed. A major advantage of this procedure over the old methods was its ability to estimate the flow resistance of woody vegetation in both leafless and leafy conditions. In determining the velocity profile and flow resistance caused by submerged flexible vegetation, the approach developed by Stephan (2002) was found to be suitable. However, a new formulation was proposed for the shear velocity based on deflected plant height. This modification offered better practical applicability than the original formulation, which requires complicated turbulence measurements.

In the field studies, the experimental results for friction factors were, excluding those for low flows, in agreement with the values presented in the literature. Overall, the gathered field data from degraded, restored, and natural channel reaches formed a reference data set, which could be useful in other similar restoration or engineering projects. The field studies showed that both flow resistance and cross-sectional geometry were vital factors in determining local hydraulic conditions. The parameters defining these two factors were found to be simple but nonetheless valuable in evaluating the success of a project which aims to restore local hydraulics. A new procedure for applying the success criteria in the post-project evaluation of local hydraulics was developed.



Terhi Renko (née Helmiö)

Effects of cross-sectional geometry, vegetation and ice on flow resistance and conveyance of natural rivers *(2004)*

At my study time, there was not any graduate school, and the work was quite independent and lonely work. At first, I did not know where to start, and teaching took quite a lot of preparation time. But when I finally got the drive on, I got quite many articles finished, and the progress was good. Towards the end of writing, I really got motivated to finish it.

Best moments of the process were planning trips to conferences and field site visits and then seeing places and people abroad. Furthermore, good feedback from journal evaluators made me feel that I am doing the right thing, especially in Journal of Hydrology and Journal of Environmental Modelling and Software. Most challenging times were being unsecure about getting the financing for the whole time.

Biggest change during the process was that the original plan for which we got the financing from Academy of Finland was not possible to do and we had to adapt during the project.

In terms of key interactions during my Thesis process, the cooperation with Juha Järvelä was highly valuable. We had our good and bad moments as co-workers, as although we agreed on many things, we also did not see many things the same way. However, I think the cooperation taught us both a lot. Tuomo Karvonen inspired with his high skills and supportive feedback.

The most important skill learned during the process was that to finish something you can only rely on yourself: others may help or may not. Another was that I learnt that I am able to finish what I start, whether I want it or not.

Your advice now to yourself then?

Think about if this is really what you want. If it is, then find people who want to support you in it.

Abstract

The accurate estimation of local hydraulics, i.e. local flow velocities and water depths, is necessary for the restoration and protection of biodiversity. The aim of the thesis was to develop methods and models for designing and evaluating the hydraulic aspects of restoration, rehabilitation and environmental flood management in running waters.

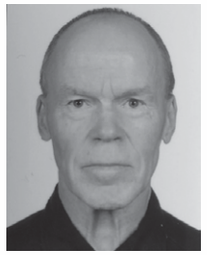
Methods for the estimation of flow resistance in natural complex rivers and channels that have composite flow resistance and/or a compound channel shape were tested, and an unsteady 1D flow model for partially vegetated channels with complex geometry was developed. These methods were used to quantify different factors causing flow resistance, e.g. cross-sectional geometry, vegetation, ice cover and momentum transfer, in lowland rivers of different shapes and sizes. The relationship between the flow resistance and the cross-sectional geometry was analysed.

Traditional methods used to estimate composite friction factors were found to be accurate in simple concave channels with simple hydraulic properties, but an adjustment of the methods would be necessary for reaches with significant head losses due to lateral momentum transfer. It was seen that the effect of the momentum exchange process between the main channel and the floodplain or streambank vegetation was significant. A procedure for applying the success criteria in a post-project evaluation of local hydraulics was developed, based on the hypothesis of flow resistance and cross-sectional geometry determining local hydraulic conditions in boreal streams.

Based on the results from the proposed flow model, the restoration of flood retention areas and local hydraulics is a vital component of the restoration of catchment-scale hydrology, but not sufficient by itself to restore flood peaks to their earlier state, because the changes in land use have often been drastic.

Mikko Jauhiainen

Relationships of particle size distribution curve, soil water retention curve and unsaturated hydraulic conductivity and their implications on water balance of forested and agricultural hillslopes *(2004)*



The first things that comes to my mind now regarding my doctoral research are laboratory devices for measuring soil water contents. They were used in order to get knowledge of soil physical properties in Finnish forest soils. The second things I can see the ceramic cups installed in Siuntio hillslope spruce forest. They gave basic knowledge of soil moisture in podzol during the growth period.

Starting the work and finishing the work were the moment that felt most. Measuring works in the laboratory and the forest was hard work without too much thinking. Some good lessons of numerical methods for engineers and mathematical exercises gave me insight into applying mathematics. Pre-examining stage was too long.

The biggest change during the process too place in Sjökulla scientific meeting. I met the supervisor Tuomo Karvonen and started learning mathematical modelling techniques. Shift from the University of Helsinki to Otaniemi was followed by the meeting.

In terms of help and cooperation, Tuomo helped first with the money, then with the methods and writing. Basic measurements in the laboratory and hillslope were good bases of the work. Colleagues gave good conversations, excellent company and even friendship.

It was not difficult job to keep the target in front of me. The motivation to get the work done some day in the future did not fluctuate disturbing the work. Surely many things could have been done better, more rapidly or in a different way.

The most important skill that I learned during the process was that colleagues form a family with its joys and sorrows.

Nowadays, I experience visual differences of Finnish forest types and can imagine many soil hydrological secrets when picking berries or mushrooms.

Your advice now to yourself then?

Be curious, energetic and courageous. Try to become acquainted with divergent views. The path in front of you will not be even and hopefully not even dull.

Abstract

The primary objectives of this study were to determine selected soil water retention curves for Finnish forest sites and to develop a methodology that predicts the water retention curve and unsaturated hydraulic conductivity from the particle size distribution curve. The method was obtained by modifying Andersson's method. Selected soil water retention curves were determined for four Finnish forest site types. Parameters of 360 soil samples were estimated. The samples were collected from 90 forest soil profiles. In each profile four podzol horizons were selected for sampling. The parameters are usable for water balance calculations of various scales.

The study includes results of numerous water retention characteristics and hydraulic conductivity predictions from the particle size distribution curve. These predictions were accomplished for both forested and agricultural soils. Predicting water retention characteristics from particle size distribution curve could be accomplished at a reasonable level of accuracy when the semi-physical and van Genuchten's methods were used. Predicting the water retention characteristics using Jonasson's method was successful when clay content of soil was less than 25 percent. Implications of soil hydraulic properties on water balance of forested and agricultural hillslopes showed reasonable agreement with the measured values. The best overall fit between measured and calculated values was obtained in the case that water retention curve was estimated from particle size distribution curve and unsaturated hydraulic conductivity using Andersson's method.

Katri Rankinen

Analysis of inorganic nitrogen leaching in a boreal river basin in northern Finland *(2006)*

One day I noticed that the work I was doing would have the opportunity for a new scientific knowledge. In the project I got enough background support, and I also received funding from the Academy of Finland to write a doctoral dissertation.

The result was a dissertation entitled 'Analysis of inorganic nitrogen leaching in a boreal river basin in northern Finland' in the Laboratory of water management and civil engineering at the Helsinki University of Technology. The dissertation ceremony and party after it went smoothly, even though the heavy snowfall at the end of March surprised both the doctoral candidate, the opponent, and the party guests. Though I don't remember much about the defense itself because I was so focused.

The work was certainly of the greatest importance to me personally, as I saw how far I could go if for once I had sufficient resources to concentrate on the work. After my doctoral dissertation, I have worked in interesting national and international research projects. In recent years, I have also expanded my expertise to model ecosystem services and biodiversity.

What is the main advice you would like to give now to yourself when you were just starting to do you dissertation?

Take it easy! There is also life after the thesis...

Abstract

In this study the dynamic, semi-distributed INCA-N model was applied to the boreal Simojoki river basin in northern Finland to outline inorganic nitrogen (N) leaching patterns and N processes in catchment scale. Special emphasis was paid to the quality assurance of the modelling work. The dominant human impacts in the area are forestry, agriculture, scattered settlement and atmospheric deposition. In order to assess the effectiveness of current environmental policies and to implement river basin management plans, it is essential to know the relative significance of the different sources of pollution. INCA-N explained main features of the hydrological pattern and seasonality of inorganic N concentrations in river water when N processes in soil in sub-zero temperatures were included. Over-winter N mineralization processes in soil accounted for 38% of annual N mineralization. The lowest concentrations during the growing season were not reproduced, which indicates that there are some retention processes missing from the model. As summer is typically a low flow period the simulation results are reliable as long as the interpretation is based on daily or annual loads. Loading from the river basin was mostly dependent on annual hydrology and it was concentrated to peaks during the snow melting period. In the upper parts of the river inorganic N load originated mainly from commercial forests. At the outlet of the river anthropogenic sources accounted for more than half of the overall inorganic N load, with agriculture, forestry and scattered settlements making almost equal contributions. Expected changes in atmospheric N deposition would not have any significant effect but the combination of water protection measures both in agricultural and forestry areas and in scattered settlement areas would decrease inorganic N load by 18% of the total load. The expected increase in forest felling of 20% would not have an influence, but increase in agricultural land due to the EU's Common Agricultural Policy might lead to increased N load to the sea.

Olli Malve

Water quality prediction for river basin management *(2007)*

I remember the flash of excitement when learning and doing new things together with the people who were ahead of the times and showed the way forwards. The best moments were the participation to the domestic and international projects and the year visit to DUKE University in NC, USA.

The synthesis was the most challenging and rewarding part of the work. I learned new ways to combine data and models using Bayesian inference and MCMC sampling in order to advise real-world water management.

Several people inspired, motivated and helped me, particularly Prof. Heikki Haario in LUT University, Dr. Marko Laine in FMI, Prof. Peter Richert in EAWAG and Prof. Song Qian and Kenneth Reckhow in DUKE University. Co-authoring was the most important way of collaboration.

During the work I found a solid ground and clear vision to the rest of my career as a researcher in Finnish environmental administration.

Your advice now to yourself then?

Adhere your dreams, count on your blessings and enjoy while ascending towards the peak of your work. And, thrust your society on, and work with whose, who share common views and give you a fair backlash.

Abstract

Water quality prediction methods are developed which provide realistic estimates of prediction errors and accordingly increase the efficiency of river basin management and the implementation of EU's Water Framework Directive. The resulting river basin management decisions are based on realistic safety margins for restoration measures and accompanying targeted pollutant load limits. The realistic error estimates attached to the predictions are based on Bayesian statistical inference and MCMC methods which are able to synthesize two distinct water quality prediction approaches i.e. mechanistic and statistical. What is more, a hierarchical modeling strategy is employed in order to pool information from extensive cross-sectional lake monitoring data and consequently to improve the accuracy and precision of lake specific water quality predictions.

Testing of the methods using extensive hydrological and water quality data from five real–world river basin management cases suggests that Bayesian inference and MCMC methods are no more difficult to implement than classical statistical methods. Even models with large numbers of correlated parameters can be fitted using modern computational methods. Moreover, the hierarchical modeling strategy proves to be efficient for river basin management. Guidelines for adaptive river basin management are also set up based on the experience gained. It is proposed that monitoring, prediction and decision making should be integrated into an efficient management procedure.

Matti Kummu

Spatio-temporal scales of hydrological impact assessment in large river basins: the Mekong case *(2008)*

To start with, I did not plan actively to conduct doctoral studies, at least not right after the MSc degree from the former Helsinki University of Technology. After the MSc thesis I was actually planning on going for a long hiking trip to the foots of the highest mountains of the world in Himalaya. But then, as so often, life took me elsewhere — I came across an interesting opportunity to join an international team of archaeologists in Angkor Wat, Cambodia, and a potential DSc thesis topic of the Angkorian water management over the 10th–15th centuries.

Without any secured funding, I packed my backpack and headed to Phnom Penh, where Finnish WUP-FIN team was based and for which Olli Varis and Marko Keskinen were working. I started to apply for some personal grants from Finnish foundations while the University of Sydney, who was leading the Greater Angkor project, paid the field work and WUP-FIN project my accommodation in PP. I joined the field seasons (Jan–Feb) for two or three years in Angkor, and for most parts of the rest of the year I lived in PP, where I was working with the data, joined seminars and conferences, and did some small works for the WUP-FIN team.

Gradually, my interest moved away from the very speculative archaeology towards the inspiring work in understanding the Mekong flood pulse, future threats on that and intensive capacity building in the region's universities and research organisations — all led by Dr Juha Sarkkula (SYKE) and Jorma Koponen (EIA Ltd). Together with Marko, and many others shorter term employees, we were working for the WUP-FIN continuation and PhD came along on the side — or so it feels now. At least the process was much different to the current, rather structured and research focused Doctoral path that most of the Doctoral researchers are today doing.

I feel that the freedom I got from my supervisor Prof Olli Varis and a combination of research consultation to the Mekong River Commission, tens of capacity building sessions with the local young students and academic research work was a very good mix that fitted me well back then. The four years, over which I mostly lived in Southeast Asia, taught me much more than a work behind a desk in Otaniemi would ever have done – it gave me a very diverse set of skills, lots of life-long contacts and friends as well as a cultural knowledge of the region. But then, at the same time, when I moved back to Finland and started to finalise the articles for the DSc thesis, I had much to learn from the academic world including how journals differ from each other and how to best publish journal articles.

At the end came another challenge: how to put together a thesis that was a compilation of several articles, ranging from study of trapped sediments behind the dams to flood pulse analysis of the Tonle Sap Lake and ancient water management in the Angkor?

I somehow managed to tie them together, but it might have helped if I had been thinking about it a bit earlier. But then, it would not have been a reflection of the work I had done over the years.

Your advice now to yourself then?

Believe in your own path, keep on exploring and learning, and work with others.

Abstract

River alterations, being either natural or anthropogenic, have impacted the environment and riverine communities, and nature, throughout human history. During the last two centuries, the scale of the anthropogenic impacts has expanded significantly as a result of larger water resources related projects. Numerous human activities have consequences for the environment measured along multiple scales and levels. The multiscale/-level nature of the problems related to the impact assessment discipline requires that researchers address key issues of scales and levels in their analyses.

The thesis aims to present the spatio-temporal scales of the hydrological impact assessment (HIA) process in a large river basin context and analyse how the scales should be taken into account when conducting the assessment. A special focus is on the data and methodologies used within the HIA. The levels of this work are hydrology, hydrodynamics and sediment transport, forming the sub-disciplines of the HIA. The geographical focus is the Mekong River Basin in Southeast Asia where HIA is presented at different scales through seven case studies, based on the appended papers. The Mekong is facing rapid development activities and in this work their consequences on the above-mentioned levels have been analysed and discussed at different scales.

Scales are particularly important when a) identifying the critical processes and areas of possible consequences, b) selecting the spatio-temporal scales of the assessment, c) identifying the data needed and available, d) selecting the methodologies and tools related to the process, and e) presenting the results of the assessment to the decision- makers and planners. The thesis concludes that, instead of down-/up-scaling, a multiscale approach often appears to be a more preferable solution. A more extensive inclusion of scale issues in the impact assessment process is believed to contribute to building a more profound connection between researchers and decisions makers.

Ulla Heinonen

Can the poor enhance poverty reduction? Rural and urban perspectives on water resources, poverty & participatory development in the Tonle Sap Region and Phnom Penh, Cambodia *(2009)*

What comes first to my mind when thinking about the doctoral thesis process was the painful publishing process of international journals. The topic of my dissertation was very holistic, and it was very difficult to find a journal that was interested in publishing articles that focused on water resources management and governance but also on migration and other social themes. I was able to publish three articles, but the time was running. Due to these challenges and time pressures, I changed my dissertation approach from articles to monography. This was a good decision, although it may have hindered the consistence of the work.

Other challenge that comes to my mind was the availability of data, especially about the socio-economic indicators and their trends in Cambodia. When I started the thesis work, Cambodia did the first population census in years. And based on one year information, it was rather difficult to analyze any trends. Luckily, there were great local NGOs that studied the situation and shared their data. The NGOs were not easy to find, but by being active and discussing with local people, I'll found the right contacts. Collaboration with Cambodian and Thai NGOs was very important — supported the data gaps and gave new perspectives on the research topics.

Although there were some challenges on the road, the doctoral thesis process provided me memories that I will never forget - great international colleagues, adventurous field trips and interesting participatory studies with villagers. I addition to memories, I gained a lot of new skills - sales skills in selling the topic to funders, facilitation of the discussions with heterogenous people groups, finding the key points from the data and leading my own work.

There were some motivation gaps in the middle of the process but the topic and the discussions with villagers and NGOs highlighted the importance of my research topic and kept me going.

Your advice now to yourself then?

Before starting and choosing your topic and hypothesis, discuss your research idea with multidisciplinary team and experts from the various fields of expertise. This will in the beginning of the work help you to understand the bigger context of your thesis work and gives you plenty of topics to start the work.

Abstract

In recent years, Cambodia has seen a significant economic growth. However, this development has not reached the poorest dwellers, resulting in escalating inequality. The Tonle Sap Region is one of the poorest regions in the country. The livelihoods of the region's poor are greatly dependent on water resources. The livelihoods are thus vulnerable to possible changes in water resources associated with the current development plans. By contrast, Phnom Penh, which is the main destination for the region's migrants when searching for a better level of living, is struggling with increasing poverty, informality and inequality.

Participatory development is considered crucial when aiming at equal poverty reduction. Consequently, this study analyzes the strategies used by the poor to participate in decision-making and to enhance poverty reduction in urban and rural areas of Cambodia. Furthermore, the study analyzes the role of water resources and migration in the country's poverty reduction. The study focuses especially on grass root level observations. Hence, the participatory studies and expert interviews undertaken serve as a major source of information for the research.

This study identifies various strategies used by the poor for participating and enhancing poverty reduction. Many of these, however, are rather narrow, project-based and fragile, and thus have only limited impacts on general poverty reduction and empowerment in the study regions. To conclude, poverty reduction is hindered by the lack of competent authorities and sound policies to address poverty, inequality and informality as well as mistrust and weaknesses within the communities. Improving the possibilities of the poor to enhance poverty reduction calls for several changes at both the community and decision-making level.

Marko Keskinen

Bringing back the common sense? Integrated approaches in water management: Lessons learnt from the Mekong *(2010)*

My doctoral research process was far from straightforward. I had never really planned to complete a doctoral degree, but was already during my studies interested in to work on international water issues. So when I was offered a Master's Thesis position on Cambodia's Tonle Sap Lake in a consultancy project called WUP-FIN, off I went! That original 2-month visit led to several years of working in Cambodia, Vietnam and Laos in a number of consultancy and research projects. As most of those projects were done through Helsinki University of Technology and included also some research, my supervisor Olli Varis persuaded me to apply for a doctoral student position. This led to a path I hadn't really envisioned for myself — and had ultimately major consequences for my entire career.

My Doctoral Thesis process was first and foremost a collaborative process: I would have not been able to do it alone. Particularly Olli's encouragement throughout the process was remarkable, but I did enjoy from the support of numerous other colleagues. I counted that in the Acknowledgements of my Thesis, I thank around 100 persons who helped me during the process, ranging from my closest colleagues to partners in different organisations and countries. My Thesis process was also a very practically oriented process, given the scope of my research was largely defined by the projects that I was participating in the Mekong. This also makes it very different to most current Thesis processes: it now feels (as it did quite much already then) that the doctoral research was just some kind of additional project to all those 'real' projects that I participated in.

At the same time my doctoral research was, of course, very much a learning process. For while writing those research articles was not easy, I did increasingly start to enjoy the fact that my research forced me to both critical consider and reflect the practice-driven work I did for the different projects. This deepened my expertise and also encouraged me to broaden the theoretical basis I built on: the courses I did during my doctoral studies ranged from development studies to sociology and from Asian studies to anthropology. Particularly the basic courses on sociology and anthropology shook the very knowledge foundations that I had as a water engineering student at TKK learned, and emphasised at a very concrete and personal level the significance of multi- and interdisciplinary approaches.

In the hindsight there are many things I my doctoral research process that I could now do differently — and still I would not change a thing. For while my Thesis process did have its twist and turns and took over 6 years to complete, I feel it was a process that suited me very well.

Your advice now to yourself then?

Be open for collaboration and enjoy the journey!

Abstract

Water management is changing: the narrowly defined management practices that have for long been dominating are being replaced by more comprehensive approaches. Integrated approaches — including the Integrated Water Resources Management (IWRM) — represent the forerunners of this change, and they are thus loaded with expectations. The reality is, however, more complicated, with many of the integrated processes failing to live up to their promises.

This Thesis looks at integrated approaches used in water management and impact assessment, with a focus on the transboundary Mekong River Basin and the related Tonle Sap Lake area in Cambodia. The seven appended articles discuss an array of water management and assessment contexts in the region, sharing practical experiences on the use of integrated approaches. The synthesis places the current integrationist drive into the broader context through an analysis of the development of integrated approaches as well as through a review of multi-disciplinary research approaches. Despite their emphasis on integration between different sectors and disciplines, integrated water management approaches are found to have surprisingly weak linkages with similar approaches in the other fields.

In terms of the actual implementation of integrated water management, the Thesis recognises six key elements to be particularly critical: Comprehensiveness, Institutions, Politics, Methods, Team and Inclusiveness. Experiences from the Mekong on all these elements are summarised, and their significance and contribution to the practices of integrated water management is described. The Thesis concludes by noting that while the current integrated water management practices are often strong on practical integration methods, they at the same time partly neglect the broader philosophical and contextual aspects related to integration. Yet, since integrated management always involves a range of actors with their intricate interconnections, integration is not just a mechanical procedure, but very much a personal and political issue as well.

What really matters are therefore not only the technical methods for integration, but also the ways the management and research teams in specific management contexts communicate, collaborate and interact with their various stakeholders as well as — an issue that is frequently forgotten — internally within their teams.

Lassi Warsta

Modelling water flow and soil erosion in clayey, subsurface drained agricultural fields *(2011)*

After my Master's thesis in the Helsinki University of Technology was finished in the end of 2005, Professor Tuomo Karvonen asked me if I would like to continue in the group by doing a Doctoral thesis. I guess I seemed to be a bit apprehensive of the suggestion because Tuomo continued and said that "I could easily do it", comment that probably should have rung some alarm bells in my mind. Tuomo had noticed that reports on problems related to effluents from agriculture had started to accumulate in media in the mid-2000. There was some data available from experimental fields that showed that nutrient and sediment loads were lost from the fields via both surface runoff and subsurface drains, but theoretical descriptions were not available or incomplete.

From the very start of my dissertation work, I discussed technical issues with Tuomo and about more general agricultural water management topics with Professor Pertti Vakkilainen, who was leading the group and the department at the time (portrait of him is hanging in the Water building). I also got Maija Paasonen, a researcher who had worked extensively on field scale agricultural water management and nitrogen processes, onboard to instruct me. Work with an experimental researcher was rewarding and frustrating at the same time because she would quickly point out that a clever solution of mine did not actually reflect the physical phenomenon at the field, and a more realistic and usually more complicated approach was needed. Later Tuomo and I understood that we needed help with the theoretical description of erosion processes in the model. Someone, probably from the lab, suggested that we should contact Dr Antti Taskinen who had made his PhD in Ireland about modelling erosion. Fortunately, it did not take much to convince him to join the team because he was, like most of the researchers I met, just extremely interested about his research topic. He accepted my request and even bought me coffee and a bun at the cafeteria on the first floor of the Radio building where SYKE was located at the time.

Around this time Tuomo decided to leave the university to work on projects on deep geological disposal of radioactive waste. Pertti took the supervisor reins from Tuomo and Tuomo took a role as an instructor in the team. Then after the position of Tuomo was filled by Professor Harri Koivusalo, he became my supervisor and Pertti joined the instructor team. Sometimes I joke that it took three supervisors for me to get my thesis done. Even though there was rotation in the roles in the team, everybody stayed in until the very end, which provided much needed support and stability and for that I am extremely thankful.

Harri was a scientist to the bone and when he looked at the state of my Doctoral thesis, he immediately demanded more progress

and rigor on the scientific approach. It was pretty evident at this time that we were not going to be able to fulfil all the original objectives in the designated time and we had to do some pruning. The plan shrank into developing a model for simulating water flow and erosion in subsurface drained, clayey agricultural fields during warm seasons. Before this I had put my effort mostly into building the model but after Harri's comments I understood that if I could not convince people with my thesis that the system works, it would be the same as if the model did not exist at all. After this, I spent intensive writing periods at the Virolahti cottage to concentrate on advancing the monograph thesis into pre-examination form.

Finally, my Doctoral defence was held on 11 November in 2011. Professor Jiri Šimůnek acted as my opponent and Harri as my custos in the event. I am usually petrified in public performances, but I think Dr Marko Keskinen put it well when he tried to encourage us that once you get past the beginning you are kind of immersed in the discussion and forget the crowd, and this was the very thing that happened to me.

Your advice now to yourself then?

The main advice I would now give myself would be to never believe someone who says to you that you can easily do it! On a more serious note, the most important things that I got from the process was the possibility to make friends with all the wonderful people in our group and researchers from other institutions and universities in various meetings and conferences in Finland and abroad.

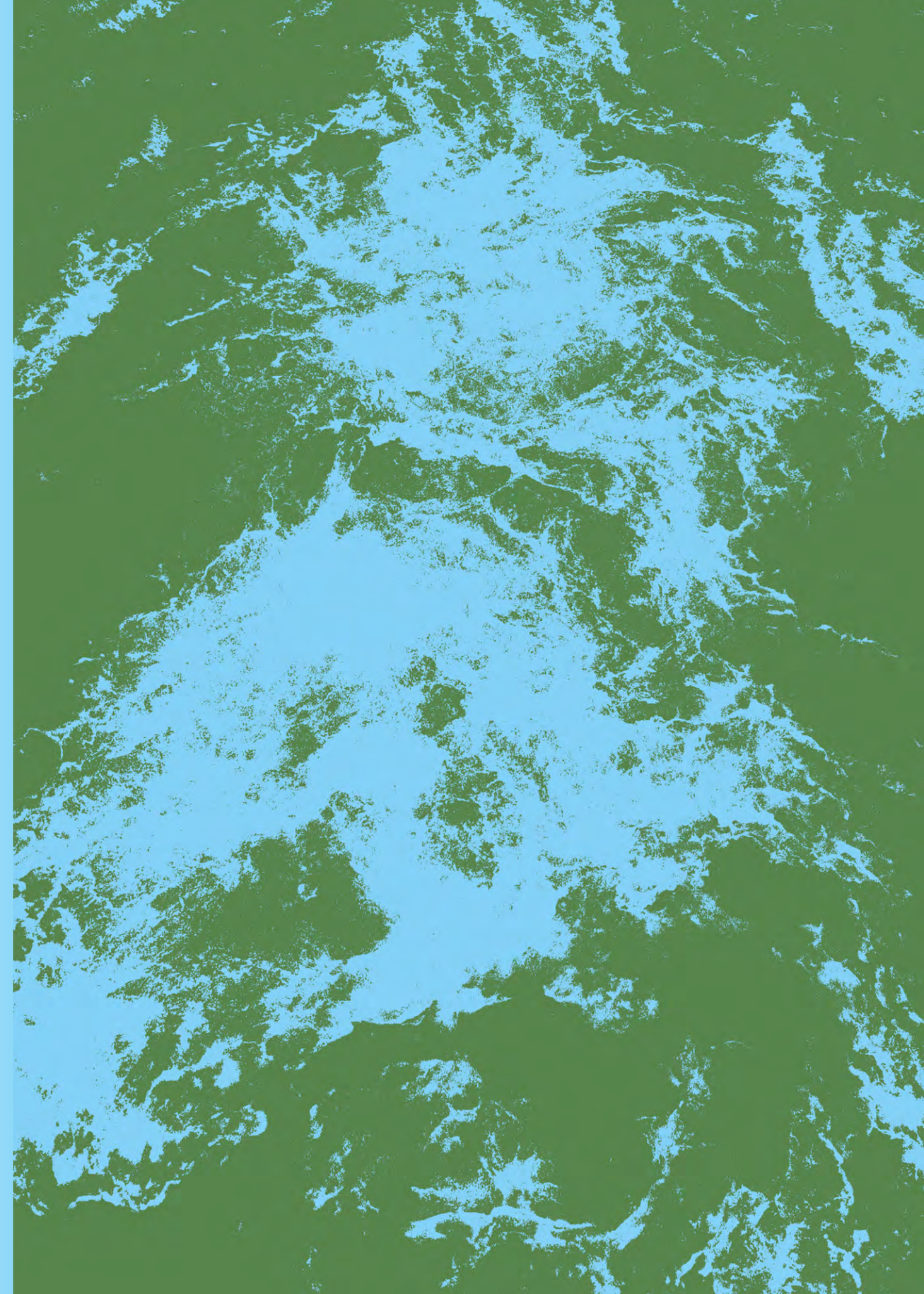
Abstract

Soil erosion in clayey, subsurface drained agricultural fields in Finland can cause problems due to the export of suspended sediment and sediment-bound nutrients into nearby waterways. Suspended sediment is transported from the field via two main hydrological pathways: 1) surface runoff and 2) preferential flow in macropores to subsurface drains. In clayey fields especially, the sediment load via the subsurface drains can be a considerable part of the annual load. The mechanisms contributing to the sediment load during the growing season and the following autumn were quantified with a new numerical model (FLUSH) developed in the study, using sample data from two clayey, subsurface drained field sections in southern Finland.

The simulated field was computationally divided into two-dimensional overland and three-dimensional subsurface domains. Existing mechanistic approaches were applied to describe both surface and subsurface domain processes in the model. A dual-permeability model can simultaneously simulate flow in both soil matrix and macropore systems.

The model supports simulation of suspended sediment transport in macropores, drainage systems, soil swelling and shrinkage processes and the effects of cropping and tillage operations on water and sediment yields. A new pentadiagonal matrix algorithm-based solution was developed to directly solve subsurface flow in both pore systems. A custom time integration method was derived to run the solution algorithms with different time steps in concurrent fashion. All the finite volume-based partial differential equation solution algorithms were parallelised with the OpenMP application interface. Computational grids, created with an automatic grid generation system, were used to test the effects of grid resolution on results.

The numerical model successfully described water flow and soil erosion in the study fields indicating that the hypothesised mechanisms for water flow and soil erosion were appropriate. The simulation results confirmed that preferential flow has a profound impact on field-scale hydrology. Runoff distribution between surface runoff and drainflow changed in the autumn due to tillage operations and soil swelling. Soil erosivity also increased after autumn tillage. In the simulations, hydraulic erosion was the primary process leading to high erosion rates in the Sjökulla field. In the Hovi field, lack of surface runoff notably lowered the sediment loads. Simulations with 1-D and 2-D grids indicated that the application of a 3-D model to undulating, clayey, subsurface drained fields was well justified. Tests with spatial variation of macroporosity presented evidence that the spatial variability of soil properties has a notable effect on runoff and sediment loads.



Virpi Stucki (née Lahtela)

In search of integration: Analyzing the gap between theory and practice of Integrated Water Resources Management with case studies from West Africa and international policy processes *(2011)*

Little did I know when I started to write my Doctoral Thesis in September 2000 about the journey that ended up taking 11 years. I started my Thesis in the research group of Professor Varis working in the project of Global Changes and Water Resources. As a recent graduate, I was very keen on my research topic: water resources in West Africa. Yet, at the same time, I was concerned about theoretical nature of my work as a research associate, and the lack of hands-on experience from the field.

As I wished for more practical experience, I decided to apply for a job in Burkina Faso, as an Associate Professional Officer at the International Union for Conservation for nature (IUCN). As a researcher, I was used to write policy recommendations based on the research results. Yet, I felt a need to "walk the talk" and see if the research can be put into practice in real-life conditions.

A break from the University that was originally planned to be two years continues as of today. Yet, and to my good fortune, in Finland the Thesis format can be composed of manuscripts in peer reviewed journals. I managed to write and submit my first research articles before going to West Africa. Two years became four, then six, then ten. During the years outside of the University, I kept on writing articles related to my work with my colleagues.

When I published my fifth article in 2009, Professor Varis told me that my Doctoral Thesis would be almost ready. It took some unpaid leave of my job at that time to write the introduction and conclusions of my Thesis and defended it in September 2011 — after 11 of starting to write it.

The best moment in the Thesis process was that I was writing about what I was passionate about at the different times of my career. I was writing about practical problems, backed by academic literature and research results. This led to the biggest challenge of the Thesis writing process: finding the famous red thread. As my articles were from relatively wide range of topics, it took a good amount of time to find the commonalities and logic between them.

My Thesis was done in collaboration with many partners and organizations as I wrote about my work topics. This made the writing process very interesting. The main motivator was Professor Varis and all my friends and colleagues from the Water and Development research group, whom I was in contact with during my years outside the University.

If you were ever contemplating whether to write a Thesis, my advice would be to go for it. With the current format of manuscripts, you can chop the process into pieces allowing the flexibility one might need in ones' current work and life setting. For me, the most important learning

about writing the Thesis, apart from the academic findings, was to be able to start and finish a relatively complex project. Even if you are not planning for an academic career, employers will appreciate such a skill.

Your advice now to yourself then?

Think about the Doctoral Thesis as a project among others. Every project has challenges, which need to be solved. The same goes for Doctoral Thesis. Good luck!

Abstract

Integrated Water Resources Management (IWRM) is one example of integrated approaches to natural resources management that has been widely promoted during the past decades. In this thesis, IWRM is understood as a strategic management procedure that integrates the natural resources and society (users and institutions) around a body of water. Numerous international conferences and meetings have promoted IWRM as a key approach to water management and subsequently a way to sustainable development. Yet, practical implementation of IWRM on the ground has had uneven success.

The overall objectives of the thesis were to increase understanding of the high-level, strategic issues that hinder or enable the translation of IWRM from policy into practice and based on that, to distil special considerations of IWRM in Senegal River and Lake Chad, for integrated approaches, and among practitioners. This was done by examining the gap between theory and practice of IWRM with the help of case studies representing IWRM in practice (Senegal River, Lake Chad), and IWRM in theory (IWRM in international policy, climate change adaptation policies as a driver for integration). A framework was developed and used in order to systematically analyze the appearance and implementation of IWRM in the four case studies. The methods used in examining the case studies varied from a literature review and field visits, to Bayesian Causal Networks, comparative analysis and qualitative data analysis. The thesis concluded with four high-level, strategic issues that hinder or enable the translation of IWRM from policy into practice. These include i) the importance of recognizing externalities, ii) defining and understanding the "IWRM area of influence" (the confluence between theory, practice and externalities), iii) the key role of institutions and especially management and communication aspects, and the fact that iv) understanding, analyzing and managing the above is more about nouns than numbers.

Noora Veijalainen

Estimation of climate change impacts on hydrology and floods in Finland (2012)

My process of completing my Doctoral thesis was somewhat different to most people. I did almost all of my thesis while working full time as a hydrologist at Finnish Environment Institute (SYKE), where completing the Doctoral studies was never the main part of my job.

The subject of the thesis, climate change impacts on hydrology and floods in Finland and modelling these impacts with hydrological model was relatively clear from the start. The methodology and details did of course get refined during the process, but the main idea stayed the same. What changed during the years was the sense of importance and urgency about the subject. When I first started climate change was still considered a relatively distant problem, to be studied and planned for, but not of acute urgency. There was also still some scepticism around the subject and its importance in the first years of 21st century. That changed during the years, when climate change impacts started to become more apparent and the need for climate change mitigation and adaptation became obvious. The relevance of the whole subject has continued to grow also after the completion of the dissertation.

I started the process in 2005, a year after finishing my masters' degree, but at first the progress was quite slow due to the other work. But I did manage to complete the necessary courses in a few years, mostly studying on weekends and evenings.

My first article was published in 2008, after quite a long and slow process. I had perhaps too little help and too little time for that article but managed to get it finished in the end. But then I had some good projects at SYKE which enabled more collaboration and few more articles, speeding the process and providing important help and advice from researchers and professors at SYKE, Aalto University and University of Turku.

The positive side of working while doing the Doctoral studies was the ability to use the extensive hydrological modelling system (WSFS) and infrastructure at SYKE s well as hydrological and meteorological data of SYKE and Finnish Meteorological Institute. Also, the knowledge of the colleagues at SYKE and collaboration with them was very useful. The material for the articles was produced in several projects, which meant that there was a large number of results and data to use. Working at SYKE also enabled a variety of skills from project management to (small scale) coding to be acquired during the time.

The last part of the work was writing the overview, for which I acquired a grant from Maa- ja Vesitekniikan tukisäätiö. That enabled me to spend in total of five months on study leave from SYKE and greatly speeded up the process of getting the Doctoral studies ready. I defended my thesis on 1st on June 2012.

Your advice now to yourself then?

The main piece of advice to myself would be to collaborate even more with other researchers and to take time at the beginning of the process to attend writing courses or workshops to learn the scientific writing in a more structured way

Abstract

Climate scenarios project increases in air temperature and precipitation in Finland during the 21st century and these will result in changes in hydrology. In this thesis climate change impacts on hydrology and floods in Finland were estimated with hydrological modelling and several climate scenarios. One of the goals was to understand the influence of different processes and catchment characteristics on the hydrological response to climate change in boreal conditions.

The tool of the climate change impact assessment was the conceptual hydrological model WSFS (Watershed Simulation and Forecasting System). The studies employed and compared two methods of transferring the climate change signal from climate models to the WSFS hydrological model (delta change approach and direct bias corrected Regional Climate Model (RCM) data). Direct RCM data was used to simulate transient hydrological scenarios for 1951-2100 and the simulation results were analysed to detect changes in water balance components and trends in discharge series.

The results revealed that seasonal changes in discharges in Finland were the clearest impacts of climate change. Air temperature increase will affect snow accumulation and melt, increase winter discharge and decrease spring snowmelt discharge. The impacts of climate change on floods in Finland by 2070-2099 varied considerably depending on the location, catchment characteristics, timing of the floods and climate scenario. Floods caused by spring snowmelt decreased or remained unchanged, whereas autumn and winter floods caused by precipitation increased especially in large lakes and their outflow rivers. Since estimation of climate change impacts includes uncertainties in every step of the long modelling process, the accumulated uncertainties by the end of the process become large. The large differences between results from different climate scenarios highlight the need to use several climate scenarios in climate change impact studies.

Possibilities to adapt to climate change impacts through changes in lake regulation were also estimated. Changing the management and permits of many of the regulated lakes in Finland will become necessary during the 21st century in response to climate change induced shifts in hydrological regime.

Tanja Tuutijärvi

Arsenate removal from water by adsorption with magnetic nanoparticles (γ-Fe2O3) *(2013)*

I worked within three different laboratories/Universities when doing my Doctoral Thesis. I was living abroad while I got the idea to start post-graduate studies and my main motivation to Doctoral studies has been to gain work experience and of course learn more about water treatment.

What comes to the process of Doctoral Thesis, at first it felt like there is no process and everything was new and different in Hong Kong compared to Finnish Universities. I had no clue about the adsorption theory or experimental set up, nanoparticles and not to mention their synthesis and many analytical instruments which was used to characterization of nanoparticles. Luckily for me, I was sharing a room with French post-doc (Claire Gerente) who had studied adsorption and she helped me a lot at the beginning. After the initial confusion I started to get the process and research on-going. Regular meetings with whole group and professor helped in creating the overall picture and gave the deadlines for the experiments since everybody showed in the meetings what they have been working with between the meetings. This also helped to put the data together and it was easier to write the article.

I proceed the study in Finland and when a well-functioning process was created I continued with the same principle with new supervisor(s). What changed was the socialization with other people in research groups. I realized that this was the downside in Hong Kong and it was really rewarding to have a coffee breaks and lunches regularly with group. Not to mention parties!

In hindsight, I have realized that I sort of had four projects which end result was an article — exception that this was a one-person project. This is actually something I would suggest to think when doing Doctoral Thesis, would it be thought and implement as a personal project if there does not exist project — which quite often, however, is the case. It will give structure and deadlines which help the thesis to proceed. This kind of project-thinking would also support the changeover to industrial R&D world (if this is in interest).

Last thing, what actually came as a surprise within whole process was the article approval process and how time consuming it could be!!

Abstract

Arsenic is a poisonous and carcinogenic heavy metal that exists naturally on the earth's crust, from where it can leach into the groundwater — a common water source worldwide. Therefore, arsenic-rich areas pose the risk of chronic exposure, which is prevented by removing arsenic from water using various technologies. Adsorption with conventional adsorbents, as activated alumina and iron-based adsorbents, is commonly applied for arsenic removal. This study introduces a nanoscale adsorbent, maghemite-magnetic nanoadsorbent, for arsenic removal.

The overall aim of the study was to compile fundamental information on novel maghemite nanoparticles and their suitability for arsenic removal from water with laboratory—scale batch experiments. The study was conducted with three kinds of maghemites: sol-gel, mechanochemical, and commercial maghemite. Sol-gel maghemite was the main research target; the others were studied for reference. The research consisted of the preparation of maghemite nanoparticles and their characterization, the study of adsorption kinetics, an investigation of arsenate adsorption properties on maghemite, a determination of the adsorption mechanism, and the evaluation of maghemite stability and regeneration properties.

The results indicated the applicability of sol-gel maghemite for arsenic removal by adsorption. The reasons are several: sol-gel maghemite synthesis is fast, convenient to work with and produces repeatedly high-quality particles, adsorbs arsenate satisfactorily, and there is no need for preliminary treatments prior to adsorption experiments: it is easy to handle and separate via an external magnet, it maintains its initial arsenate uptake capacity after six regeneration cycles, and it is stable, which are important factors for cost-effectiveness. And it produces only a small amount of "arsenate-maghemite" waste. Moreover, sol-gel maghemite is competitive with activated alumina in adsorbent properties. Both adsorbents need careful monitoring due to pH control, interference of other ions, and regeneration. Activated alumina can remove slightly more arsenate than sol-gel maghemite, but sol-gel maghemite is more stable, forms less waste, and is separated simply and rapidly by external magnet.

Anna Mikola

The effect of flow equalization and low-rate prefermentation on the activated sludge process and biological nutrient removal *(2013)*

The first thing that comes to mind when thinking about the PROCESS of doing my Doctoral thesis is BABIES. The fact is that during that process I was pregnant and on maternity leave four times. All the publications in the thesis are written while the baby (or one of the babies depending on the paper) was having a nap. The writing session could vary from 15 minutes up to 2,5 hours. When the submission deadline was approaching I usually invited my mother or my mother-in-law for a visit to make sure to be able to work for more than 15 minutes without interruption.

The best moments are the conference trips to IWA Nutrient removal and recovery conferences where I was able to meet other researchers and practitioners working on the same topic. In Finland I actually felt quite alone. I started my doctoral project in 2001 with Professor Heikki Kiuru. During the first years I received good support and help, but unfortunately Prof. Kiuru suffered a stroke very soon after his retirement and could not participate to my project anymore. The Water and wastewater engineering team also went through a period of not having any professor for some time. The thing that really saved me was the international community of nutrient removal researchers. I think that I was extremely lucky to end up presenting in the same sessions with e.g. Prof. Jacek Makinia, Prof. Diego Rosso or Dr. Julian Sandino. The discussions both on scientific aspects and on personal level carried me through the thesis process. I've kept these friendships for 15 years and am now building nice collaboration with these great researchers.

My first motivation when returning to the university to do a PhD was to do something different after three years of working for a wastewater treatment equipment supplier. It was only later I fell in love with my topic and understood the beauty of biological wastewater treatment. Overall, the driver for me has been the same since the beginning when I selected water and wastewater engineering in my MSc studies – I think that we are lucky in this field that we don't need to look for any far-fetched explanations to justify our work – our objective is to save the humankind and the planet!

Your advice now to yourself then?

The main advice I could give to myself when I was just starting to do my dissertation is "Don't spend so much time in questioning your thoughts, in testing different methodological approaches and in writing and then deleting what you've just written!" But I will not give this advice because I think every second and every detour were worth it!

Abstract

The flow and load variations in the wastewater plant influent complicate the operation of the biological treatment process and harm the process performance. Moreover, when the biological nutrient removal (BNR) process is implemented in the plant, the plant influent is often lacking readily biodegradable organic matter. Readily biodegradable organic matter can be produced by prefermentation. In this research project, the primary clarifiers at the Pihlajaniemi WWTP in Savonlinna were modified in order to tackle the problems caused by flow variation and the lack of suitable organic matter.

This study demonstrated that diurnal flow variations were efficiently levelled out in the existing primary clarifier basin volume. Surprisingly, a significant amount of organic matter was transformed into a more accessible form for the BNR bacteria when only flow equalization was in operation, but the attempt at enhancing the VFA production by adding an internal sludge recycle was not successful. The raw sludge removal in the equalization/prefermentation basin was not compromised in the modified operation. There is no commonly accepted method for assessing the magnitude of flow variations or the efficiency of the flow equalization. This thesis introduces a coefficient of flow variation that can be used for this purpose.

The modifications in the pre-treatment were beneficial for the process performance. The main improvement in the biological process performance was observed with nitrification. The improvement could be mainly attributed to the diurnal flow equalization. Moreover, it could be demonstrated that the increased heterotrophic assimilation and also prefermentation influenced nitrification. The results on nitrification are of high importance because the effects of dynamic influent and feed water characteristics on nitrification have not been widely studied, especially not in full-scale. Moreover, the sludge settling characteristics were improved in the equalization/prefermentation process train compared with the reference process train. This, together with the more constant flow rate, enabled better hydraulic control of the secondary clarifiers.

It can be concluded that the modification of the existing primary clarifier to a multifunctional pre-treatment basin is a feasible solution for the improvement of the BNR process performance. This process modification could be widely implemented in Finland because the majority of middle-sized and large WWTPs have primary clarifiers. Nitrification is usually the limiting part of the biological wastewater treatment. Therefore, implementation of equalization/prefermentation would enable a reduction in the aerated process volume. The economic balance of the modifications is clearly positive.

Timo Räsänen

Hydrological changes in the Mekong River Basin - The effects of climate variability and hydropower development *(2014)*

Looking backwards I see the doctoral thesis process as an important part of my life. It gave me professional abilities that enabled me to work in different jobs with various subjects, and the feeling that I can make a positive contribution with these abilities. The thesis process took me also to various countries and places, and my understanding of the world grew. The process was also challenging, and it pushed me to grow as a person even after the thesis process ended.

I made my thesis on hydrological changes in the Mekong River in Southeast Asia at the Water & Development Research Group, which is part of Water and Environmental Engineering Group. The working environment was free, encouraging, and supportive. My instructors and professors were Matti Kummu and Olli Varis who were always available and provided support and guidance throughout the process. Their role was crucial in the success and quality of the thesis, and I am extremely grateful for them.

During the process I learned to become self-driven and achieve targets that require long-term effort and continuous learning. I learned what scientific research is about and how to approach the task at hand analytically and systematically. I learned many technical tools and methods that made me professionally proficient and capable, which in turn enabled quick learning of new tools and subjects. These skills have been important in finding new jobs.

The everyday challenges of the thesis process were probably very typical. It took long-time to finish anything and feelings of accomplishment and satisfaction were rare. The writing of research papers involved plenty of feedback and critical comments, and the feeling of inadequacy was common. Often it was difficult to be convinced that I had done enough work and it was time to focus on something else.

However, the greatest challenge was related to the very personal nature of the thesis process. The thesis was not easy to finish, it took many years of hard work, and its finalisation became naturally a measure of my success. This, however, led to excessive concern on my own success, which was not conducive to happiness and long-term productivity. I learned this only afterwards and it is the most important lesson from the thesis process. Now I think that happiness and outcomes are greater when we work together and support each other as well possible. In the end, the most important memories of the thesis process are of the people I met and worked with.

Would I have embarked on this thesis journey if I have known all what I know now? For sure, yes!

Your advice now to yourself then?

Work together, help others.

Abstract

The world's large rivers are increasingly exploited for human use and are affected by changes in global climate. Dams, the consumptive use of water and a changing climate have resulted in river fragmentation and flow alteration on a global scale. The Mekong River Basin has been one of the world's less affected large rivers, but recently the development has started to shape the river. In the Mekong, the livelihoods, the economy and food security are closely connected to the river environment and its productivity. The productivity in turn is largely driven by the hydrology. Therefore, an understanding of the ongoing hydrological changes is crucial.

This dissertation aims at fulfilling hydrological research gaps in the Mekong. These research gaps concern the climate induced hydrological variability and the impact assessment of hydropower development in the Mekong. The main research framework of this dissertation is based on hydrology and water resources research and the methods are based on statistical and mathematical models. In addition, the dissertation discusses the role of disciplinarity in the hydrological knowledge production.

The dissertation found that the Mekong's hydrology has been strongly influenced by El Niño — Southern Oscillation (ENSO), and that in recent decades the Mekong's hydrological variability has increased to levels that may not have been experienced within the past 700 years. The recent increase in hydrological variability was, at least partially, attributed to an increase in ENSO activity. The dissertation developed new assessment approaches for assessing hydropower development and found that river flows will be considerably affected and this development leads to increasing complexity and trade-offs among different sectors of society. In addition, it was found that climate variability and the development of the water resource infrastructure result in cumulative impacts that need further attention.

Altogether, the dissertation concludes that the Mekong has entered a new hydrological era, where humans have become a major force transforming the Mekong's hydrology. The ongoing hydrological changes are likely to have an impact on ecology, livelihoods and food security. This new era requires new holistic planning and assessment processes, and in the case of hydrological and water resources research and education, the dissertation recommends the recognition of complexity, uncertainty, and co-operation across disciplines and societal sectors as future directions.

Aura Salmivaara

Spatial Vulnerability Assessments for Water Resources Management - Cases from major Asian river basins with a focus on spatial unit of analysis and the use of big and open data *(2015)*

I'm glad the process of writing doctoral thesis is in the past, but I am grateful for it since otherwise I could not be working where I am working now. There were many times I was really in doubt that what I was doing would result in a doctoral thesis, but then few things happened that I think were crucial for the completing the work: firstly, buying a wooden sailing boat which takes up so much time that one has to stop wandering loosely and keep strict working hours to be able to do some varnishing in the boat yard after office hours and secondly, accepting the fact that one does not have to decide by themselves whether the work is enough to be a doctoral dissertation but the scientific community will do that. I decided to try to make my best and leave the rest for the review. Well, in the end the dissertation got accepted and I even received a price for it.

Instructors and supervisors have an important role in getting the candidate through the process. Particularly prof. Marko Keskinen helped me to overcome the big challenge of firsts: writing the first scientific article as a first author based on the master's thesis, which was the first thesis (since I hadn't written a bachelor's thesis as the structure of the studies was different at those times). We actually had writing sessions, where we went through word by word the manuscript and discussed what is the point. Once it finally got into such condition where it was approved, the relief was great as it was possible to see that maybe the other articles can also emerge.

One thing I do not miss from being a doctoral candidate is the urge to prove that one has their own expertise and the research one is conducting would be unique and different to other doctoral candidates. In my current work, almost everything is done through collaboration and I think that is how one can contribute to science more efficiently. My doctoral dissertation subject was such that there were whole UN organisations with dozens of people working on reports with almost similar titles, so it was clear, one could not achieve the same by oneself. I had to come up with a niché within the subject and I found it by thinking what I enjoy working on the most: exploring maps and making spatial analyses.

I guess some amount of anxiety is inevitable and even needed for one to become a doctor of science, at least, for people with similar mindscape as mine. For many trying to find one's own path is difficult, and nobody else can really do the job. It is hard but the day of defense will be easier, when you have made the choices yourself, and you just talk about those. In the end, hard work and hard times will pay off.

Your advice now to yourself then?

Work every day on the things that interest and excite you the most, and balance out by doing other stuff than work as well. Use better your mornings for getting things done. Document well your thought processes and learn to organize your files, it will be useful later when working with multiple projects simultaneously.

Abstract

This dissertation looks at the use of spatial analysis with big and open data for water-related vulnerability assessments in major river basins of Monsoon Asia. Special focus is on the spatial unit of analysis by exploring various ways to define it and by examining systematically the related Modifiable Areal Unit Problem (MAUP).

The extent and availability of spatial data have grown rapidly. This big and open spatial data, when combined, mapped and analysed, increases our understanding of interlinked issues and provides support for decision-making. However, the seemingly transparent way of map overlay and zonal analysis require closer examination. This is particularly important, when GIS and spatial analysis are applied for water resources management, which involves actors, values, and demands from various sectors and drivers of change on multiple scales.

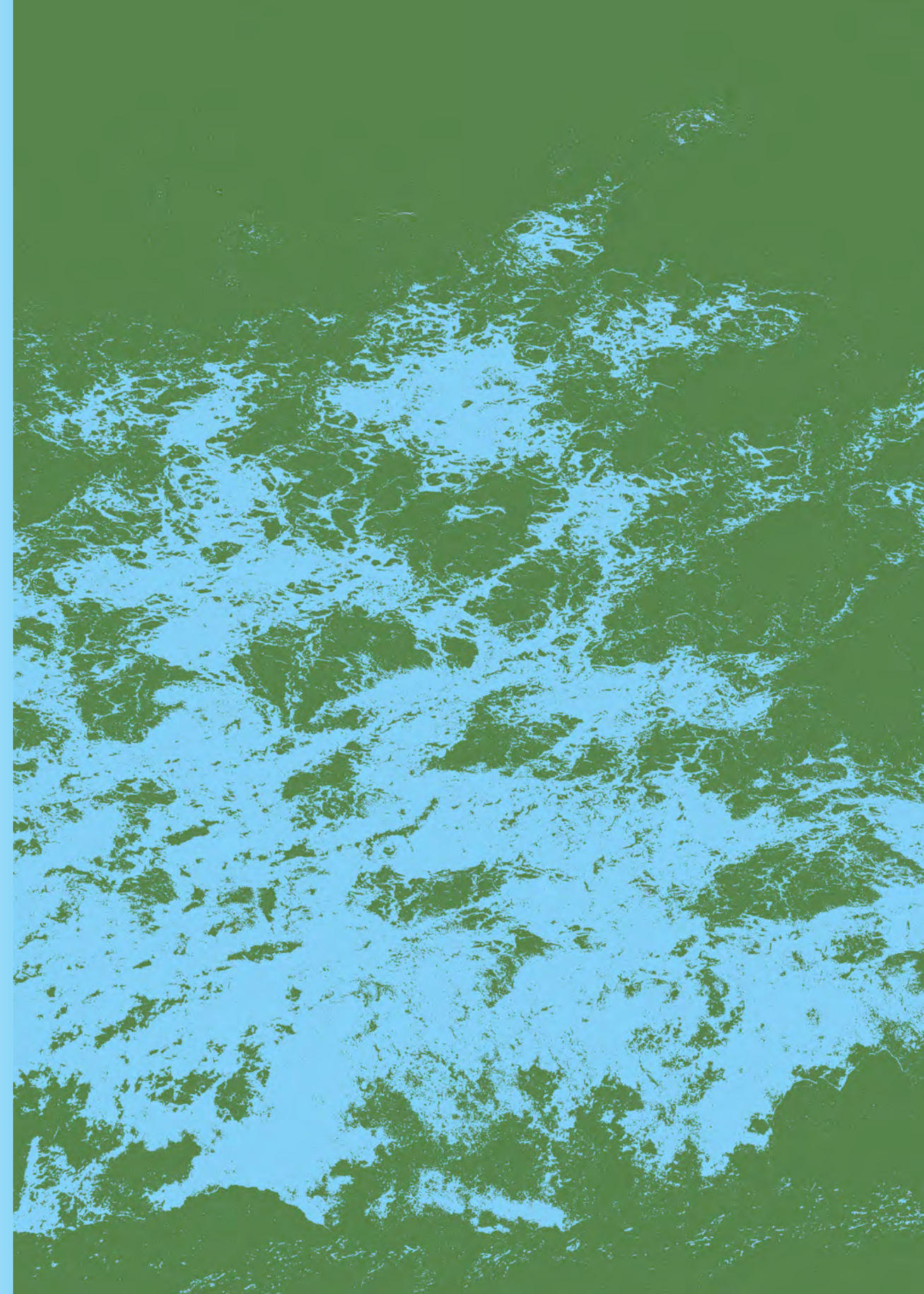
In Monsoon Asia (covering the area from China to eastern Afghanistan, with a population of 3.52 billion) the drivers of change include: climate change, population growth, urbanisation and various development pressures. The region has major and transboundary river basins making management of water resources particularly challenging.

This dissertation includes four case studies that draw findings from three scales: regional, basin and subbasin. Both data-driven and a priori methods were utilised in defining the spatial unit of analysis and new approaches to finding appropriate spatial units of analysis were developed.

Based on the case studies, this dissertation demonstrates that the big and open spatial data is extremely useful for water resources management. Yet, the findings indicate that the scale influences profoundly the applicability and performance of the spatial datasets. Moreover, the spatial unit of analysis through the MAUP has significant influence in the analysis results. A multizonal and multiscale approach was found to minimise the negative effects of MAUP. Through such approach it is possible to find appropriate spatial unit of analysis.

The findings reinforce the importance of reporting explicitly the choices and assumptions behind the spatial units of analysis. Classifying spatial data to avoid

accumulation of uncertainty and identification of data gaps is strongly recommended. Finally, simplicity should be emphasised when conducting vulnerability assessments to ensure comparability. However, also more complex methods were found to have potential to support the process of analysis. The findings help to develop spatial approaches to vulnerability assessments, and thus, enhance the applicability of big and open data for water resources management.



Kaisa Västilä

Flow–plant–sediment interactions: Vegetative resistance modeling and cohesive sediment processes *(2015)*

Back in 2009, seeing the call for a doctoral position in the field on environmental hydraulics, I felt motivated by the possibility to provide knowledge for developing environmentally sound river engineering and water management. Like many others, at the start I felt like it was going to be a very long process and that there would be plenty of time to solve many, many research problems... I was lucky to have a very devoted, knowledgeable and skilled advisor, who helped me in setting the right scope and cutting some of the excessive branches of my research plan. This was helpful in focusing the work, as I soon realized that the field work at our experimental two-stage channel was going to give me plenty of challenges — which is actually the typical case for anyone doing experiments: breaking sensors, development of "one-of-its-kind" measuring systems, wind almost blowing away the field notes, very cold feet after wading in the channel in the chill of winter-time flows, and on top of that so many natural processes happening even in such a small brook! This being said, at the end of the field days it felt great to have successfully completed the planned tasks or at least some of them. So designing and conducting experimental research was definitely an asset I learned– something that you learn well only after doing it quite much.

Scientific writing was another very important skill I acquired during the process and I have benefited of it extensively in my later career. I liked to see the manuscripts getting clearer and more reader-friendly after iteration — although receiving the review decisions detailing "a need for major revisions" (typical for early-career scientists!) and the iteration itself meant stepping out of the comfort zone... But then, how rewarding it was when the manuscripts got accepted for publication! I was, and still am, proud of some that found their way to well-ranked journals.

I am greatly indebted to my advisor, who provided critical comments and was always one step ahead of me, seeing the next challenges and possibilities. The thesis would not have been possible without the always helpful laboratory personnel. My two visits to TU Braunschweig were very beneficial, not only by leading to two journal papers but by teaching that doing science benefits from collaboration. Also the connections to the more practical work on the topic at the Finnish Environment Institute kept me motivated and paved way for my next career steps.

I got a baby during the thesis process, and that changed the boundary conditions for working quite much. Combining doctoral studies and motherhood is completely doable but requires good management of your time and work as the hours are limited. Finally, I encourage those considering doctoral studies to be confident in following their interests — complementing a D.Sc. degree is hard, but motivation helps you to get there!

Your advice now to yourself then?

Document metadata also on the data processing and analyses conducted, so that you won't be lost in the tens of different file versions!

Abstract

Riparian vegetation growing on river banks and floodplains has pronounced impacts on the flow of water and the transport of substances, including fine sediment. These plant-mediated processes shape fluvial ecosystems and are essential in applications of environmental hydraulics, such as in compound channels with vegetated floodplains. The flow–plant–sediment interactions need to be estimated at different scales, but suitable parameterization of natural flexible vegetation for hydraulic analyses has been difficult. The objective of this thesis was to provide new insight on flow resistance and cohesive sediment processes in compound channels with riparian vegetation. The cross-cutting aim was to improve the parameterization of natural, flexible, foliated plants. The drag forces and the flexibility-induced reconfiguration were examined for five woody species in a laboratory flume. The flow resistance, net deposition and the suspended sediment transport were quantified under differing floodplain vegetation conditions (bare, grassy, woody) in a cohesive agricultural compound channel. The experimental investigations were accompanied with the application of existing and new models.

The drag forces and reconfiguration of foliated woody plants were controlled by the leaf-area-to-stem-area-ratio, because both the foliage and the stem contributed notably to the plant-scale drag. The flow resistance of natural foliated vegetation was successfully modeled using a novel drag–density parameterization (Eqs. 18–23) that accommodates the reconfiguration and density separately for the foliage and the stem. The new parameterization improved the description of woody vegetation compared to the conventional approach of considering plants as rigid cylindrical elements. The flow resistance in the compound channel could be estimated by a two-layer model using the drag–density parameter and the vegetation height represented by the cross-sectional blockage factor. These same vegetation properties explained the net erosion and deposition of cohesive sediment on the floodplain, although deposition was supply-limited in long and dense plant stands. The timing and magnitude of cohesive sediment transport in the agricultural compound channel were governed by out-of-channel processes.

As a practical implication, the sediment load transported in compound channels can be managed by appropriately maintained floodplain vegetation. In conclusion, straightforward approaches accompanied with a physically-based vegetation parameterization can be successfully used to describe the effects of natural flexible riparian plants on flow resistance and sediment deposition.

Leena Stenberg

Erosion and sediment transport mechanisms in drained peatland forest catchments after ditch network maintenance *(2016)*

In the beginning I didn't know much about drained peatlands, but I was motivated to learn, and when I was offered a four-year position in VALUE doctoral school, I decided to take on the challenge. I started my thesis process without really thinking about what I have got myself into. From the start there was a 'black cloud' hanging somewhere nearby, the thought that all this would eventually end up in defending the thesis in the public examination. How could I ever survive such a thing? Compared to that, writing the thesis seemed like a piece of cake. I decided to focus on that cake and tried to forget about the other scary stuff for a while.

The research went smoothly, thanks to excellent supervisors and a great team that they had gathered around my thesis. Of course, there were also difficulties to deal with; my first article took a while to publish but, after that, writing and publishing became easier. My last article led me into the world of coding, as the data was too big to analyse using Excel. That was one big leap I wish I had taken sooner. And it was surprisingly fun!

The best and most memorable moments relate to field work. It was always quite a challenge; there were logistical challenges, as the sites were in the middle of forests far away from Otaniemi, technical challenges with all the field equipment, and physical challenges like cold, heat, mosquitoes, long days, and so on. But in the end, all went well, and it always felt like a small victory that we celebrated with a good meal after a long day - whether in ABC petrol stations or fancier venues such as the Bomba House in Nurmes.

For me, there were two kinds of processes going on; the dissertation work, and the challenge of being able to give a decent presentation so that the audience could focus on the subject and not my anxiety. Events organised by VALUE let us regularly practice presentations, which was great but also very stressful. A couple of months before the public examination, I participated on a course that focused on how to give presentations... better late than never. Surprisingly, the dreaded dissertation defense day actually turned out to be very nice. Although I still don't like to speak in front of an audience, I feel that day was a kind of turning point for me.

I would like to encourage all of those people who have the academic curiosity to attempt doctoral dissertation, but who are nervous about having to stand up and speak in public, not to let that obstacle get in their way.

Your advice now to yourself then?

Enjoy the process, don't stress too much about little things, and start learning how to code at once.

Abstract

It is common practice to drain peatland forests in order to obtain better conditions for tree growth. Ditch network maintenance (DNM), the cleaning of existing ditches and digging of new supplemental ditches, is needed every few decades. DNM causes some of the most harmful environmental effects of forestry due to the sediment load induced by the increased erosion in the ditch network. The main objectives of this thesis are: 1) to identify the key mechanisms inflicting erosion and sediment load following DNM, 2) to compare pin meter measurements and terrestrial laser scanning (TLS) for roughness assessment and the change detection of peatland forest ditch topography, and 3) to discuss the practical implications of the results.

Two experimental areas were included in the thesis. In Santamäensuo, bank erosion induced by seepage was studied in a short-term experiment post-DNM by using artificial irrigation and pin meter measurements to quantify the changes (erosion and deposition) in the topography of a cleaned ditch bank. In Koivupuro, erosion mechanisms were monitored for two years following DNM by applying pin meter measurements and TLS for the change detection of ditch topography, as well as simultaneously measuring discharge and suspended sediment (SS) load at the main catchment and sub-catchment outlets. A paired catchment method was applied using a nearby reference catchment to estimate the impact of DNM on the SS load. Reference catchments were also utilized to assess the changes in unit hydrographs caused by DNM.

The results indicate that several interacting processes and mechanisms affect erosion and sediment generation from the ditch network. Subaerial processes, such as frost and desiccation, prepare the bank for erosion. Bank erosion had an important role in producing sediment in the network, while the role of bed erosion was more modest. In the area of thin peat layer, erosion was the highest during the winter-spring period, while in the peat ditches, most of the erosion occurred during the summer time. Erosion inside the ditch network was significantly higher than the SS load at the catchment outlet, indicating that there is a vast potential of easily transportable sediments deposited at the ditch bed. Vegetation started to develop in the first summer following DNM stabilizing the banks and reducing sediment transport. The hydro- graph analysis showed that DNM increased the discharge peaks and shortened the mean transit times in the catchment. The timing of the peak was more influenced by the proportion of the drained area of the catchment. There were differences in the results, but both methods (pin meter measurements and TLS) indicated that more erosion and higher roughness occurred in the ditch with a thin peat layer, especially in the fine-textured mineral soil part of the ditch bank, which emphasizes the importance of avoiding cleaning areas of thin peat where possible.

Suvi Sojamo

Water-using corporations as agents of water security, management and governance - Exploring cases from stewardship initiatives in South Africa to global networks of power *(2016)*

In spring 2010, I sat at the bank of River Thames in front of Tate Modern in London and felt torn between two worlds. I had finally started to feel like home in the UK and enjoyed tremendously the intellectually ambitious and critical spirit at the University of London and its colleges, attracting leading scholars, practitioners and activists from all around the world. The reason for my inner battle was an invitation from professor Olli Varis to return to Finland and the Water and Development Group, joining a project on Central Asian water security as a PhD researcher. It could have been the birches fluttering their leaves which were planted for and installation in front of the Tate, but more likely the calling of a community I knew to be equally driven and frankly, more humane than that of British academia back then, that made me decide to come back home. On the additional plus side, Helsinki had real birches.

My PhD process, best described as a winding road with several ups but downs too, took almost immediately its most dramatic turn — with a change of the government, the envisioned funding for the work in Central Asia was withdrawn. Olli and my instructor Dr. Marko Keskinen gave me the liberty to decide whether to remain and what to focus on. I chose to continue exploring the role of big water using businesses in water security, management and governance I had started in London with Professor Tony Allan and then Dr. Mark Zeitoun, an unexplored and thus risky but at the same time rewarding pioneer topic.

Having chosen a topic none of my colleagues at Aalto had previous expertise in, what helped me the most throughout the process, besides the unwavering backing from Aalto WAT, was building an extended international network of devoted instructors, mentors and peers and lifelong friends with whom to navigate the uncharted waters.

With the network, I joined the Water Security Research Centre at the University of East Anglia as visiting research fellow hosted by Mark, benefiting from the pros of the well-structured UK doctoral system. Furthermore, I was given an opportunity to contribute to the real-life processes of developing corporate water stewardship principles and practices as a consultant at Water Witness International led by Dr. Nick Hepworth, conducting field work in South Africa and contributing to international guideline development. While I did not do my PhD as a part of a bigger research project, consulting work granted me a context to test my concepts and hypotheses in and an access to invaluable research data, and vice versa, a channel to feed my analysis results and recommendations back to the ground.

Navigating between disciplines meant I could not publish my articles in the highest impact or the broadest readership journals, but my work felt meaningful due to its direct relevance to the developments in the rapidly evolving and practical field of corporate engagement on water.

During my process, I learned many things the hard way. If I was to start anew, first, I'd spend more time on building a workable research plan with a robust methodology and doable scope — all the pieces fell into their places eventually, but with less rush at the beginning, I could have built a more solid foundation. Second, I would and will not anymore work nights and weekends just to meet overtly ambitious deadlines set by people with worse time management skills than mine. Finding a sustainable work-life balance is a key to being a sustainability professional with resilience. Third, academia, especially in the UK back then, was often a very hostile environment for a foreign young woman. Even though I reached out, many experiences would have been less painful with more support. Demanding respect, celebrating diversity and defending the more vulnerable can never go wrong.

I was happy to engage in starting discussions on addressing these issues at Aalto during my doctorate and am really glad to see how the doctoral programme has developed into something others internationally are keen to learn from.

Today, it would take me a lot of convincing to go to do a PhD anywhere else.

Your advice now to yourself then?

Trust your instincts, take your time and don't try to solve it all alone.

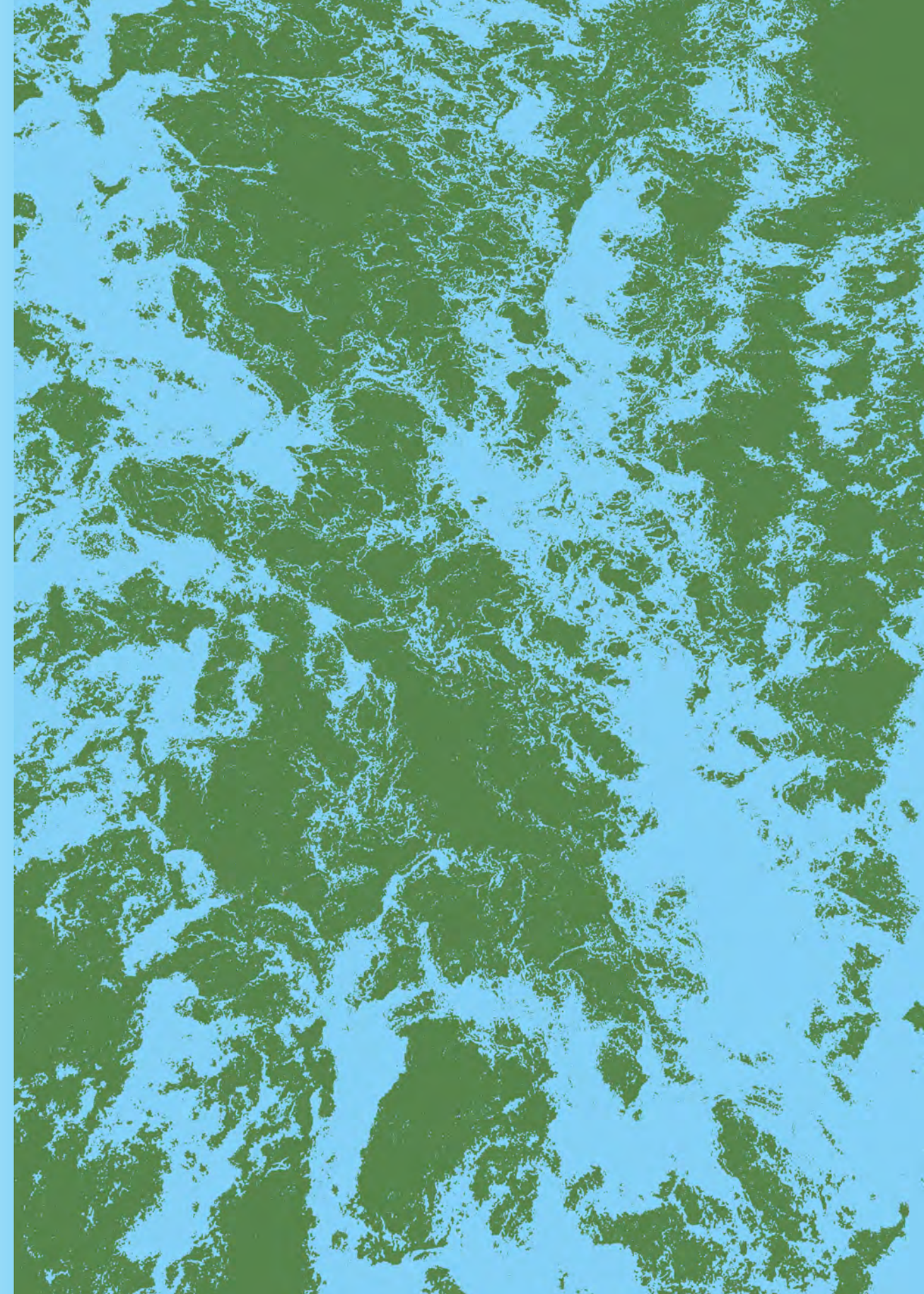
Abstract

This dissertation explores the largest water-using corporations as agents of water security, management and governance. An analytical framework is constructed to investigate different forms of corporate power and strategies, their drivers and legitimacy to engage on water. The framework is applied to, and tested with, three case studies: 1) corporations dominating the water-intensive global agro-food value chains and networks, 2) corporations engaging in the development of corporate water stewardship principles and practices, and 3) corporations engaging in corporate water stewardship initiatives and projects in South Africa.

The corporations studied are found to have remarkable power to change water management and governance processes with implications for water security from global to local level. The corporations dominating the agro-food value chains and networks

are identified to be part of a global 'virtual water hegemony', and corporations engaging in the development of the corporate water stewardship principles and practices to be contributing to an emerging transnational water governance regime. Predominantly driven by water scarcity, stakeholder pressure and public sector failure to act as the custodian of water resources, the corporations are shown to have become increasingly active and proactive in their water engagement strategies and tactics. Legitimacy of their engagement is found to be questionable, however. The corporations studied are yet to embrace water in their strategic cores. Equal participation, accountability and transparency are found to be in need of improvement in all the engagement processes in focus. Outcomes of the processes are shown to include much needed drive and resources for multistakeholder collaboration on water, but previous concerns of fragmentation, re-inventing wheels and private capture of public institutional processes and resources are also confirmed.

The findings of the dissertation show how water-using corporate engagement has become increasingly central to processes of water management and governance. If water security for all is to be reached instead of risk management for a few, however, corporate engagement demands further scrutiny and guidance. The analytical framework developed is proposed as one tool for this purpose. Policy efforts globally are recommended to be targeted towards ensuring equal participation, accountability and transparency in corporate water stewardship initiatives and broader processes of water management and governance where corporations engage.



Miina Porkka

Securing global food supplies with limited resources - Lessons from the past *(2016)*

I started my Doctoral studies a couple of months after finishing my Master's thesis at WAT, without really discussing the process with anyone or thinking about what it would require of me. Perhaps it was a good thing, because knowing what the process will be like might have made it feel all too daunting. That's not to say I don't think it was worth it — quite the contrary. I learned a lot about research, the world and myself, and as a researcher, a doctoral degree is a must. But would I have done it had I known what it is like? I never know what to answer to that.

When I think about the actual research process, I mostly remember the difficulties: being frustrated with the slowness of it, feeling stuck, feeling like I never knew enough of my topic or the methods I was using. The highlights of doctoral studies often had little to do with actual research. My fondest memories are probably from staying in late with other doctoral students with the aim to finally tackle that research problem I'd been stuck with for weeks but ending up talking about our struggles with research or whatever else was going on in our lives, turning the office into an arena for made-up games using office supplies or writing a comedy show about socially awkward IT engineers. The one research-related highlight that still makes me smile is my defense day, which completely surprised me by being very enjoyable. Everyone had told me to "try to enjoy it", but I didn't think it would actually be possible.

Six years after receiving my doctorate I still struggle with the same aspects of research that I found most difficult during my doctoral studies. The difference is that I now know that those struggles are a part of the process (or at least my research process) and that I know how to deal with them, although I'll need to remind myself of it every now and again. So, to my younger self and anyone else who might find it useful – and as a reminder to my current self — here are a few pieces of advice:

1. Be honest about your struggles with your supervisor, advisors, mentors and peers — or really anyone who will listen. Talking about the process and its difficulties can often be more useful than just trying to work through it. Most people will want to help you, either by offering advice, concrete help or peer-support. No-one will judge you for finding it difficult.

2. Remember that meaningful research takes time. During my doctoral research, I would get frustrated by how slow the process was and how little of it actually ends up in a paper. "Someone who knew what they were doing could have done this in two months, whereas it took me a year after all the detours and dead ends", I would think.

That's a very silly thought, because the detours and dead-ends are an essential part of the process. What would be the point of studying something if you knew what to expect and where to go beforehand? It's a silly thought also because I am not and never will be anyone else, so why not just work with my strengths and trust that it is enough.

3. Don't aim for perfection. Done is almost always better than perfect. Ask for feedback in the early stages of planning, doing analyses and writing. It can be scary because school and university studies don't prepare us for it. Before doctoral studies, you were almost always asked to deliver the final product of homework, essays and projects for evaluation and feedback. I remember feeling crushed after receiving feedback on my first dissertation paper from co-authors and supervisors. I had worked for weeks drafting the manuscript, editing and polishing the text until it was perfect, only to receive dozens of comments on how to make it better. Constant feedback gives you a chance to learn while doing the work, not after you've already given it everything you have.

4. Have a life outside of doctoral studies. I think this is essential, to help take your mind off research and to put things in perspective. It's easy to take research (particularly your doctoral research) very personally because your work is constantly being evaluated and critiqued. Note, however, that you are not being critiqued — if you are, try to find better people to work with. Research is just a job, after all.

Abstract

Humanity's ability to sufficiently feed the growing population has been under debate for centuries. To sustain the growth, we have had to push the boundaries of our planet, which has increased the scarcity of land and water resources needed for food production. This race was notable particularly during the latter half of the 20th century, when both the world population and food production more than doubled. To meet future demand, food production would once again have to double by the year 2050. Humanity's responsiveness has been remarkable in the past, thus to gain insights into where and how we can improve in the future, there is much we can learn from the past.

This dissertation examines the effect of resource scarcity and agricultural trade on food availability globally. Temporal focus is on the time period after the green revolution, 1961–2009, during which population, agricultural production and global trade all exploded. By focusing on the historical context, the dissertation aims to identify different conditions and strategies for securing local food supply and, on the other hand,

barriers that hinder this goal. The global framing of the research provides a comprehensive overview of the issue, building foundations on detailed, more localized studies.

The dissertation found that food availability improved considerably in most regions within the study period. Much of this development can be credited to increased food production through improvements in resource use efficiency, while rapidly increased global trade has also helped to distribute global food supply more evenly. Resource scarcity in food production has increased notably with intensifying population pressure. It was found that food imports have nearly universally been used cope with these local resource limitations. Currently about 60% of the population experiencing resources scarcity lives in areas where adequate food supply has been made possible with food imports. Despite the generally positive effects of trade in terms of food availability, in some water scarce regions, excessive water consumption in production of goods for export may increase water scarcity.

Achieving future food security will require many overlapping measures. The likely increases in food trade will need to be accompanied with efforts to reduce the vulnerability of the network and improve trade policies. On the supply side, sustainable intensification of agriculture could increase food production in regions where full potential has not been reached yet. Sustainable consumption patterns, such as eating less animal based food and reducing food waste, are needed to reduce food demand. Ultimately, achieving future food security will also require solutions to improve social justice and equity.

Henri Haimi

Data-derived soft sensors in biological wastewater treatment - With application of multivariate statistical methods *(2016)*

When I started working in professor Riku Vahala's Water and Wastewater Engineering group in HUT, I had no idea that I would do PhD one day. My first project in the group was on treatment techniques of a new WWTP in Espoo, the location of which not decided yet, but today known as the Blominmäki plant. The second one was a survey of instrumentation, control and automation in Finnish WWTPs, done in collaboration with Dr. Michela Mulas from the Process Control and Automation group. Then game the third project, focusing on the post-filtration unit of the Viikinmäki WWTP — done together with Michela, who had now moved to Riku's group, and Dr. Francesco Corona from the Environmental and Industrial Machine Learning group. During that project Riku asked me one day if I want to do a PhD. I was fine with that and after some paperwork I was officially a PhD student.

Straightforwardly, Michela and Francesco became my thesis advisors. My earlier research background was mostly on wastewater treatment processes, and together with my advisors we formed a team with variety of competences useful to study and solve challenges in WWTP operation. And Riku as the thesis supervisor supported us with his excellent contacts in the water sector and valuable experience in research funding.

The technical approach we used the third project was developing software sensors by means of data-driven (or data-derived, as we called it) modelling. Soft-sensors also formed the central theme of my PhD thesis. We applied mainly multivariate statistical methods for modelling and analysis. Fortuitously, I already had some earlier experience on using multivariate statistics from the licentiate thesis, which I had done for professor Markku Hurme of the Plant Design research group. But the use of those methods was now in my PhD research on a much more competent level, thanks to my advisor's expertise.

The best moments during my PhD project obviously include getting research papers accepted and receiving positive financing decisions. I also remember many moments in the office when I learned valuable lessons about scientific work from my thesis advisors. The specialist conferences I attended to were among the definite highlights: I met many of "big names" whose literature I had studied, and they actually were pleased to notice a researcher from a Finnish university attending.

One of the highlights naturally was the PhD defense where my opponent was emeritus professor Gustaf Olsson, who had made a long and groundbreaking career in the field of automation and control of WWTPs. In fact, Michela had recommended me to read his books

as the first thing when we started to collaborate. I had earlier met Gustaf in conferences, where he always was very supportive to newcomers like me and gave inspiring keynotes. Therefore, having Gustaf as the opponent closed the circle in a perfect way.

One of the main challenges during my PhD project was that funding for my research was in many small pieces from here and there. That also meant that research was planned in several pieces, which sometimes made it challenging to see the big picture of the PhD thesis, especially in the early stages of the project. In the end, those pieces formed nicely a whole in the thesis synthesis and creating the storyline was a relatively easy task.

My main motivation for doing PhD was learning new things that would make me a better professional for solving problems and developing new solutions. And I did learn a lot. Not only new technical skills, but also scientific writing, applying new information, combining things from different scientific fields and working with people from different backgrounds. I got new insights as a wastewater treatment professional as, in the end, the focus of our applied research was in solving practical challenges in treatment process operation.

Your advice now to yourself then?

Remember to zoom out from details of your research at times, learn from all the talented people around you and consider visiting another top-quality research group abroad.

Abstract

The increased awareness about the ecological status of the waterbodies and, on the other hand, the advances in the treatment technology have acted as driving forces behind the gradual tightening of wastewater purification requirements. Achieving the stringent treatment targets of wastewater treatment plants cost-efficiently is crucially dependent on the high-grade monitoring and control of the process units. Those, in turn, necessitate reliable real-time information about the primary process variables. In spite of the considerable developments of on-line sensors, demanding conditions in biological treatment processes sometimes give rise to an insufficient performance of instruments.

The main motivation for this thesis was to design software tools that enable more efficient and safer treatment process operation by complementing conventional instrumentation. Since modern facilities are amply instrumented and there are plenty of accessible historical data, data-derived approaches were used in the studies. The data were processed together with predictive models providing virtual instruments often referred to as soft sensors.

In this thesis, the models at the core of the soft sensors are based on multivariate statistics. In particular, principal component analysis with its variants and least-squares-based regression methods were employed in the soft sensor development. The moving-window techniques were applied so as to adapt the models to time-varying wastewater treatment processes. Both linear and nonlinear regression methods were explored.

The technical studies of the thesis concern a large-scale municipal wastewater treatment plant. An array of soft sensors for the on-line prediction of nitrate concentrations was developed to support the operation of the biological post-filtration unit. Then, a system that enables the complementary use of the soft sensor estimates and the corresponding hardware instrument measurements was designed. The soft sensors were found to model nitrate concentrations accurately and, especially when integrated with the proposed switching system, to allow for a more secure control of the unit. In addition, a soft sensor for detecting process and instrument anomalies in the activated sludge process was investigated. The presented anomaly detection system motivates a more efficient use of sensors in the process control. It was demonstrated that soft sensors were applicable to the considered tasks and that they have strong potential for providing support to the operations of treatment facilities. The employed multivariate techniques proved to be capable of extracting easily understandable and practicable information from the high-dimensional data.

Mirja Kattelus

Framing wicked water problems: Cases from large Asian transboundary river basins *(2017)*

I first got interested in the topic of Integrated Water Resources Management listening to a lecture given by the Water and Development Research Group during my third year in University. It struck me as especially fascinating due to its search for solutions to the water challenges on a global scale, emphasizing the need for holistic perspectives and embracing cross-disciplinary solutions. I also thought of it as an impactful and meaningful topic, the lecture giving me the first push towards the development sector, where I have worked since my graduation. Once a Master's thesis position was advertised for the same research group, I immediately got interested. After completing my Master's thesis in the topic of water resources management in Myanmar, I got an opportunity to continue to do a doctoral dissertation. I felt both curious to continue to explore the topic as well as overwhelmed by the possibilities and responsibility of doing a doctoral thesis.

I was lucky to get a place in a Doctoral School for Built Environment, which meant a four-year funding for my doctoral dissertation. However, the first challenge I faced when starting my thesis was that the research plan I wrote for the funding was extremely broad and did not serve me as a guidance for the first steps of my doctoral dissertation. As this was the plan I had written to get my funding, I was hesitant to reiterate it, and felt tied down by it as I progressed with the research. The lack of focus and unclear framing of my research questions weighed me down throughout the process of writing my dissertation, no wonder I finally titled the thesis 'Wicked water problems'!

I would call the process of my dissertation very meandering and laborious, with numerous side steps and back and forths. Although afterwards I am aware that this indeed is part of the process, while in the depths of writing the dissertation, it feels like you keep taking the wrong turns. The most helpful moments were when finding ways to collaborate with colleagues and receiving peer support from the fellow doctoral students. This brought in fresh ideas and also led me to experiment with new methodologies and approaches as I was exploring my research questions. It also reminded me that one is not alone with the struggles, but many others face similar challenges while writing a doctoral dissertation.

Writing a doctoral dissertation is a personal process, and makes you question your skills, level of thinking and confidence endless times. The most valuable lessons for me from the process were that each experiment and "wrong turn" helps you forward in one way or another, and there is nothing like wasted effort in doing research or in work life. It also taught me how important it is not to let the amount of time passed and the challenges you faced to overburden you, but to give oneself an opportunity to continue with a fresh outlook at any stage of the process.

Your advice now to yourself then?

Embrace the unique opportunity to focus on a topic that really is in the core of your interest, and not feel so overpowered by the endless directions the research can take you. Openly seek for advice and support when you feel stuck or lose track, and discuss the uncertainties and doubts that go hand in hand with doing research.

Abstract

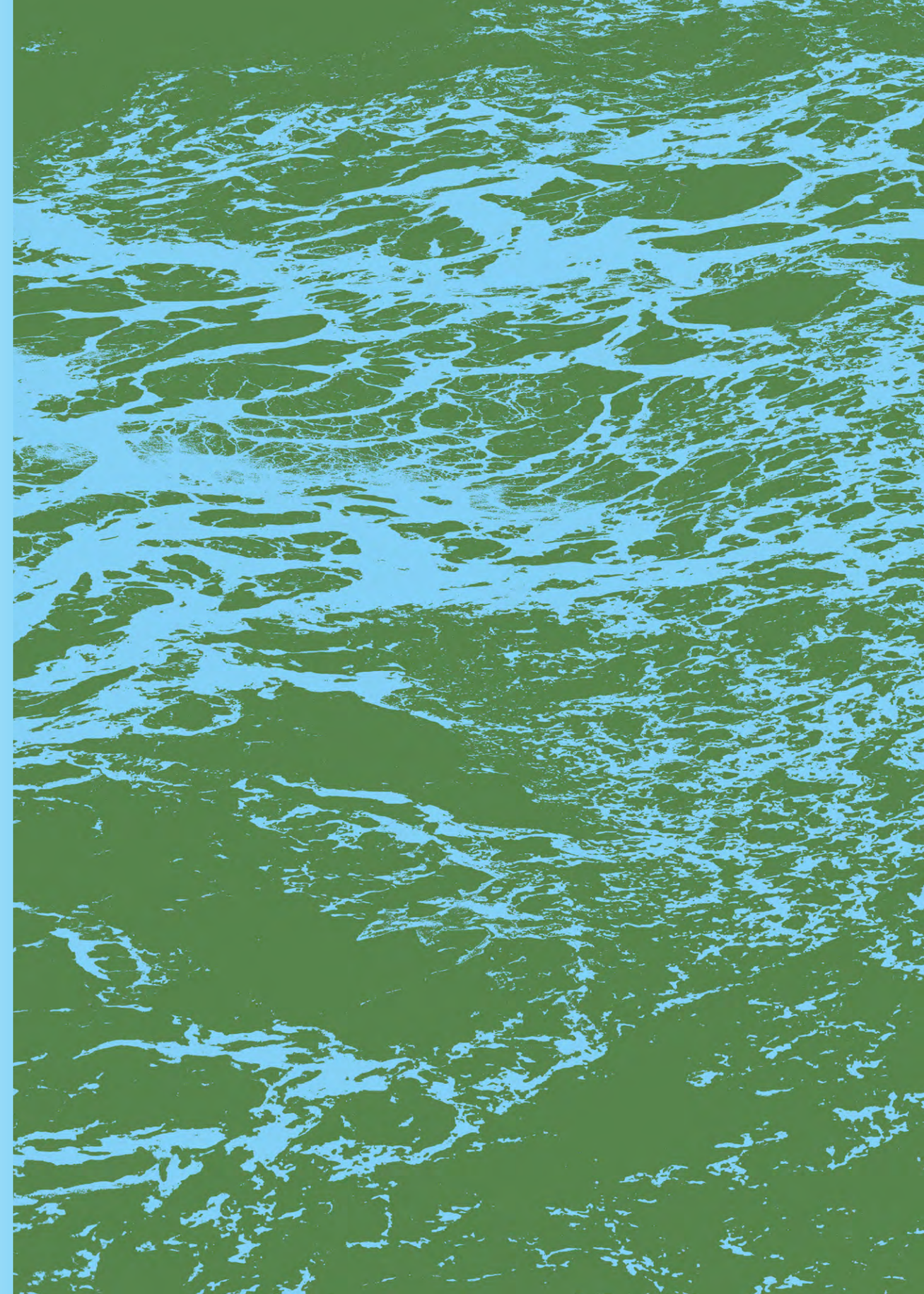
The recent two decades have witnessed major economic growth and development in South and Southeast Asia. This has led to massive changes and development pressures in the region's transboundary river basins, posing major stress to ecosystems, natural resources and livelihoods. The growing pressure on the existing water resources, close links between water, energy and food as well as the complexity of the problem setting, call for holistic approaches towards managing the shared water resources.

Integrated approaches such as Integrated Water Resources Management (IWRM) and Water-Energy-Food nexus (WEF) have been broadly promoted as exemplary holistic processes for guiding water resources management while understanding the broader connections to ecosystems and society. However, through critical examination it is found that they have not yet fully succeeded in providing solutions for transboundary water management: Firstly, they regularly fail to reach and engage other sectors apart from water, the solution potentially remaining limited and water-centric. Secondly, they seek to harmonise the water management policies and practices, while the reality is imbalanced, asymmetrical and dynamic.

To better capture this complexity, this dissertation proposes exploring transboundary water management through the framing of wicked problems. Wicked problems are considered to be difficult to solve due to the following characteristics: The problems are ill-defined; Knowledge is incomplete or contradictory; There are a large number of people and opinions involved; The problem creates a heavy economic burden; and These problems are closely interconnected with other ones.

Based on the findings of this dissertation, it is argued that characterising water management as a wicked problem — while not providing a concrete set of tools or methods — brings new perspectives to the water-related development challenges in a transboundary context and addresses some of the shortcomings of the integrated approaches. It provides a 'reality check' to the management problems by featuring their complexity in contrast to the more harmonic approaches and by stressing the importance of setting the problem and solution boundaries across relevant thematic, spatial and temporal scales. It further highlights the complexity of the actor space by emphasising that the problem and solution depend on

the underlying perspectives, values, interests and the role of power. Despite its inherently pessimistic echo, wicked problems as a concept brings forth an idea that partial and satisfying, instead of optimal or final, solutions need to suffice, as long as they together lead to an overall improvement.



Mika Tähtikarhu (née Turunen)

Assessing water and sediment balances in clayey agricultural fields in high-latitude conditions *(2017)*

There and back again: A traveler's guide to the sources of knowledge

I propose to speak of the sources and formation of scientific knowledge, even though I recognize that it is a rash adventure. While all of us have used scientific knowledge for a range of purposes, I claim that the primary sources still remain familiar only to a rare audience, to sparse travelers. Some call these brave travelers doctors, but they have also several other names. And it is not merely a coincidence that the realms of knowledge have only a few travelers. Exploring the realms is harsh and the journeys are full of pitfalls, especially for the overbold. I have explored the realms for some years and would like to share my findings and advice with you, fellow traveler. Note however, that my advice comes with a warning. The realms are deep, wide and unforeseen, and no one knows them thoroughly.

During the first journeys you would most likely just get lost or come to a dead end without the guidance of a mighty supervisor and advisor. Thus, choose them wisely and be active to seek wisdom from them! Remember, however, that it is your journey. But companions can show you where to begin, supply you with the necessities for the long journey and provide help when you are stuck or lost on the way. They will also show you how to build proper tools and use rigorous methods to be able to step beyond the frontiers of knowledge, to travel through mists and mountains to new domains of science. All journeys are different, and your companions can tell you what kind of toolbox you likely need in the landscapes where you are heading. Use time to find out what you need, and use a lot of time to build new tools if necessary!

Traveling to new landscapes is a long journey and finding them is more exciting than anything. Luckily, previous travelers regularly leave notes, papers, which report their findings and guidance. When beginning your journey, the notes might seem scattered, like leaves in the windwhirl. Some, though not many, may even be unclear or miss details. My advice to you is to keep reading diligently, and slowly you will start to understand the big picture and different phenomena which underpin and control the realm. Thorough reading will help you to focus on the essentials and to find areas where no one else has travelled. Look for places where you can see far, but make sure to understand details well when you move — else you will lead yourself to a pitfall. And keep your eyes open all the time, as the landscape can move a bit when new findings appear!

When you find new areas in the realms of knowledge, it takes a lot of time to make sense of the findings. A lot of time. Probably during your previous studies you have never constructed new scientific knowledge, and will thus get confused when trying to map a new area in the realm.

It is important to understand that often it is not possible to map a new area entirely at once. Despite your hard work, some shady corners can remain in the territory and cast a shadow of uncertainty on your findings. But do your best, and be prepared to come back frequently with different toolboxes and improved resources. Mapping and reporting a new area is like forging a sword. It is hard and requires endurance. Sweat and tears. And skill. Integrity. But in the end you might have a new shiny piece of knowledge — and a paper. And when you learn to do science, knowledge will always look different than before your journeys.

My final advice for you is that after you have travelled in these realms, make sure to travel back home frequently and take a lot of time to recover and relax. During my journeys, I have seen some companions who have travelled too fast too far and got exhausted. Thus, even though the realms are filled with wonder and grandeur, don't let it drive you over-enthusiastic. Work hard, enjoy the journey and take care of yourself. I wish you fulfilling journeys and I'll meet you on the road!

This text was inspired by the essay "On Fairy-Stories" by J.R.R. Tolkien.

Your advice now to yourself then?

(can be found from the text above)

Abstract

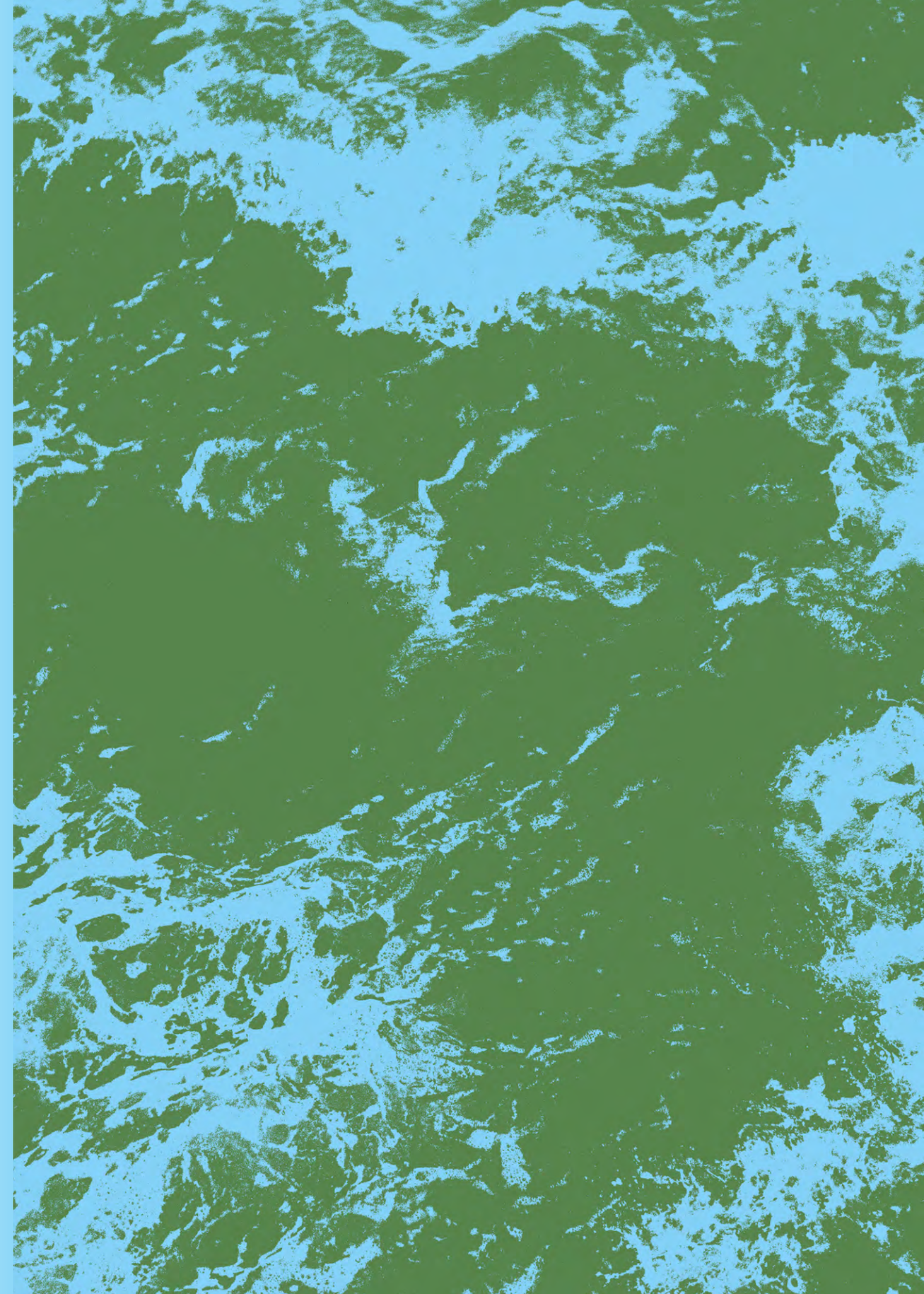
Comprehensive knowledge of hydrological processes controlling water flow, erosion and transport of substances is a prerequisite for the design of water management procedures for sustainable crop production. Knowledge gaps currently exist regarding hydrological processes and flow paths of water and sediment in subdrained clayey soils in high-latitude conditions.

This thesis aimed to quantify the dominating water and sediment balance components in subdrained clayey soils in different drainage, topographic and hydrometeorological conditions. Moreover, the thesis aimed to quantify the dominating erosion processes and evaluate the capability of a three-dimensional (3D) dual-permeability model to tackle the preceding objectives.

The simulation results and data covered a range of experimental conditions and produced a closure of water and sediment balances. Lateral preferential groundwater outflow, which has not been quantified in previous studies, was shown to form a major water balance component, and terrain slope was shown to control its magnitude. Due to the groundwater flow processes, field areas were linked to non-local processes. Topography of the field areas and the surrounding areas were shown

to have an impact on the hydrological effects of drainage installations. Evapotranspiration (ET) dominated the annual water balances. However, the results suggested that standard ET estimation methods have to be adjusted to accurately estimate ET in high-latitude conditions. During the growing seasons, groundwater outflow formed the highest outflow component. Most water and sediment outflow occurred outside the growing seasons when ET was minimal. Drain discharge was the highest outflow component during the dormant seasons, and subsurface components dominated the water outflow. The results suggest that tillage layer runoff (TLR) typically occurred due to saturation a excess mechanism. Typically, soil frost did not have a high impact on runoff generation, although occasionally frost conditions increased the amount of TLR.

Subsurface transport pathways dominated the sediment loads. Load via subdrains formed the highest load component, and load via groundwater outflow contributed to the simulated load generation. Simulations provided a quantification of sediment balances and demonstrated that the majority of the eroded particles at the field surface did not form load. Three model structures demonstrated how structural uncertainties can impact the simulation results. The 3D dual-permeability approach was found to be a suitable method for water and sediment balance analyses. More detailed analyses would require detailed data on hydraulic properties in deep soil layers and erosion and sediment transport processes within the fields. The results suggest that the design of drainage and water protection measures should focus more on subsurface flow and load pathways.



Tero Niemi

Improved Precipitation Information for Hydrological Problem Solving - Focus on Open Data and Simulation *(2017)*

The first thing coming to my mind... Probably banging my head against the wall and waiting to see which one gives up for the first couple of years. The field of stochastic precipitation modeling was new to me and in fact new to almost everyone in Aalto before I started my process. There were not many who I could ask for help regarding the subject matters, but instead I had to read and try to understand a huge pile of papers. Luckily, at least some of them were somewhat more understandable than the rest.

Because of doing somewhat lone work with my subject, the best moments during the process were by far the coffee and lunch breaks we had together with the WAT people. Those of us who had been located first in Meritekniikka and later in TUAS and WAT-buildings formed a very tight group. I have a strong feeling I would not have finished my doctoral process without these venting breaks or the extracurricular activities we organized. And, of course, it was also always nice and worth celebrating when my paper was published. Somehow the feeling is not nearly the same after the dissertation is finished and getting your degree does not depend on publishing papers. Not that I miss the pressure.

The biggest change during the process was me forcing myself into URCA-project as a semi-formal hang-around member after publishing two papers regarding stochastic rainfall modeling. This meant a turning point for me both in the scope of my thesis (stochastics were out, urban hydrology was in) but also in the way I got to work from this point on. Now, for the first time during my thesis process, I was (almost) in a project and within a real project group. Coffee and lunch breaks were still great, but now I had the chance to also work in an actual group and to participate in other people's work. Highly recommended!

Besides the URCA people and our coffee/lunch break groups, two individuals are worth mentioning somewhat more than the rest who helped me along the way. Teemu was my thesis instructor, and he was invaluable. Despite being a thesis instructor, since the field of my thesis was new to everyone including Teemu, he could not always help that much with the subject matters. What he always did, however, was listen. Quite often that was enough, and just having someone who I could try to explain the problems helped me understand something. Pirjo called Teemu my reading dog, like the ones that help you in a library. And, I must admit, Teemu also did have some good ideas every now and then. The other invaluable individual was Alan. He was my host/supervisor when I was visiting CAWCR/Bureau of Meteorology in Melbourne, Australia for half a year. Alan is one of the gurus in the field of stochastic precipitation modeling. To me it was, however, a huge confidence boost when I walked into his room to ask him something regarding the model only to get the answer "That's a very good question Tero, I don't know [the answer]." If this guy, who is one of the handful of people

who DO understand something about stochastic precipitation modelling, does not know the answer, maybe it means I do not need to know it either. At least not yet.

Your advice now to yourself then?

Interact with others. Preferably formally but do not forget the social side either. Also, be determined and persistent. That is what it takes. And varying amounts of time.

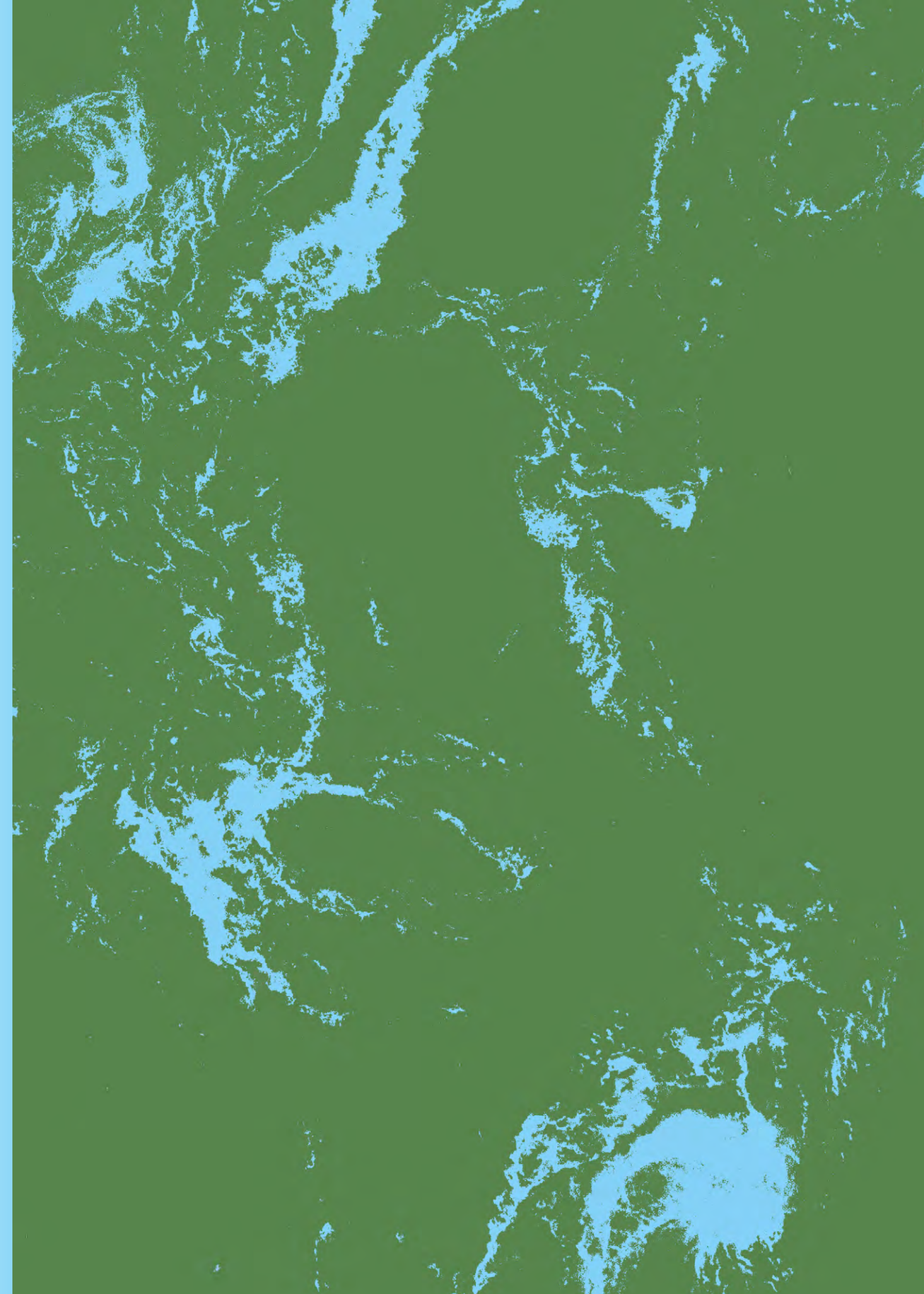
Abstract

Precipitation acts as the starting point and the driving force in nearly every field of hydrology. Rainfall-runoff models in particular require accurate rainfall input data in order to provide accurate runoff results. The data requirements are emphasized in urban environments due to small sizes and rapid runoff responses of urban catchments. In recent years, the amount of open precipitation data has increased due to changes in governmental policies and legislations. However, since measuring everything is ultimately impossible, there remains a need for precipitation simulation models no matter how much data is (openly) available. This thesis studied the benefits of improved precipitation information in hydrological assessments by addressing the following questions: 1) How can open precipitation data be utilized more extensively in hydrological research? 2) How can simulation models be improved via more realistic spatial description of precipitation fields?

The feasibility of open weather radar and rain gauge data for urban hydrological assessments was studied by conducting high-resolution rainfall-runoff simulations at small Finnish catchments utilizing open precipitation data and rainfall-runoff data collected at the catchments. The open gauge data performs well, given that the gauge is located at the studied catchment or close to it. When the distance to the gauge increases, gauge corrected radar data can give superior results even when the studied catchment is much smaller than the radar data spatial resolution.

A new method was developed to quantify the anisotropic shape of precipitation fields and the evolution of the shape during storm events utilizing the linear Generalized Scale Invariance formalism. The shape description was implemented into a state-of-the art stochastic precipitation generator to provide a parsimonious way for a more realistic description of precipitation features. Impact of the field shape on the catchment response was studied by conducting rainfall-runoff simulations replicating an extreme storm event. While the description of anisotropy allows for creating stochastic precipitation events that produce the desired rainfall accumulations without sacrificing other event characteristics such as storm advection or storm evolution, its effect was attenuated when exploring the catchment response.

This thesis lays groundwork for future advances in understanding the precipitation process from coarse radar scales to detailed urban scales by utilizing the open precipitation data more comprehensively. Amongst other things, the open data enables studying precipitation features across scales. The presented anisotropy quantification method allows for building better stochastic precipitation simulation models capable of reproducing more realistic precipitation fields for situations where measurement data, open or not, is unavailable.



Olli Sahimaa

Recycling potential of municipal solid waste in Finland *(2017)*

When I look back to my thesis writing process, I get a warm feeling in my chest. Maybe memories grow sweeter with time but the time of doing my doctoral thesis was mostly very positive time in my professional life. That is mainly due to the following reasons: 1) Having a very clear target that felt personally meaningful 2) Constantly learning something new 3) Increasing trust in own abilities and feeling of flow towards the end of the process.

I did my PhD during years 2014 and 2017. The process got started as I got funding from Aalto University School of Engineering to write a journal article based on my master's thesis. Quite soon after that, I got a position from Finnish Environment Institute (SYKE) and could continue my doctoral thesis there. It is hard to name a single best moment during my dissertation process. Getting the first paper published was maybe one of those. Writing the summary part of the article-based dissertation was also a good period as you could finally see the closing finish line.

There were a bunch of challenges also, for sure. As one of the projects did not produce the kind of results I expected, I decided to narrow the focus of my thesis from larger circular economy related themes to municipal solid waste only. That required some restructuring of my thoughts and giving up some of the topics I felt passionate about. Without separate funding for my thesis, I had to build my thesis as a part of different projects in Finnish Environment Institute. That required being very intentional with the limited time slots I had for my thesis. Looking back now, I had probably not finished my dissertation so fast without this necessity to scrupulous planning and using my time in a very structured way.

In the first place, the main motivation for me to decided to pursue a doctoral degree was the desire to improve my learning abilities. There is no denying also that the thought of having a doctoral degree as such felt fascinating. During the process, I learnt a bunch of new skills, most importantly self-leadership, planning, time management and broader, more systemic analysis of different phenomena.

I would like to thank several people who made it possible for me to pursue my dream and do the dissertation. My superior in Finnish Environment Institute, Tuuli Myllymaa, was extremely helpful and flexible in letting me proceed with my thesis and planning my work. My supervisor Jaana Sorvari and advisor Jyri Seppälä also offered valuable support. With the help of Hanna Salmenperä, I learnt a lot about municipal waste sector in different projects. Overall, without the supportive colleagues in SYKE, I would not have been able to proceed with different journal article projects that smoothly.

For someone considering pursuing a doctoral thesis, I would give the following advice: Try to create collaborations even though the academic working culture does not always support that. Remember that doing a PhD is special season where you (hopefully) have time to concentrate specifically to the topic you are interested. That can be a great experience.

Be prepared for the potential "post Phd blues" after finishing your thesis. This means that after the euphoria and the well-earned sense of achievement for getting the degree, you may feel lost and empty.

Your advice now to yourself then?

It is very difficult to perceive amount of work required for a doctoral degree when you are just starting the thesis process. You probably think you can do much bigger contribution to much broader area than it is realistic.

Try to publish the first journal article soon. That will give you a nice sense of achievement. Then you will also have a measure stick to evaluate the length of the rest of the process

Abstract

Increasing municipal solid waste recycling rate is a highly topical issue within Europe at the moment because European Union has set its member countries the target of a 50% municipal solid waste recycling rate by 2020. Finland is far behind from achieving the target: the recycling rate in 2015 was only 40.6% and it did not develop between 2006 and 2014 at all. This dissertation analyzes the recycling potential of municipal solid waste in Finland in order to provide scientific knowledge for the policy-making towards the 50% recycling target. A new method to study the composition and recycling potential of mixed municipal solid waste was established by compiling different stakeholders' information needs concerning municipal solid waste and examining the best practices in European composition study methods. The method includes a classification system, which ensures the accumulation of comparable mixed municipal solid waste composition data throughout Finland. The classification system was tested by conducting two mixed municipal solid waste composition studies. After that, mixed municipal solid waste composition data was utilized to build a waste flow model, which represents the generation and recycling of different municipal solid waste fractions in the various operations. The model was applied to develop a 50% recycling rate scenario for Finland. Municipal solid waste recycling potential was also measured at the city-level by testing the applicability of material loss indicator. The results indicate that Finnish mixed municipal solid waste from households contains averagely around 70–80% of recyclable materials. The largest additional recycling potential lies in biowaste and plastic. Achieving the recycling rate of 50% for Finnish municipal solid waste requires multiple significant actions. These actions include stricter obligations on separate collection in the door-to-door system, advice campaigns and pay-as-you-throw schemes to improve sorting efficiency of households, as well as developing the background data and expanding the collection of recyclables from administrative, service and business operations. Measuring recycling potential at the city-level by material loss indicator is challenging because current data sources are insufficient. The results of this study can be used for the strategic development of municipal solid waste management systems.

Julia Talvitie

Wastewater treatment plants as pathways of microlitter to the aquatic environment *(2018)*

The subject of my dissertation was wastewater treatment plants as pathways of microlitter to aquatic environment. It was first dissertation in Finland concerning microplastics and one of the firsts in a world about microplastics in water sector. When I started my PhD project in 2014, microplastic wasn't such a hot topic as it is nowadays. I got to work in a new and exciting field of research. And while the novelty brought me some challenges, it also gave me some advantages.

The motivation for microplastic research derives from the global environmental problem of marine plastic pollution. My background is in marine biology and microplastics was a term I had heard few times during my studies. The term microplastics describes the specific type of plastic pollution; tiny little pieces of plastic in size range of 1µ to 5mm. Marine scientist detected already very early on that these tiny pieces outnumbered the larger litter items in marine environment and that they were everywhere. This observation let to a question; where does this pollution comes from?

Wastewater treatment plants were suggested to act as one of the sources (or routes) for microplastics to the aquatic environment. In 2012, HSY (Helsinki region environmental services authority) and Viikinmäki wastewater treatment plant wanted to find out if their wastewater contained microplastics and if they indeed were the route for microplastics to the environment. HSY contacted my boss at the time at City of Helsinki and asked if this type of a research could be performed. In 2012 HSY was ahead of their time. There was practically no research done on the subject and there weren't any readymade methods to use. When my boss told me about this project, I got very excited and put a lot of effort to convince everybody that I'm more than up for a task to develop new methods! So, we started from the scratch; developing methods for sampling, processing, and analyzing microplastics from the wastewater. Big thank you to HSY for their patience and understanding on how slow and uncertain the progress was in the beginning. This preliminary investigation grew into my PhD project. It got me my funding from Maj and Tor Nessling foundation and my place at Aalto University water engineering group.

The research methods nowadays look very different from what we did back in the day, but nonetheless, we got valid results. Our main results still hold truth; municipal wastewaters contain microplastics, but most of them (in size class 20 um–5 mm) are removed from the wastewater during the treatment processes in Finland. This was good news, because the treatment processes are not specifically designed to remove these small and light (buoyant) particles from the wastewater. Many new questions have since raised about the faith of microplastics

in wastewater treatment plants and it's been a joy to follow how next generation of researchers now look more deeply into this topic. I enjoyed my time as a pioneer!

My fondest memory from my PhD years (apart from my Karonkka party!) is my time well spent with my colleagues. We had a close and supportive group and I had fun with staff members as well as with other PhD students in and outside of the office. My office mate Antonina became one of my closest friends. Having a good friend to share the joys and struggles of (academic) life was the greatest gift from my PhD years. Overall, I feel very lucky that I got to work with such a great group of people.

In addition to great colleagues at Aalto, I enjoyed the changes to travel around the world and meet other students and researchers in conferences, during research visits and summer schools. This was vital for my own research as it gave me the energy but also valuable information and contacts as very few people could help me with such a novel topic. I really appreciate that international co-operation was so strongly supported by our group leaders, my supervising professor Riku Vahala and my thesis advisor Anna Mikola. These international contacts are valuable for me even today when I continue my research in new projects.

Your advice now to yourself then?

Like for many others, PhD project was also very stressful at times, particularly during the final months. Time was running out and I had so much to do. During the final year I had to skip having holidays and in the final autumn I couldn't even have weekends off. This let to exhaustion and exhaustion led to negative feeling and thoughts. I was so afraid that I would fail, that me, my project, and thesis would never be good enough for PhD. When I now look back, I understand how ridiculous those thoughts were. I had done good work and I had good supervisors helping me finalize the work. I wish I could go back and say to myself that do not worry that much, get out of that dark place, everything will be ok. Because everything went ok.

Abstract

Microlitter and its synthetic sub-type microplastics, defined as anthropogenic particles less than 5 mm in size, are an ever-increasing form of marine litter that has received considerable attention over the past decades. Among the numerous possible sources and pathways that allow this microlitter to enter aquatic environments, wastewater treatment plants (WWTPs) have been suggested as one of the more significant pathways. This thesis examines the step-wise removal of microlitter during the purification process within conventional WWTPs utilizing conventional activated sludge processes.

In addition, the removal of microplastics from wastewater effluents using five different advanced final-stage treatment technologies was investigated and the microplastic discharge from existing Finnish WWTPs into the aquatic environments was assessed. To further evaluate the environmental risk that microlitter may pose to aquatic food webs, their ingestion by Baltic blue mussels (Mytilus trossulus) was studied at a wastewater receiving area in the Gulf of Finland in the Northern Baltic Sea. These results show that conventional wastewater treatment using primary and secondary treatments can efficiently remove (>99%) microlitter arriving at the WWTP in influent. Most (98%) of the microlitter was removed during primary treatment. The activated sludge process further decreased (~ 88%) the microlitter concentration. During the wastewater treatment, most of the microlitter (>99.5%) was retained in the raw and excess sludge. However, part (~20%) of the retained microlitter was recycled back to the treatment process along with the reject water. The removal of microplastics can be further enhanced by advanced final-stage wastewater treatment technologies. Membrane bioreactor removed an additional 99.9% of microplastics during treatment. Sand filtration removed 97%, dissolved air flotation removed 95%, and disc filtration removed 40–98.5% of the MPs. Biologically active filtration did not have any impact on the microplastic concentration. According to our estimations, Finnish WWTPs annually discharge ~480 billion microplastic particles into aquatic environments. As vast volumes of wastewaters are constantly discharged into the aquatic environments, the role of WWTPs as pathways may be significant. However, to further evaluate the relative importance of the role of WWTPs as pathway for microplastics, information on other pathways are also needed. The results from the wastewater receiving environment indicate that the WWTPs may influence the microlitter and microplastics abundance and composition detected in biota. Blue mussels collected from the wastewater receiving area had higher microlitter content than those from the reference site.

Antonina Kruglova

Biological removal of emerging micropollutants in nitrifying activated sludge at low temperatures *(2018)*

I did my BSc in microbiology working on soil bioremediation and studied water microbiology for my MSc. After that, I left academia and worked for almost 5 years in industry seeking for the practical use of my knowledge in the field of soil and urban water purification. In 2011 I decided to continue my scientific career and applied for Aalto doctoral program with the specific dream of doing high-quality scientific research in close collaboration with industry. I wanted to see the need of my studies and practical application of my Doctoral Thesis. It took some networking, persistence, and creativity with funding applications, but my dream came true.

So, the most exciting part of the process for me and the greatest inspiration was communication with stakeholders and other colleagues working on the same issue. Learning all the open questions and knowledge gaps and trying to fill them. The tremendous support of supervisors was another driver and motivator for me. I received help always when I asked for it: with research ideas, collaborations, travelling opportunities, communications with Finnish authorities, analytical money and of course research planning.

The funding was my biggest challenge! The original plan of me being part of a bigger project didn't work and I had to apply funding for myself almost every year of my doctoral studies. Not knowing if I have money for the next year of my research (meaning, contract, meaning, visa) was very frustrating. My advice for other students with similar problem is to talk early on with supervisor about it. Be very open about all the schedules, queues in immigration office etc. and plan several options together. Writing funding applications is also a challenge itself. It takes a lot of time and distracts you from research. At the same time, writing successful grant applications is a very important skill for continuing academic career so at the end I was very happy with my experience.

Another challenge is time management. In my doctoral studies I had to continuously run pilot bioreactors and perform experiments while also find time for writing articles and research proposals; participating courses; preparing, and rehearsing presentations; travelling for research visits and conferences. I also had some teaching duties and wanted of course to have my personal time inside and outside of campus. So, again, multitasking, planning, and prioritizing were the important skills I had to learn while preparing the thesis.

All in all, I think, doctoral research gives students (in addition to deep knowledge in their field) an amazing set of skills for almost any job they would choose in a future. For ones, risk management!

And so, my advice for the new students would be to look positive on all the challenges they face and see each one as, for example, an extra asset in their job application. And of course, boost your motivation every once in a while, by talking to somebody who inspires you, who went through the career you are seeking, share your struggles with colleagues and supervisors to hear their experiences and don't be afraid to ask any question or advice from scientific community! You are not alone!

Your advice now to yourself then?

Contact other research groups more, you are good enough! Apply more funding for travelling and research visits! It's easier than you think, It's super fun and extremely useful for your future career!

Abstract

Growing concentrations of emerging micropollutants (EMs) such as pharmaceuticals, endocrine disruptors and personal care products are found in the aquatic environment worldwide. These substances could pose the risk on humans and animals due to their chronic ecotoxicity and persistence. The main route of EMs emission into the natural waters is through effluents of wastewater treatment plants (WWTPs).

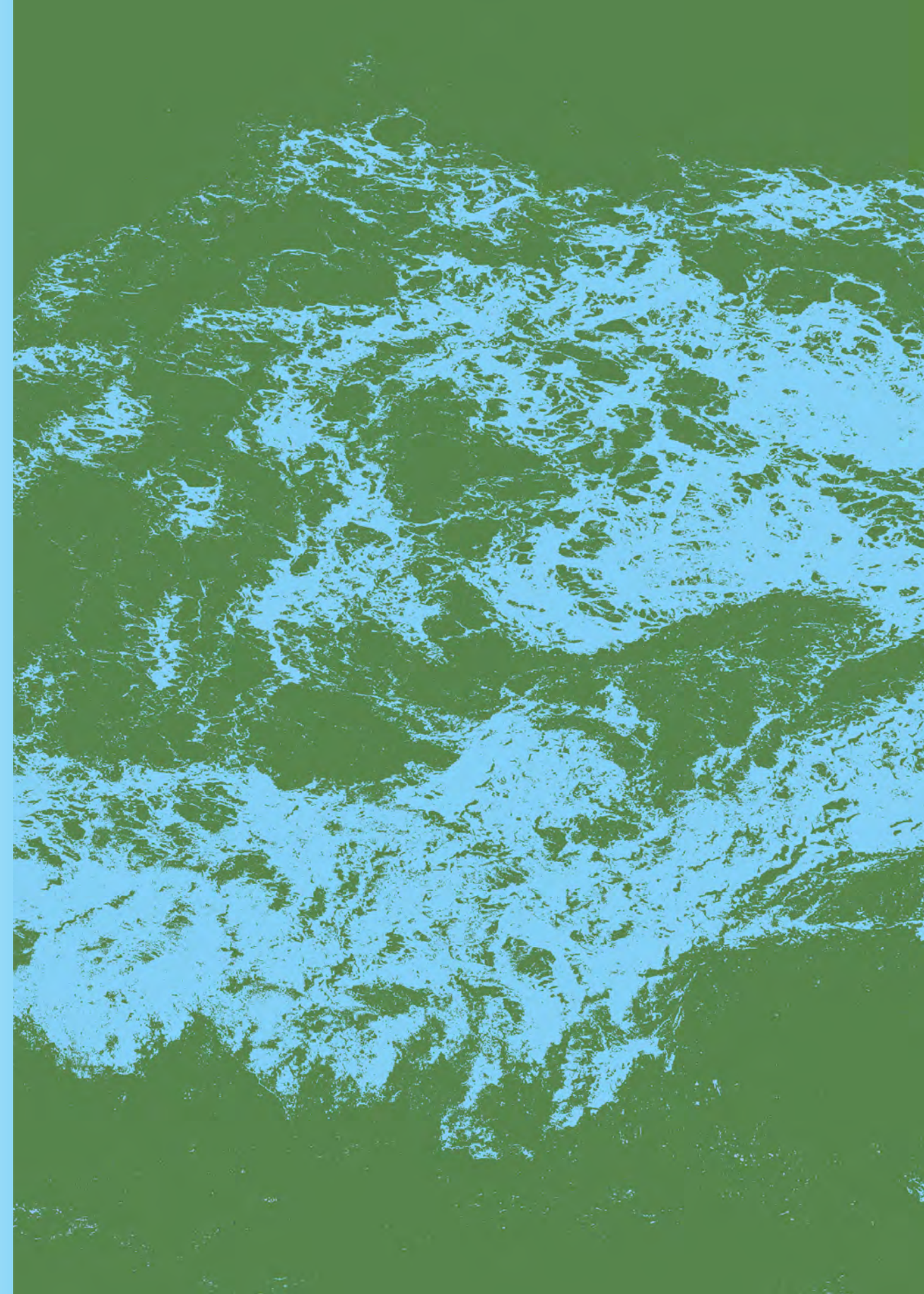
Operational conditions can significantly affect biodegradation of EMs during wastewater treatment. In particular, low temperature limits biological processes due to slower metabolic reactions and decrease of bacterial diversity in activated sludge.

In this thesis, biological removal of EMs from wastewater was studied at low temperatures (8–12˚C). Different operational conditions were compared in order to increase removal efficiency and therefore enhance the quality of WWTPs effluents. Laboratory-scale Sequencing Batch Reactors (SBRs) and Membrane Bioreactors (MBRs) were used to mimic existing wastewater treatment processes. Data from full-scale WWTPs of Helsinki region were taken into account.

The study presents the removal rates for widely-used EMs ibuprofen, diclofenac, carbamazepine, estrone, 17β-estradiol and 17α-ethynylestradiol. Altogether, obtained removal efficiencies were much lower compared to published data for higher temperatures. Biodegradation studies demonstrated that EMs might accumulate in activated sludge cells at large extent. Depending on the substance, this accumulation could be followed by biodegradation or by return of the compound to the wastewaters with the cell decay. Therefore, following the concentrations of EMs in solid phase of activated sludge is necessary for the assessment of biodegradation potentials.

Sludge retention time (SRT) proved to be an effective operational tool for regulating biological processes during wastewater treatment. Prolongation of the SRT demonstrated positive effect on activated sludge performance and EMs biodegradation at low temperatures. At the same time, decrease of the temperature raised the negative pressure effect on activated sludge, limiting the removal potential of EMs as well as inhibiting nitrification. Thus, SRT optimum is closely related to the temperature fluctuations.

Contribution of different microorganisms in performance of nitrifying activated sludge and EMs removal at cold temperatures is discussed in this study. In addition to six above mentioned EMs effect of antibiotics sulfadiazine and trimethoprim was studied. Described microbial communities significantly differed from typical nitrifying activated sludge at class level. EM removal potential and the need for further research of bacterial class Deltaproteobacteria and domain Archaea is proposed. Overall, prolongation of SRT improved stress resistance of microbial community resulting in stable performance of activated sludge.



Mika Jalava

The water we eat - Methods for estimating water use of diets in changing food systems *(2019)*

I started my doctoral studies in 2013, after a career of 17 years in a network security company, and the differences between the two periods are in many ways more prominent than the similarities. My previous working life had been intense, busy, and rapidly changing. Now things seemed to calm down, as I felt I was first and foremost working alone towards the thesis and defence, still a few years ahead, even when much of the daily work was collaboration with others for the publications. In some ways this feeling of a personal project proved to be true, but the longer I worked in our research group, the more it turned out to be quite a tightly bound bunch. Alone wasn't that much alone after all.

I think the most process-like thing about my studies was how my thinking about what I am actually doing changed. In the beginning, I thought I had a pretty clear idea of what is to be expected as if the process was written in the list of required steps and outcomes. Study credits, check. Articles, check. Synthesis, check, and many little bureaucratic twists, fair enough. But those were just some milestones, not the process. Obviously, there was much work that went into producing the contents of each step, but even that is not really what I would call "the Thesis Process". The process really was how my thinking changed about how to achieve results. That evolved step by step, along with the practical steps of fulfilling the study requirements.

At this age and with some career behind me, I was quite confident that whatever the hurdles, I'll pass them, no problem. And of course, that was true – I did graduate. But not quite the way I expected. In the beginning, I tried to find the tools and resources to fulfil a task at hand. A dataset. A programming tool. An algorithm. And I found those – that's what I have learnt to do. A problem – a solution. But "a solution" wasn't quite enough, as it wasn't quite enough to "feel right" about something. Not even to get someone's approval, as many things had to pass a long list of approvals before you got to "the solution". Supervisor, instructors, co-authors, reviewers, pre-examiners, department officials, and others. How do I know how to perform my work in a way that will pass all this scrutiny?

I think the biggest thing to learn was really becoming a part of a community, or rather multiple communities. Success is not about finding people you can benefit from but rather about becoming a part of formal or informal teams that produce useful and enjoyable things.

The challenges and successes in learning all the subject matter involved must not be downplayed – after all, that's a large part of what the teams involved in the doctoral thesis process are doing. But for me the people were, and are, the key.

What is the main advice you would like to give now to yourself when you were just starting to do you dissertation?

Many paths taken could be considered failures afterwards. Don't worry about failures in advance, but try to identify them as they occur,

as early as possible. That saves a lot of time but still allows you to learn both from successes as well as failures!

Abstract

Water scarcity already affects more than half of the human population. The largest water consuming human activity, food production, is at the centre of the quest for sustainable use of this natural capital. How much resources are required to satisfy the global food demand depends on more than just the number of us and how much we eat. It is largely determined by what the human diets consist of and where the food is produced, as well as how much of it is lost and wasted.

This dissertation focuses on water consumption in agriculture as a key determining factor in achieving food security. It does so by studying three overarching themes: the resource-saving effect of changes in human diets, modelling the supply chains within the complex food systems, and methods used to evaluate agricultural water use and its impacts. A substantial body of existing research aims to find relationships between consumer choices and resource use in agricultural production, but many aspects in the methodologies and in their results remain controversial. This dissertation points out challenges in using current methods to define alternative diets in global studies and presents a novel, optimisation-based method that adjusts diets according to chosen dietary guidelines and level of diet change. It combines the diet change analysis with food system models in a way that can capture interactions between different resource-saving measures and presents estimates of their global, regional and country-level potential to improve food security. A novel food system model, Aalto OptoFood was developed to allow analysing resource efficiency of large changes in food demand and in system dynamics, such as synergies between crop and livestock-based food production.

The dissertation found that replacing livestock-based foodstuffs in human diets with crop-based alternatives is an efficient way to reduce agricultural water consumption. Theoretically, the water thus saved could supply food for up to 1.8 billion people. Yet, the opportunity cost of livestock in terms of water may be lower in practice. Shifting water from the production of one foodstuff to another requires the availability of other resources, such as suitable cropland. Non-arable rangelands may support livestock production that positively contributes to food security. Nevertheless, many current production systems depend heavily on water and land resources that could be more efficiently used for crop production. Optimal spatial distribution of production changes would allow diet change to preferentially reduce livestock with highest opportunity cost in terms of water, and offer high initial returns with relatively small changes.

Finally, this dissertation uses the framework of the Cultural Theory to discuss how modelling outcomes are affected by decisions stemming from different worldviews. It argues that modellers should be conscious of such decisions and communicate them clearly to avoid real or perceived biases.

Heidi Salo

Assessing the effects of subsurface drainage on hydrology and nitrogen transport in Nordic fields *(2019)*

The first thing that comes to my mind when I think back my doctoral theses is joy. This is probably as the last year and moments of my doctoral journey were full of good memories about writing the synthesis, getting it to the pre-examination, getting positive but constructive comments. After all the hard work I was truly able to enjoy the final week before the defence followed by awesome evening with colleagues and friends who joined me for celebrations. I can feel joy also when I think different parts of the journey. The best moments have been the lunch and coffee breaks as well as the off-work activities doing sports or drinking beer.

There were three big journey points during my doctoral process: First important point was that I had the chance to start my doctoral process in Marine building. I became part of a group and there was always someone to talk to. Second important point occurred when my advisor left Aalto and I was forced to survive without constant support or helpdesk. This also forced me to become slightly more independent as a researcher. The third important point was the start of a synthesis group. I had the privilege to write my synthesis at the same time and with support of new close colleagues. This, I think, was also one of the corner stones for me to not struggle towards the end of the thesis process. There was constant peer support with people being in the same stage and it was nice to hear about other's synthesis process and to share my own work-in-progress.

Even though I was motivated due to the interest towards my research topic, most of the motivation throughout the doctoral process came from the people and the atmosphere in the workplace, which made it enjoyable to come to work every morning (okay maybe not every morning). I hope that the newbies can also find motivation from their colleagues and being part of a research team.

The most important skills that I learned during my doctoral thesis process were not the technical know-how or knowledge of the research topic. I learned the most important thing in research is the people and ability to be curious about everything, thinking outside the box and be open to new ideas around you. You need to communicate your work to colleagues (and to the public as well) so others will know what you do and why it is important.

Now when I meet someone planning or thinking about starting doctoral research, I tell them about my own experience of world full of open and curious people and unlimited possibilities to develop yourself in multiple areas. The process does not include just research, but inspiring colleagues, supportive guidance from advisors and supervisor, and a skillset that gives you great start for academic career. It is hard work but pays off not only at the end but throughout the journey.

Your advice now to yourself then?

Spend time with people and be opened to make new contacts. Networking

is not the easiest part, but one of the most beneficial things you can learn during the process.

Abstract

Subsurface drainage is the primary water management approach in field cultivation in Nordic areas. Installing and improving a subsurface drainage system change water flow dynamics and routes in the soil, which affect nitrogen (N) load from the field. The role of soil properties, drainage system improvements and surrounding areas in the formation of water flow routes is not fully understood. The objective of this study was to quantify the effects of subsurface drainage on water flow and N transport using field monitoring data, statistical analysis and mathematical modeling.

The performance of two drainage installation methods applied in the Sievi experimental field were investigated with statistical analysis. Differences in groundwater level occurred due to drainage installation method and soil type at the drain depth, but the absolute differences were small (0.1 m). A state-of-the-art process-based hydrological model was applied to investigate the effects of soil properties and drainage systems on water flow routes. Field subsurface drainage schemes were simulated with 3D, 2D and 1D model applications using data from a clayey field in southern Finland (Nummela). Model applications showed how field drainage can be described with models of different dimensions and scale (from drain spacing to field section scale). The 3D drain spacing simulations demonstrated the benefits of using detailed soil data in model parameterization as an alternative to model calibration. In the 2D long-term simulations, the 3D soil parameterization was up-scaled to field section scale. The short-term 3D model simulations showed the dominant nature of soil macropores over the drainage system description. Comparison of the long-term 2D model simulations revealed that the improved drainage installations changed the shares of all the water flow routes, including groundwater outflow. A generic solute transport component was developed and tailored to describe N cycle transport and processes in 1D model simulations. Autumn period simulations of a poorly and well drained field sections showed that nitrate N loading was mainly controlled by the initial soil N storages after harvest and the timing of the precipitation events, while the soil moisture content differences explained the magnitudes of gaseous N losses.

Long-term monitoring data series, statistical analysis and process-based modeling showed that the practical effects of subsurface drainage are site specific and comprehensive view on the local water and nutrient management is needed when controlling the environmental impacts of field cultivation. The 1D, 2D and 3D model applications could all be used to replicate the measured drain discharge data, even though the drainage system description differed between the cases due to the differences in water flow directions and the boundaries of the simulated domain. The finding of the research suggests that field water management moves the N load from one path to another rather than affecting to the total amount of the water volume or N loading.

Hafsa Munia

Global analyses of drivers of water scarcity indicators in transboundary river basins *(2020)*

The first thing that comes in my mind regarding the process of doing my doctoral thesis is the water building. I think, I wrote the entire thesis sitting there. I had my days of success and failure in that building. I spent 7+ years, the longest time of my career, in that building- so the water building will be always in the lane of my memory whenever I will think about my doctoral journey.

My doctoral journey is something that I will cherish for sure for the rest of my life. Not only I met some wonderful people through this journey, but it has also made me what I am today. The process has made me to be able to believe on myself. It has helped me to gain my self-confidence which I had lost before. I had best supervisor and one of best advisor anyone can ever want for. Yes, I was lucky to get all the support, technically and emotionally, a doctoral student ever needs. People around me were more like friends than colleague. Every time, when I got stuck somewhere in my work or got a news of failure, I use to take a coffee break. There was usually always someone in the coffee room to take my mind off.

One of the best parts of your PhD is that you get to travel to conferences and meet a host of people who connect with you and your work and a sort of bond is made. As a result, above and beyond everything, it is the immense wealth of people you meet that make up the best part of your PhD. One important thing that I learned is not to feel shy to ask help from others. I think researchers in general tend to be some of the nicest and most engaging people. It is always a good idea to discuss your problem while you are stuck. Freedom to think, to read, to investigate and to collaborate – were the motivation for me through out this process. I had all these freedoms of work, that kept me motivated.

Someone once said that the the two best days in a boat owner's life are the day, they buy a boat and the day they sell it. For me, the best parts of my doctoral journey were the first day when I was offered to start working in the PhD program. The other best part was at the end of my public defense, when the opponent congratulated me and called me "Doctor..."

Your advice now to yourself then?

I used to get very nervous at the beginning. I was very shy to ask help. It took me long time to come out of my shyness and ask help from others. I even had sleepless nights overthinking of the outcome. I only realize it later that, even though it is my research journey, it is always good idea to ask, discuss your problem. I wish instead to stressing on finishing, I would have enjoyed the journey more.

Abstract

Water scarcity management in the context of transboundary river basins is not limited to local water use and availability — upstream water demand and availability play an important role. The distinction between local and upstream water use and availability across countries sets transboundary water scarcity analysis apart from other water scarcity analyses.

This dissertation aims to improve the general understanding of the causes of water scarcity in the transboundary context. A novel framework is developed to understand the evaluation of water scarcity, as well as downstream dependencies on upstream water resources, for global transboundary river basins. By applying the framework with existing datasets and water scarcity indicators, it was possible to identify transboundary water scarcity hotspots, the dominant factors behind the scarcity and the role of upstream water both historically and under future socio-economic and climate change conditions. This global work thus provides new insights for transboundary water management.

Supported by global maps for this type of analysis for the first time, the thesis emphasizes a number of insights that are specifically relevant to the development and implementation of transboundary water scarcity adaptation strategies. One of the most important findings is that in the majority of cases, the down-stream water stress is mostly due to local "overuse" of water. In the context of securing water availability in the downstream parts of a basin, a critical point is passed when local water demand is higher than the threshold for the sub-basin in question to be self-sufficient with locally originated runoff. In many basins, nevertheless, upstream water use intensifies water scarcity. This is expected to be more significant in future scenarios, due to both local and upstream population growth and the associated increased water demand. Most importantly, the dissertation highlights that to make sound decisions for transboundary water, a well-rounded understanding of the water demand and availability in both local and upstream sub-basins is needed. Analyses of this type provide unprecedented opportunities for understanding the physical relationships within transboundary river basins at a global scale.

Matias Heino

Susceptibility of global crop production to climate variability and change *(2022)*

I got interested in doctoral studies during the final year of my master's in 2016. At that time, I pondered, what I would like to do after I graduate and figured that writing a doctoral thesis would allow me the opportunity to dig deeper into issues that I had learned about during the past couple of years, and importantly it would give me the opportunity to study completely new topics.

Fairly quickly after I started at the beginning of 2017, I was in the deep end of doing research as the review deadline for an article, based on my master's thesis, was due within a few months. Although getting back to my old Matlab codes was a bit of a struggle, I got the revision done, just to get some more corrections to do after a couple of more months. Trying to convince the journals that a manuscript is good enough and worth publishing was always the trickiest and most frustrating part of the research arch.

The best part of my dissertation process were definitely the other doctoral students and colleagues who were working in the research group at the time. Working days went by quickly; I wonder if work will ever be as much fun. This was also probably the main reason why the 2020 Covid-lockdowns were so draining — most of the collectivism dropped out and all that was left was the individual work.

I'm still a bit flabbergasted about how challenging writing a doctoral dissertation was. It is hard to imagine a nicer job than being a full-time doctoral student, but at the same time I'm so happy it is over.

Abstract

For millennia, humans have grown their food in relatively stable Holocene climatic conditions, which are now perturbed by anthropogenic climate change. Weather is an inseparable part of food production, and floods, droughts, and heatwaves remain a nuisance to farmers around the globe. Approximately, a third of global crop yield variability is caused by climate variations with even higher sensitivities reported for maize and wheat, both highly important global food commodities. Hence, a comprehensive understanding about the impacts of climate variability and change on global crop production is imperative to ensure a sufficient and stable food supply for the growing global population.

Although the threats posed by climate change are widely acknowledged and researched, the extent of global food crop production at risk of experiencing novel climatic conditions due to climate change has not yet been quantified. Climate change is also projected to increase the frequency of extreme weather events. However, it remains unclear how these changes will relate to agriculture. For example, it is not fully understood how co-occurring extremes impact crop yields, and whether there have been any historical changes in their probability. Interannual variations in climatic conditions are also partially driven by climate oscillations. Predictions about their status could potentially provide useful information for preparing against adverse weather. However, this would require more detailed understanding about their relationship with crop productivity.

This dissertation reveals that climate change might push up to a third of global food crop production to unprecedented climatic conditions if nations continue to increase their greenhouse gas emissions. Further, it finds that weather extremes often reduce crop productivity, with co-occurring heat and drought leading to the largest impacts. Alarmingly, the probability of hot and dry weather has increased in recent decades, especially during the wheat growing season for example in Europe and North America. Finally, this dissertation finds that large-scale climate cycles, such as the El Niño Southern-Oscillation, influence agriculture across all continents that produce crops, with strong impacts observed, for example, in many parts of Australia, Africa, and South America.

Climate change has already affected global crop production; future solutions should therefore concentrate on increasing the resilience of farming systems to anomalous weather, in addition to mitigation actions. Development of early warning systems, and agricultural monitoring as well as improving water and soil management with, for example, irrigation and conservation agriculture could provide viable options to manage these increased climatic risks.

Amy Fallon

Keep it Complex - Critical perspectives on water governance for dynamic social–hydrological systems *(2022)*

When I reflect on the five-year process of my PhD, the first thing that springs to mind is an uphill, at-times meandering path with side quests, surprises, and terrific company. I decided to apply for a PhD in 2016 while working in South Africa, where I'd ended up as a continuation of my master's thesis fieldwork in the Limpopo working with farmers on agricultural groundwater management (which became my main study area). Coming from abroad was a big jump, but I found a group of intelligent, kind, and supportive researchers in WAT!

The PhD process inevitably has ups and downs, but I'm happy to say mine had more 'ups'. The best part was being a member of the Majakka team – funded by MVTT, we were a group of six PhD candidates starting at the same time, with a focus on developing doctoral education. We published a paper together on water security and the SDGs, and the group provided invaluable support for moments of doubts and insecurities. They also became firm friends, as did my other colleagues, who were all incredibly kind and supportive.

I learned a lot during my time at Aalto, largely thanks to being a social scientist surrounded by engineers! I forced myself to take some more technical courses rather than stay in my qualitative comfort zone, and while I didn't use many of them for the research itself, they did give me a better idea of different quantitative approaches and to understand different perspectives on a given problem. I didn't fully realise until leaving Aalto that I'd also picked up some project management skills along the way!

Of course, not everything went according to plan; my research plan and schedule changed frequently thanks to shifting research goals and journal delays (I waited ten months for the first comments on one of my articles, and six for another). I also somewhat shifted my focus to the Mekong region to align more closely with my group's research, and ultimately scrapped a planned fourth article so I could graduate before I turned grey. My pre-examination process was also delayed due to one examiner falling ill, and the COVID-19 pandemic had an impact on my schedule and planned research visits.

I connected with many interesting people during my PhD and received a lot of support. My supervisor, Professor Marko Keskinen was a rock throughout the process, helping me with everything from refining research questions to co-writing papers, to ordering me to take a few days off when I threatened to throw my laptop in the sea after a particularly gruelling period of article revisions. I also had a great advisor from the UK (Professor Bruce Lankford), and co-authors based in South Africa and Cambodia. Dr Maija Taka and Professors Olli Varis and Matti Kummu also gave valuable advice over the years.

Your advice now to yourself then?

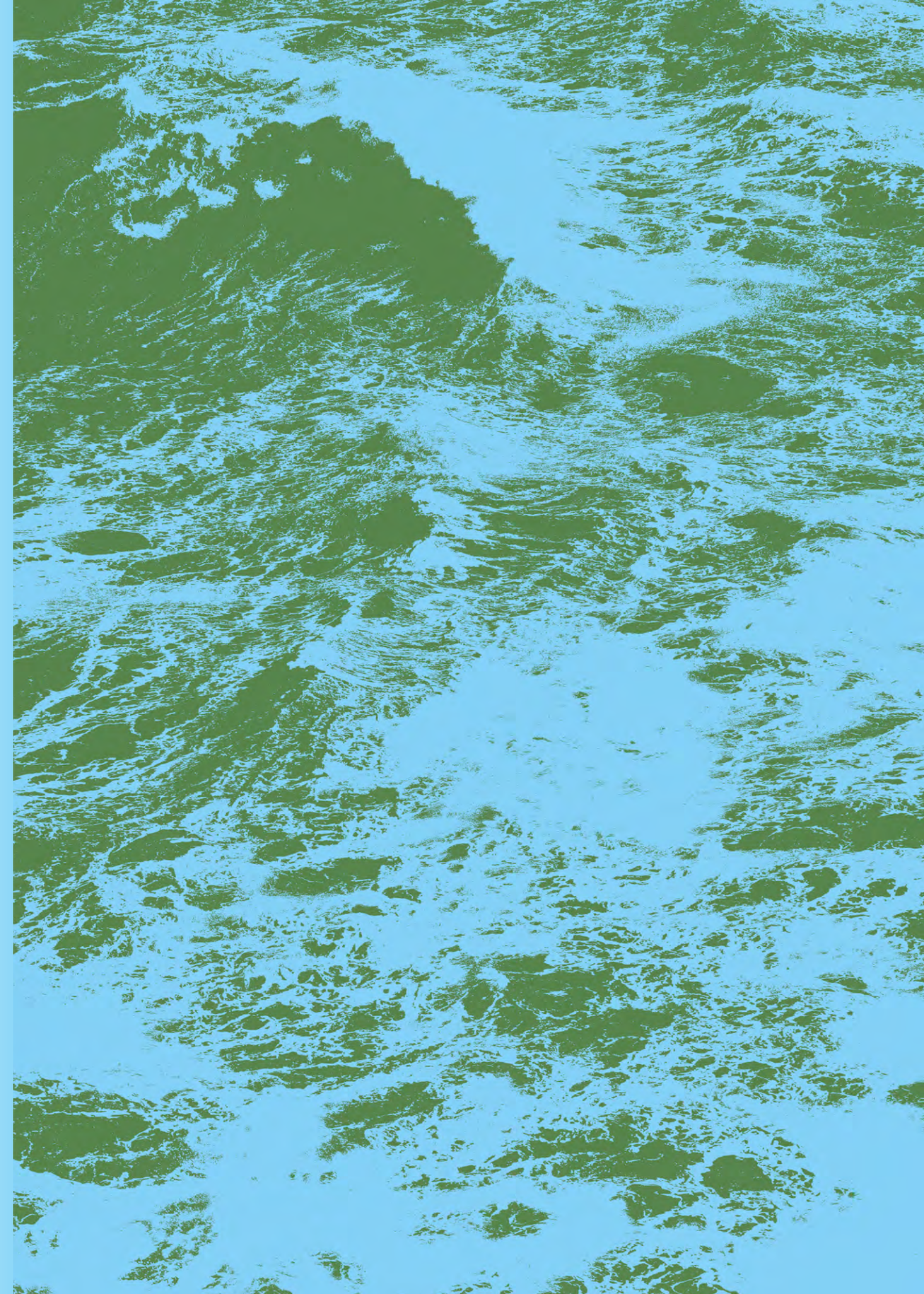
My advice to my younger (less wrinkled) self would simply be to not rush and to trust the process. Quite often it feels like you're not making progress, but even if it's invisible, you are. I'd also tell myself to find the joy in every hurdle. It's easy to get caught up in the negatives – a PhD is hard! – but if you surround yourself with the right people, prioritise your health, and adopt a growth mindset of curiosity instead of competition, it may just be the most intellectually stimulating and worthwhile four (or five or seven) years of your life.

Abstract

Freshwater resources are experiencing mounting social and environmental pressures, including growing competition over resources between water users and sectors, and a rapidly changing climate. Addressing these concerns is largely an issue of governance, which is often embedded in complex socio-political contexts and compounded by hydrological complexities such as nonlinearity and uncertainty. Integrative responses that capture complexity without over-simplifications are therefore needed; nevertheless, complex problems can rarely be fully 'solved' due to multiple, often conflicting, perspectives, needs and values amongst stakeholders. In this dissertation, I explore what it means to "keep it complex" as we grapple with complex water governance challenges that often defy traditional problem-solving approaches, and involve many perspectives.

The overarching aim of the dissertation is to develop critical perspectives on water governance that account for both biophysical and social complexity in social–hydrological systems. The dissertation adds theoretical depth to water governance literature through two conceptual contributions: a governance 'solutionscape', linking science, policy, practice, and participation through six possible solution-types; and a resilience–governance framework, linking theories of interactive governance, social-ecological systems, and resilience. Two case studies from a small sub-catchment of the Limpopo River Basin in South Africa and the Tonle Sap Lake in Cambodia provide empirical insights in two dynamic social–hydrological systems undergoing significant environmental and social change. In the Limpopo, water governance processes and outcomes are dictated by historical commercial farming legacies, inadequate monitoring networks, and infrequent groundwater recharge. While seasonal climate forecasts could contribute to more sustainable groundwater use, their uptake is low due to a lack of credibility, poor dissemination, and farmers' traditional beliefs. Resilience-thinking reveals rigidity traps in the Tonle Sap's governing system, which undermine its resilience to ongoing social-ecological transformation caused by mounting pressures in the Mekong (e.g., hydropower dams). Both cases demonstrate how rapid, transformative institutional change may have limited practical impact if not accompanied by changes in cultural values and day-to-day actions.

Navigating complexity therefore requires recognition of biophysical uncertainties, imperfect solutions, and value-laden questions related to governance. The dissertation's amalgamation of different perspectives on environmental change and complexity suggests an epistemological shift from focusing on institutional design and structure (governing complexity), towards capturing dynamic processes and relations within governance (governing in complexity), including the role of historical legacies, beliefs, and social relations in hindering or facilitating change. By doing so, more transformative ways forward may be imagined, negotiated, and enacted.



Marko Kallio

Towards more useful water information — methods for fine-scale spatial estimation *(2022)*

It's been a few months since my defense as I'm writing this and feel like I can finally reflect on the thesis process in a somewhat neutral manner. It was quite a ride. The word that best represents the whole process, is chaos. In a good and in a bad sense.

Chaos did not come to be from the very beginning despite the fact that my research plan was scrapped within a month from starting. I published my first paper within the first year and felt like the whole thing was a piece of cake. I remember thinking that I'll be done in three years! That did not happen for chaos ensued as I embarked to work on my second paper. The first paper was based on my Master's Thesis, and I had not realized how important it was that I had already done half a year worth of work before starting to write the paper. The second paper was a jump to the unknown, and I also started to learn to write software. At the same time, I started taking on all kinds of side projects. It finally took more than three years to get that work published.

Chaos lasted until submitting my thesis for pre-examination, but it was not all entirely bad. It did disrupt my thesis project, yes, but the final product wouldn't be what it is without the lessons I learnt from all those side hustles. They provided me with skills I would not have learnt working solely with the thesis. They also provided me context: it is easy to succumb to imposter syndrome working in academia alongside brilliant colleagues. Consulting work showed that the skills which feel woefully inadequate in the academic world, are uncommon and extremely useful outside of academia.

Cultivating the chaos by accepting all that work did lead me to meet people and work in fields I wouldn't have imagined when starting. I am an engineer, focused on computational methodology, and yet I found myself collaborating (and continue to do so) with archeologists. Working with the historic maps brought childish excitement and joy to balance the misery that most of us feel, sometimes, during the thesis process.

As the chaos finally allowed me to start working with the dissertation, Joseph — my advisor, colleague, and friend — pointed out that the thesis topic was, in the end, not that far away from the original plan that was scrapped in the very beginning. The context — water scarcity — is still there, as are considerations for both spatial and temporal features in hydrology that were prominent in the original plan. Perhaps there was structure in that chaos after all?

If I had the chance to give advice to myself at the start of doctoral studies, I would tell myself to accept that there will be chaos, but make it an orderly chaos. With a bit of planning and self-discipline I could have averted much of the misery at work and in personal life. At the same time, the chaos has made me a much more complete researcher and brought unexpected opportunities and joys.

Your advice now to yourself then?

Embrace and control the chaos.

Abstract

The world is facing unprecedented environmental issues caused by global environmental change. Knowledge about these issues is often created with the use of global environmental models. The solutions to the issues, however, need local-scale actions, and information at the local scale can be scarce. There is, therefore, a need to bridge the gap between the coarse model outputs and the local use case. This dissertation develops and tests methodologies that help to produce fine-scale estimates — i.e., downscaling methodologies — and understanding from a coarser starting point with limited data availability, focusing on an environmental modelling related to water scarcity estimates. The four case studies included in this dissertation cover three main methods with different aims.

First, understanding of processes to explain water poverty is built with the help of a computational model. I show that a combination of geographically weighted principal component analysis and a composite index is an effective way to increase understanding of the spatial variation in those processes, as opposed to a coarse, aggregated view. Its usefulness, however, is critically dependent on the knowledge of the expert. Second, I test the capabilities of the advanced areal interpolation methods dasymetric mapping/modelling and pycnophylactic interpolation in downscaling environmental model outputs (runoff generation). I show that areal interpolation is highly useful due to its ability to address spatial errors in the downscaled runoff estimates, correcting for wider spatial autocorrelation structure in the output. The ancillary data used to estimate internal spatial variation, however, needs to provide an accurate representation of the processes dominant at the finer scale. Third, hydrological routing component of distributed global hydrological models are replaced with a higher resolution alternative, producing finer scale estimates of streamflow. I show that when multiple global hydrological model outputs are used together in an ensemble, their outputs can be used effectively in a local context.

The three strategies for producing fine scale estimates, are useful because they reduce the amount of resources — time, money, data, and expertise — needed to produce locally relevant information from coarse resolution datasets, provided they are used in appropriate contexts and consider the limitations I discuss. For water scarcity assessments in particular, the methods increase the potential of identifying dominant processes driving water scarcity, and increase the usefulness of existing global hydrological data products in local contexts for various research and decision-making scenarios.

Venla Niva

The interplay of environmental and social drivers of migration - A global synthesis *(2022)*

The first word that comes to my mind regarding the process of pursuing a PhD would be chaotic. The process of learning a completely new topic while at the same time trying to navigate the literature and identify the gaps in knowledge was extremely challenging (despite very interesting). I remember that this was very much a shared experience amongst other PhD students who started at the same time, and I think the collective feeling of chaos helped a lot in enduring the feelings of uncertainty, insecurity and "I have no idea what I'm doing", which were present at the start of our PhD journeys.

My first paper is a perfect reflection of this chaos. The paper was meant to facilitate the learning process of a new topic, and even though it did so in the end, the process itself was a bit all over the place and well, chaotic. The paper started as a literature review, but when the reading was anything but systematic the paper transformed into a concept paper and eventually after many turns and twists into something that was worth publishing. Yet, despite the chaos, writing that paper was a turning point in my research. In the end I did find where I wanted to focus on. Instead of continuing with my original topic around urbanization, I shifted my focus towards human migration.

After 2010, migration had been an increasingly hot topic in global environmental change literature, and I thought the methodological tradition of WDRG in combining big data and quantitative methods to understand and study the connections between people, society and the environment could provide a fresh angle to the topic. I was highly motivated and started working on data-analysis. I felt comfortable with quantitative analysis and finally felt like expanding my comfort zone was enjoyable rather than painful. Another turning point was when I invited Dr. Raya Muttarak to join in from IIASA. The analysis turned into a paper, and produced an idea for another paper and eventually for the synthesis.

Despite occasional pain in writing and coding, the biggest challenges in the process were not necessarily work-related. One of the biggest challenges came with the pandemic. I was around two years into my PhD when the pandemic hit and we were forced to stay at home for almost two years. At first it was enjoyable to work from home and to focus without any distractions. However, after a while the isolation began to be too much. Research is most of the times an independent process and sometimes also a lonely process, and isolation very quickly fed the feeling of loneliness despite the support from colleagues. I started to lack motivation and feel cynicism towards academia. In retrospect it is easy to see I was just one of the many who suffered from, if not a burn out, at least a pandemic induced bore out. Eventually, I managed to find enough motivation to embark on the final stretch of my PhD. With the help from a big team, we compiled a new data set and finalized the last paper of my dissertation. The time I had for writing the synthesis was very little, but eventually it was maybe the most enjoyable part of the whole PhD.

As a disclaimer, I'm writing this only two weeks after my defence. And so, if I had been asked to write this a year after my defence, my thoughts could be very different. Yet, I dare to give a few pieces of advice for myself five years ago or anyone starting their PhD journey.

Your advice now to yourself then?

First, the chaos will clear out. Second, do not hesitate to change the course of your research. Third, worry less, enjoy more.

Abstract

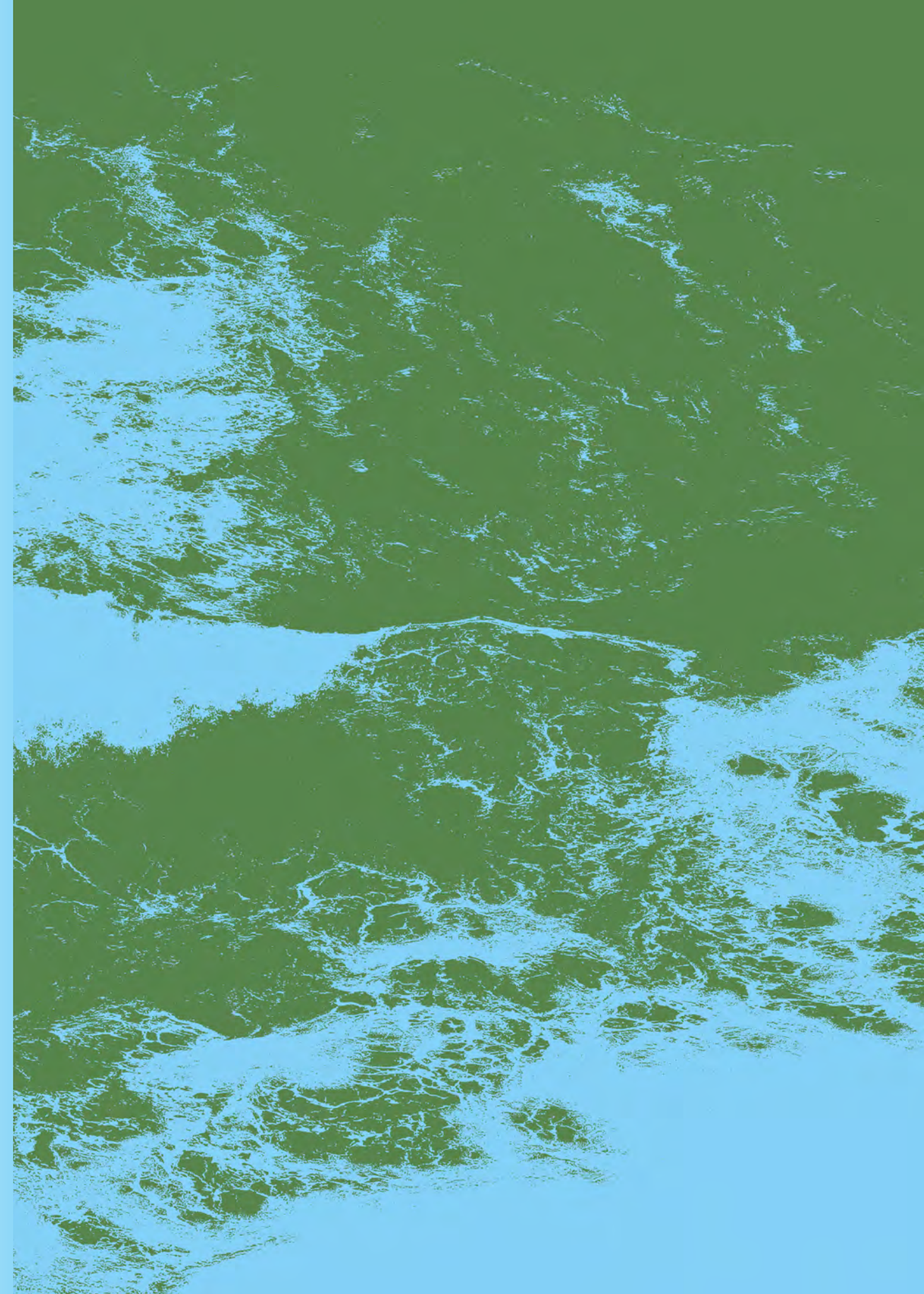
Over the recent years, human migration has risen to the top of the global agenda. Conflicts in the Middle East, Central America, Southeast Asia, and more recently in Europe have forced millions of people to flee. At the same time, hundreds of millions of people are moving from rural to urban areas as urbanization accelerates, especially in Africa and Southeast Asia. While conflict is perhaps the most tragic driver of human mobility, migration is also driven by multiple socio-economic and environmental factors. In fact, it is the interplay of socio-economic and environmental factors that is behind not only the decision to move but also behind outcomes of migration at the destination.

While there is conceptual clarity of the different drivers and outcomes of migration and their interplay, their geospatial and global representations are few. Thus, in this dissertation I address this gap by investigating 1) how human migration has developed in recent decades in different geospatial units; 2) what the key drivers of human migration are, and how these drivers have interplayed over time; and 3) what the implications of human migration are at both sending and receiving areas. In the analysis, I combine a qualitative conceptualization with quantitative analysis, the latter being carried out at a global level by utilizing spatially explicit, novel data that describe human migration and its social-environmental drivers from the past three decades. Quantitative analyses make use of spatial, exploratory and statistical methods, which allows a more comprehensive study of migration in different administrative units, rural and urban areas, and socio-environmental zonings.

The global analysis in my dissertation shows that the patterns of migration vary remarkably depending on the geospatial unit and scale used for the analysis; over the past two decades, migration between communes and provinces has been rising, while international migration has remained steady. Urban areas dominate as migration destinations at the global level, while the pattern becomes patchier at regional, national and sub-national levels, where rural areas have also experienced notable in-migration. Over the past three decades, the majority of migration has taken place in areas with medium-level human development and environmental stress,

while socio-economic drivers — especially income and education — dominate environmental drivers globally. Finally, I demonstrate that factors of adaptive capacity are instrumental in shaping the outcomes of migration, especially in urban areas that have experienced accelerated population growth caused by in-migration.

In the coming decades, migration will continue to function as one of the methods of adaptation. Understanding these complexities and causalities behind human migration and its environmental and social dimensions is key in managing migration, especially in a future facing unprecedented and unforeseen changes.



List of all Doctoral Theses from Water and Environmental Engineering Research Group and its predecessors *2002–2022*

Author	Year	Title
Riku Vahala	2002	Two step granular activated carbon filtration in drinking water treatment
Toomas Tamm	2002	Effect of meteorological conditions and water management on hydrological processes in agricultural fields: Parameterization and modeling of Estonian case studies
Harri Koivusalo	2002	Process-oriented investigation of snow accumulation, snowmelt and runoff generation in forested sites in Finland
Teemu Kokkonen	2003	Rainfall-runoff modelling - comparison of modelling strategies with a focus on ungauged predictions and model integration
Juha Järvelä	2004	Flow resistance in environmental channels: Focus on vegetation
Terhi Helmiö (Renko)	2004	Effects of cross-sectional geometry, vegetation and ice on flow resistance and conveyance of natural rivers
Mikko Jauhiainen	2004	Relationships of particle size distribution curve, soil water retention curve and unsaturated hydraulic conductivity and their implications on water balance of forested and agricultural hillslopes
Katri Rankinen	2006	Analysis of inorganic nitrogen leaching in a boreal river basin in Northern Finland
Riina Liikanen	2006	Nanofiltration as a refining phase in surface water treatment
Olli Malve	2007	Water quality prediction for river basin management
Matti Kummu	2008	Spatio-temporal scales of hydrological impact assessment in large river basins: the Mekong case
Muhammad Mizanur Rahaman	2009	Integrated water resources management: constraints and opportunities with a focus on the Ganges and the Brahmaputra river basins
Markku Lahti	2009	Two-dimensional aquatic habitat modelling
Jarkko Koskela	2009	Studies on long-term inflow forecasting
Ulla Heinonen	2009	Can the poor enhance poverty reduction? : rural and urban perspectives on water resources, poverty & participatory development in the Tonle Sap Region and Phnom Penh, Cambodia
Marko Keskinen	2010	Bringing back the common sense? Integrated approaches in water management: Lessons learnt from the Mekong
Lassi Warsta	2011	Modelling water flow and soil erosion in clayey, subsurface drained agricultural fields
Virpi Stucki	2011	In search of integration: analyzing the gap between theory and practice of integrated water resources management with case studies from West Africa and international policy processes
Hanne Laine-Kaulio	2011	Development and analysis of a dual-permeability model for subsurface stormflow and solute transport in a forested hillslope
Noora Veijalainen	2012	Estimation of climate change impacts on hydrology and floods in Finland
Tanja Tuutijärvi	2013	Arsenate removal from water by adsorption with magnetic nanoparticles (γ-Fe2O3)
Nora Sillanpää	2013	Effects of suburban development on runoff generation and water quality
Anna Mikola	2013	The effect of flow equalization and low-rate prefermentation on the activated sludge process and biological nutrient removal
Timo Räsänen	2014	Hydrological changes in the Mekong River Basin - The effects of climate variability and hydropower development
Aura Salmivaara	2015	Spatial vulnerability assessments for water resources management - Cases from major Asian river basins with a focus on spatial unit of analysis and the use of big and open data
Johanna Jalonen	2015	Hydraulics of vegetated flows: estimating riparian plant drag with a view on laser scanning applications
Kaisa Västilä	2016	Flow-plant-sediment interactions: Vegetative resistance modeling and cohesive sediment processes
Leena Stenberg	2016	Erosion and sediment transport mechanisms in drained peatland forest catchments after ditch network maintenance
Suvi Sojamo	2016	Water-using corporations as agents of water security, management and governance - Exploring cases from stewardship initiatives in South Africa to global networks of power
Miina Porkka	2016	Securing global food supplies with limited resources - Lessons from the past
Gerald Krebs	2016	Spatial resolution and parameterization of an urban hydrological model: Requirements for the evaluation of low impact development strategies at the city scale
Henri Haimi	2016	Data-derived soft sensors in biological wastewater treatment - With application of multivariate statistical methods
Mirja Kattelus	2017	Framing wicked water problems: Cases from large Asian transboundary river basins
Mika Turunen (Tähtikarhu)	2017	Assessing water and sediment balances in clayey agricultural fields in high-latitude conditions
Tero Niemi	2017	Improved precipitation information for hydrological problem solving - Focus on open data and simulation
Olli Sahimaa	2017	Recycling potential of municipal solid waste in Finland
Kersti Haahti (Leppä)	2018	Modelling hydrology and sediment transport in a drained peatland forest - Focus on sediment load generation and control after ditch network maintenance
Maryam Roza Yazdani	2018	Engineered adsorptive materials for water remediation - Development, characterization, and application
Julia Talvitie	2018	Wastewater treatment plants as pathways of microlitter to the aquatic environment
Antonina Kruglova	2018	Biological removal of emerging micropollutants in nitrifying activated sludge at low temperatures
Juho Haapala	2018	Governing water for local development - Solutions to implementation challenges in remote, rural Nepal
Pia Välitalo (Talja)	2019	Toxicity and emerging contaminants – Effect-based assessment of complex environmental samples
Mika Jalava	2019	The water we eat - Methods for estimating water use of diets in changing food systems

Heidi Salo	2019	Assessing the effects of subsurface drainage on hydrology and nitrogen transport in Nordic fields
Petra Roiha	2019	Advancements of operational oceanography in the Baltic Sea
Hafsa Ahmed Munia	2020	Global analyses of drivers of water scarcity indicators in transboundary river basins
Tuija Laakso	2020	Data-driven network asset management - Focus on sewer systems
Elina Lehikoinen	2020	Building a more resilient Finnish food system - From import dependence towards domestic natural resource use
Pirjo Rantanen	2020	Nitrification in drinking water distribution and wastewater treatment - Reasons, consequences and the effects of the organic matter
Matias Heino	2022	Susceptibility of global crop production to climate variability and change
Amy Fallon	2022	Keep it Complex - Critical perspectives on water governance for dynamic social–hydrological systems
Marko Kallio	2022	Towards more useful water information - methods for fine-scale spatial estimation
Pekka Kinnunen	2022	Resilience perspectives in global food systems - Exploring variability, localness and diversity
Walter Box	2022	The impact of natural floodplain vegetation on flow resistance and fine sediment transport
Venla Niva	2022	The interplay of environmental and social drivers of migration - A global synthesis

This book includes a collection of Doctoral Thesis Process Summaries that describe the diverse ways of "getting there" i.e. completing a Doctoral Thesis.

All Process Summaries are related to Water and Environmental Engineering Research Group at Aalto University and its predecessor Helsinki University of Technology, covering years 2002-2022.

ISBN 978-952-64-1103-3
ISBN 978-952-64-1104-0 (pdf)
ISSN 1799-4896
ISSN 1799-490X (electronic)