One-year post-graduate course curriculum

Sustainable Management of Urban Water Cycle Services

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trust

D53.4

TRANSITIONS TO THE URBAN WATER SERVICES OF TOMORROW

One-year post-graduate course curriculum

Sustainable Management of Urban Water Cycle Services - D53.4

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1. CURRICULUM OUTLINE

1.1. Introduction

The central objective of the European project TRUST is to deliver co-produced knowledge to support Transitions to the Urban Water Services of Tomorrow, enabling communities to achieve a sustainable, low-carbon water future without compromising service quality. TRUST delivered research driven innovations in governance, modelling concepts, technologies, decision support tools, and novel approaches to integrated water, energy, and infrastructure asset management. These innovations have been demonstrated by the implementation of the most promising interventions in the urban water system of the nine different participating city pilot regions.

TRUST outcomes are incorporated into planning guidelines and decision support tools, and through dissemination of the knowledge generated to a broad stakeholder community including water utilities, water authorities, technology and service providers, and academics. Among others, the results from the TRUST project can be presented through university courses; i.e. the subject of this deliverable.

Given the importance of post-graduate education, a curriculum for a one-year post-graduate course on sustainable management of urban water cycle services (UWCS) is prepared. The aim of the curriculum is to provide a reference that may be adapted or adopted by any European university or network of universities.

Although the curriculum and courses presented are hypothetical, for the descriptions actual course contents of several European universities are used. TRUST deliverables are presented as course reading.

The target groups of this curriculum are:

- Education planners through Europe, which can incorporate (parts of) this curriculum in their education on the sustainable management of UWCS.
- Professors and teachers, to enrol their course in the wide amount of offered courses regarding UWCS.
- Students, in order to get acquainted with UWCS and explore their possibilities in the European Union.

1.2. Outline of the course

This curriculum is built around the five sustainability themes presented in TRUST (Figure 1):

- Environmental
- Social
- Economic
- Assets
- Governance

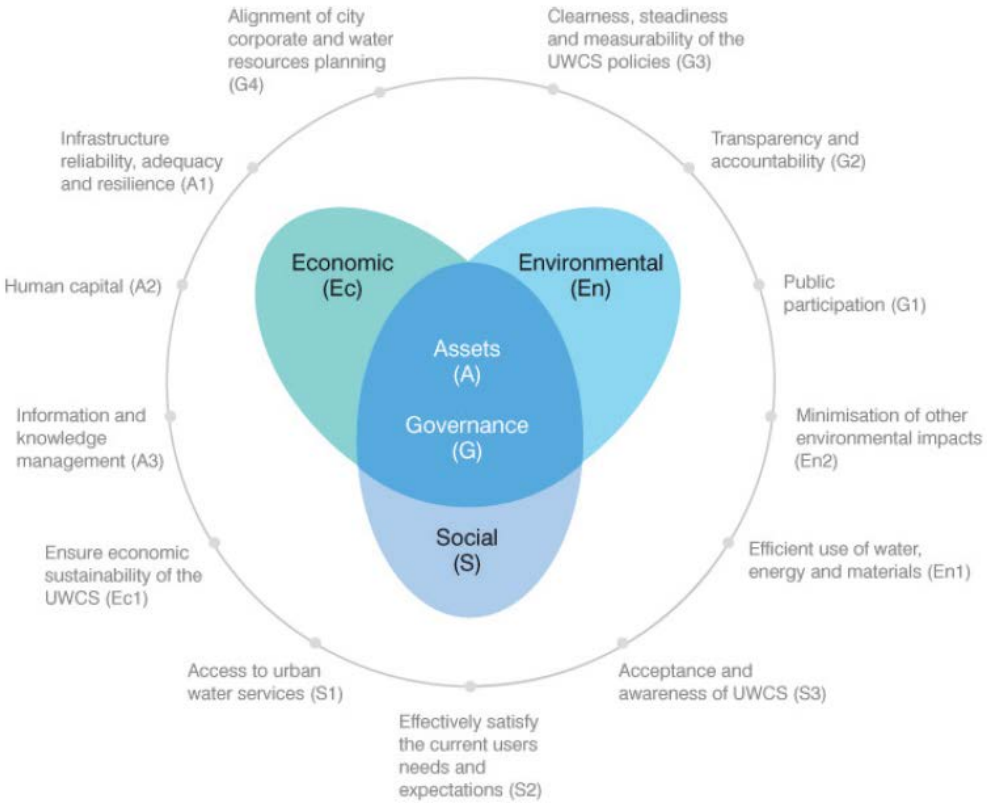


Figure 1: The sustainability themes of TRUST

These five themes are the five different specializations within this post-graduate curriculum.

The course is open for students with a minimum Bachelor degree in one of the following fields (or related background):

- Environmental Sciences
- Civil Engineering
- Urban Management

The one-year post-graduate curriculum comprises a total of 60 ECTS credits. To ensure an integrated approach to UWCS, the curriculum consists of compulsory courses in the five sustainability themes, to be followed by a minor and major specialisation with optional courses. The curriculum is structured in four periods of study as follows (see Figure 2):

Period 1 – Introductory courses

The curriculum starts with an Introduction to Urban Water Cycle Services. Depending on the students' background, this period offers to enrol in two 3-ECTS courses which have not been part in the students Bachelor study. This means e.g. that students with a background in civil engineering, have to enrol in the courses Environmental Sciences and Urban Management.

Period 2 – The basics of UWCS

Five 4-ECTS compulsory courses in the basics of environmental sciences, asset management, economics, social sciences and governance of UWCS are presented in period 2 of the curriculum.

Period 3 – Specialization 1 (Minor)

Period 3 and period 4 offer the students the possibility to specialize in two of the five presented TRUST sustainability themes:

- Environmental sciences of UWCS
- Social sciences of UWCS
- Economics of UWCS
- Asset management of UWCS
- Governance of UWCS

In period 3, from a list of optional courses, a total of 10 ECTS courses should be chosen as specialization (minor).

Period 4 – Specialization 2 (Major)

In this final period, the 2nd specialization (major) is chosen, for which a total of 20 ECTS courses should be selected.

After graduation in the one-year postgraduate course, students can continue for a Master degree in Sustainable Management of UWCS by doing a Thesis research (30 to 36 ECTS) in one of their specialized themes.

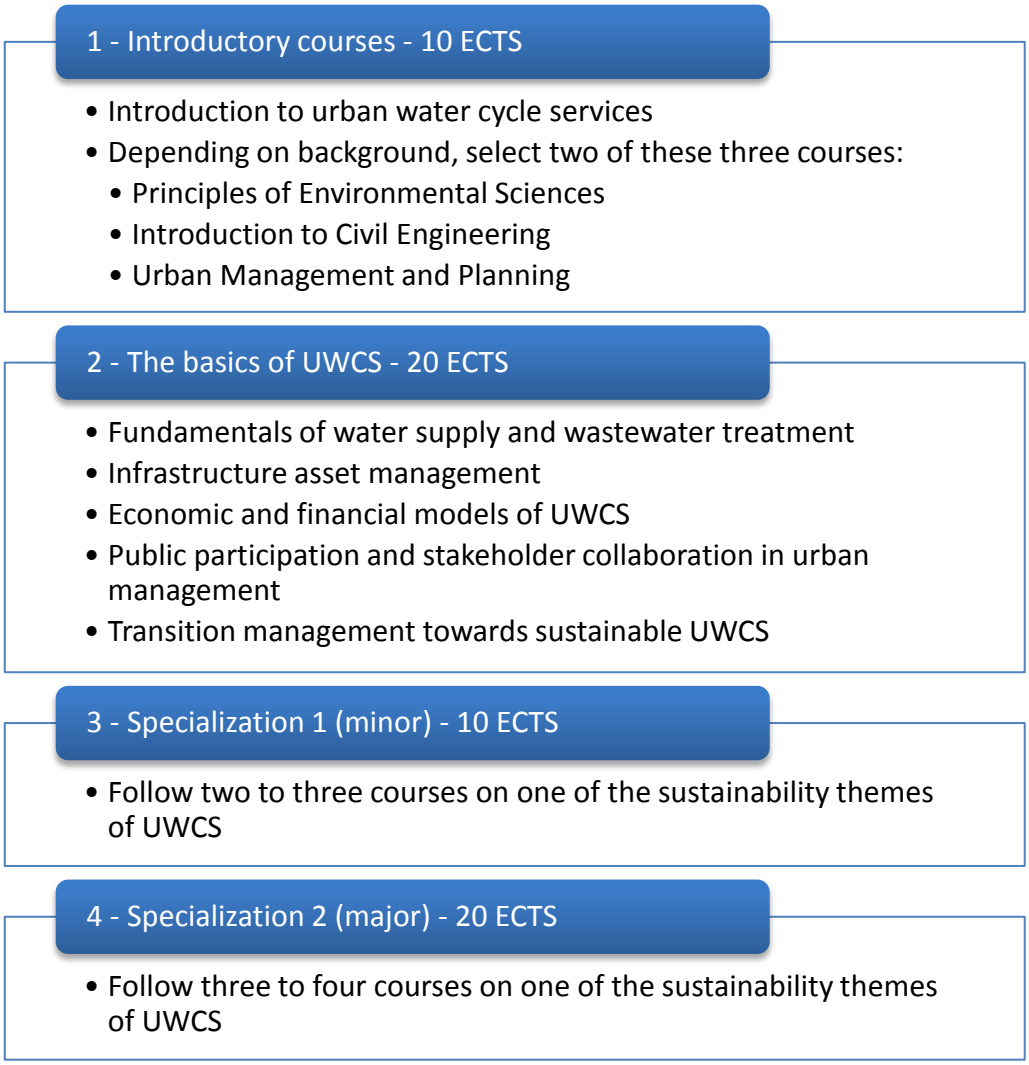


Figure 2: Curriculum outline

2. INTRODUCTORY COURSES

The curriculum starts with an Introduction to Urban Water Cycle Services.

Students enrolled in this post-graduate course will participate in two of the following three courses, depending on their background.

Environmental sciences background:

- Introduction to civil engineering hydraulics
- Urban management and planning

Civil engineering background:

- Principles of environmental sciences
- Urban management and planning

Urban management background:

- Principles of environmental sciences
- Introduction to civil engneering hydraulics

The content of the courses is described below:

2.1. Introduction to Urban Water Cycle Services

4 ECTS

Contents:

The course provides an overview on urban water cycle system (UWCS). Topics include: Surface water and groundwater. System loads and capacity, pressure, hydraulic conditions, water quality, alternative assessment. Masterplans and integrated urban water management. Modelling the water supply and wastewater system. UWCS in cold climate. Stormwater management. Pipe technology. Assessment of UWCS based on sustainability, environmental and economic aspects and risk.

Learning outcomes:

Students knows about:

- Principles for building and operation of urban transport systems for water and wastewater.
- Principles for technologies to manage runoff from rainfall and snow melt.
- Technologies for building, rehabilitation and maintenance of pipe system for water and wastewater.
- Principles for condition monitoring and functionality measurements for urban water and wastewater networks.
- Challenges and opportunities by management of water and wastewater in cities.
- General principles for cost-efficient management of water and wastewater services.

2.2. Principles of environmental sciences

3 ECTS

Contents:

This course offers students the opportunity of updating and extending their knowledge of the basic concepts of environmental sciences. Environmental problems in soil, water, and atmosphere are described and analysed. Attention is given to the socio-economic causes of these problems and their effects on organisms (including man) and ecosystems. The role science and technology can play in solving these problems is discussed, as is the role of actors such as government, business, environmental organisations and individual citizens. In a case study, small groups of students analyse a specific environmental problem, write a report and present a paper.

Learning outcomes:

After successful completion of the course students are expected to be able to demonstrate insight in the principles of environmental sciences, including:

- the functioning of life/ecosystems and their response to changes in environment; impacts of society on ecosystems and human beings.
- possible technical solutions to environmental problems.
- environmental awareness and environmental policy, and how they changed in time.
- social causes of environmental problems, and their implications for reform.
- integrate and apply obtained knowledge by analysing a particular environmental issue.
- to practice in determining one's own opinion on an environmental issue.

2.3. Introduction to civil engineering hydraulics

3 ECTS

Contents:

This course gives the basics of civil engineering hydraulics in the context of the urban water systems, i.e., the application of fluid mechanics principles to problems dealing with the collection, storage, control, and pressurized and open channel transport of water. Contents include the principles of fluid mechanics and of urban hydrology, as well the basics of systems analysis and simulation.

Learning outcomes:

After successful completion of the course students are expected to be able to demonstrate insight in the principles of civil engineering hydraulics, including:

- fundamental principles of fluid mechanics, including behaviour of real fluids, real and ideal fluids, viscous flow, laminar flow and turbulence, and Bernoulli's equation
- urban hydrology: rainfall (measurement, forecasting and modelling); urban hydrological processes (runoff processes, urban evapotranspiration); influence of urbanisation on streamflow; impacts of urban hydrology on receiving waters; integrated approaches to managing urban hydrology; assessing and managing urban runoff
- hydrological modelling of urban catchments
- analysis and modelling of open channel systems
- analysis and modelling of pressurised systems

2.4. Urban management and planning

3 ECTS

Contents:

This course offers the latest theory on urban development and management. It guides participants through economic, social and environmental urban theories and links these to the latest management theories, including theories on policies, plans, finances and governance structures. It offers the knowledge to analyse urban development and to manage the cities of the future.

Learning outcomes:

By the end of the course, participants know the latest theories on urban management and development. They will be able to:

- critically evaluate these theories and assess their relevance for the local condition.
- analyse urban policies
- argue a multi stakeholder approach
- analyse governance and planning structures
- develop neighborhood action plans.

3. BASICS OF UWCS

Five 4-ECTS courses in the basics of Urban Water Cycle Services are presented in period 2 of the curriculum. Based on these courses, the student will decide on the specialization further on (period 3 and period 4).

3.1. Fundamentals of water supply and wastewater treatment

4 ECTS

Contents:

The course gives an overview of the most important processes that are used in technological concepts or that are occurring in nature that upgrades the water quality until a specific level is reached. Physical, chemical and biological processes are dealt with in detail.

Lectures: The course deals with the fundamental background of water treatment technologies and highlights basic chemical and microbial techniques to reach water qualities for drinking, reuse, or discharge to the environment. The main unit operations in water treatment are dealt with:

- Water quality upgrading in the water chain;
- Coarse material removal (screening);
- Sedimentation and settling;
- Coagulation and flocculation;
- Adsorption of contaminants;
- Filtration processes (filter materials, membranes)
- Bioconversion principles (aerobic, anoxic, anaerobic);
- Suspended and attached growth bioreactors
- Bubble aeration, oxygen transfer;
- Removal of main pollutants prior to discharge: C, N, P.

Experiments: Several unit operations used in drinking water and wastewater treatment are simulated in pilot scale and bench scale set-ups.

- Filtration of surface water;
- Gas stripping / bubble aeration;
- Activated sludge kinetics
- Flocculent and hindered settling

Different measuring techniques and (bio)chemical analyses are used to monitor the experiments. Where applicable, the experimental results are used to design a full scale treatment unit. Each experiment has to be worked out in a report.

Learning outcomes:

- Acquire knowledge on the technological basics of water treatment technologies applicable for drinking water, process waters, and wastewaters.
- Apply this knowledge in lab- and pilot-scale experiments.

3.2. Infrastructure asset management

4 ECTS

Contents:

Infrastructure asset systems (water catchments, water treatment plants, transmission and distribution networks, storage tanks and pumping stations, wastewater and stormwater networks, retention tanks, wastewater treatment plants, etc.) play an important role in the economic development and transformation of nations. Owning and operating these assets presents continual challenges to the managers and engineers of the utilities and public service providers. Existing infrastructure is ageing while demand grows for improved and reliable water, wastewater and stormwater services responding to increasingly stringent regulation as well as population evolution. To address these challenges, there is need for strategic asset management. Strategic asset management is an integrated optimization process of "managing infrastructure assets to minimize the total cost of owning and maintaining them, while continuously delivering the service levels that customer's desire, at an acceptable level of risk".

It is an art of balancing performance, cost and risk. To achieve this balance requires a multidimensional approach that combines management, engineering principles, sound business practices, and economic theory.

Learning outcomes:

After successful completion of this course students are expected to have a good understanding of:

- Setting up a vision
- The fundamental concepts, principles and benefits of infrastructure asset management;
- Setting up a objectives, assessment criteria, metrics and reference values as a basis for transparent and accountable decision making;
- Principles and practical implementation of a roadmapping

- Asset management as an intrinsic component of the organization strategic plan;
- Best practice approaches for sustainable asset management with case studies;
- Infrastructure asset management techniques and methodologies;
- Asset inventory data and information management systems;
- Asset management decision support tools and models (performance assessment, system analysis, risk assessment and forecasting, financial models and financial assessment, capital investment planning, long term cost assessment & value optimization, etc);
- Institutional, organization, and research aspects of asset management;
- Engineering advances in asset management;
- Use of the TRUST IAM software.

3.3. Economic and financial models of UWCS

4 ECTS

Contents:

This course will introduce economic principles, concepts, and theory to build economic foundation for understanding water issues. Based on the economic foundation, the course will further elaborate on and synthesize economic approaches to managing water, including quantity and price based policy instruments, institutional role, and benefit-cost analysis. The course will also cover economic valuation of water uses and decision-making context.

Learning outcomes:

After successful completion of this course students are expected to be able to:

- Describe the principles of economics
- Identify economic instruments for water resource management
- Apply economic theory and method to analyze issues of water resource management

3.4. Public participation and stakeholder collaboration in urban management

4 ECTS

Contents:

In this course, students will gain an understanding of human settlements drawing from concepts and theories from social and environmental sciences; the spatial structure of urban and regional systems; economics of development; the legal framework of constitutional principles and rights; state and municipal law and regulations; the institutions and political processes associated with plans and planning; infrastructure; and public finance. Emphasis is on inter-organizational cooperation and public participation in urban planning.

Learning outcomes:

Students will be exposed to the tools for implementation of planning as well as the skills to:

- research, analyse and solve urban planning problems
- engage stakeholders
- manage the process of public participation

3.5. Transition management towards sustainable UWCS

4 ECTS

Contents:

This course introduces urban environmental infrastructure in the context of rapid urbanization on the one hand, and technological innovation on the other. Its main focus is on urban environmental infrastructure, i.e. the systems to provide urban households and offices with energy, drinking water, sanitation and waste (water) services. The course begins with an introduction of the different physical and organizational elements describing the existing systems to handle urban energy and water services. The development of these systems is given a historical perspective, highlighting the processes and key drivers of their development for different urban typologies (developing, transition and developed countries). A major challenge for managing urban environmental infrastructures that is addressed is the asset management of the ageing existing urban infrastructures in the context of the crowded subsurface in which many stakeholders claim room for their cables and pipes. The transition towards multi-asset management is placed in the perspective of building new infrastructures in developing areas.
In this course students will carry out a group work in which the development of the infrastructure of the city of the future is explored and presented. The assignment concentrates on the development of one infrastructure (clean water, waste water or energy)

in two possible surroundings (newly built city or transition from present to future situation). The course includes an excursion to an infrastructure company that manages multiple assets, like drinking water production and distribution in combination with a sewer network.

Learning outcomes:

After successful completion of this course students are expected to be able to:

- Explain the importance of urban energy, water, sanitation and waste services for the urban environment;
- Recognize the historical evolution and current and future trends in the management of energy, water, sanitation and wastes in developing, transition and developed countries;
- Explain how the organizational performance of infrastructure services can be measured and compared (e.g. by benchmarking) and what the balance of economics and technology is;
- Understand the organization of (utility) companies and evaluate how strategic and operational decisions may affect the performance of utility companies;
- Explain the interaction between various infrastructures, both on technical and governance level and indicate what consequences this has on asset management;
- Design a blue print for urban service infrastructures (energy, water, sanitation and waste) for a new city and a city in transition from present solutions to future blue print;
- Explain the difference between New Public Management and Public Value Management and indicate the consequences for the asset management system.

3.6. Additional reading

- A Master Framework for UWCS Sustainability
- City Blueprints: Baseline Assessment of Sustainable Water Management in 11 Cities of the Future
- Best practices for sustainable urban water cycle systems
- Roadmap guideline: A manual to organise transition planning in Urban Water Cycle Systems
- Integrated planning guidance material for example UWCS development

4. SPECIALISATION 1: ENVIRONMENTAL SCIENCES OF UWCS

Choose 10 up to 20 ECTS from the courses listed below (or additional courses in this topic domain available):

4.1. Water management in urban areas

4 ECTS

Contents:

In this course, three aspects of water management in urban areas are addressed:

- Relevant processes:
  - Functions of urban surface waters, groundwater and wastewater; functions of urban surfaces.
  - Pathtways and fluxes of water in the urban environment; urban water balances; urban climate; ground and surface water regimes; urban dessication; consequences of urbanization and of climate change on urban water system; interaction of urban and rural water systems; hydrological interaction with river basin.
  - Quality of stormwater, groundwater and surface water; sources of pollution; behaviour and degradation of pollutants.
  - Ecological quality and processes; relation with chemistry and hydromorphology of urban water courses.
  - Land subsidence, land filling and interaction with water ground- and surface water manangement.
- Design and engineering
  - Design standards and how to assess these for water quantity and quality; design loads; statistics and risks.
  - Design procedures for stormwater, surface water and groundwater drainage, land filling, subsidence and its interactions. Operational control of surface water and groundwater.
  - Design of water quality management in urban surface waters.
  - Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID), Best Management Practices (BMPs). Stormwater infiltration facilities and their design aspects.
  - Building site preparation, constructive aspects, transport and accessibility of the terrain, working conditions for building.
- Planning and management

- Planning process management; target oriented planning; guiding principles and process oriented approach procedures; collaborative planning of urban drainage projects.
- Waterwise spatial and urban planning. Climate robust urban water management.
- Urban water management plans, spatial planning and urbanism
- Transition management; mainstreaming innovative urban drainage and urban water management solutions.

Learning outcomes:

- The student should be able to develop and to manage a sustainable, healthy, climate resilient, safe and pleasant urban environment by creating appropriate conditions of land and water.
- Learn how to design and engineer a sustainable urban water system, based on a profound knowledge of all the relevant physical, chemical and ecological processes. How to monitor, manage and control urban stormwater runoff, surface water, groundwater, drinking water and waste water flows, including their water quality and how to control land subsidence?
- How to develop an urban water management strategy, an urban flood risk management strategy and climate adaptation plans? And how is the interaction between the urban water strategy and urban spatial planning and design?

4.2. Water and environmental engineering

4 ECTS

Contents:

The course covers important challenges and solutions in water and environmental engineering, and it is divided into two parts. The first part introduces the main challenges in the field, such as climate change, water pollution and growing waste generation. The principles of life cycle assessment in sustainability analysis of technical systems are also introduced. The second part gives an overview of solutions in urban systems for water supply and sanitation, explaining the design and function of such systems, water sources and quality, and technical solutions for storm water, wastewater, pipe networks and water and wastewater treatment.

Teaching comprises lectures, exercises and group work on the theoretical foundations in water and environmental engineering as well as problem based assignments for calculation and evaluation of solutions in technical systems in practice. Short excursions are arranged to technical facilities.

Learning outcomes:

The course shall give the students an introductory understanding in the field of water and environmental engineering. The students shall be able to explain the central strategies and solutions in technical systems for water supply and sanitation, for hydrology and rivers. They shall be able to carry out simple calculations for the design and evaluation of processes and technical solutions in the field. They shall also be able to explain how life cycle performance of technical systems in a sustainability perspective can be ensured, with a focus to the main principles of how to carry out environmental analysis of such systems. In group work the students shall develop awareness on how to collaborate effectively in teams and on how to write short and concise technical reports with a correct use of references to literature.

Candidate is expected to know:

- Main challenges within water and wastewater engineering.
- Principles for the environmental analysis of technical systems as a part of assessment of sustainability.
- Strategies and technical solutions from technical systems for rivers.
- Sketch technical construction of constructions for water and environment: Water and wastewater and from cities.
- Explain simple connections and provide simple calculations for elements in such systems.
- Assess simple environmental analysis for technical systems, based on indicators and use of life cycle assessment (LCA).
- Ability to work efficient in groups and for good report writing with specific weight on good use and documentation of references.
- Importance of environmental concern within civil engineering industry and how this can be used towards sustainable infrastructure.
- Importance of efficient of fair distribution of tasks in a working group.

4.3. Assessment of chemical and natural hazards

6 ECTS

Contents:

Mankind has an enormous impact on the world by trying to adapt nature for his own benefit as well as unintentionally affecting environmental quality by for example chemical pollution. However, natural disasters, such as earthquakes and flooding, as well as poor environmental quality threaten human society. It is therefore important to assess the risks of these threats. This course focuses on the application of GIS, remote sensing, geo-statistical and environmental fate modelling techniques to assess natural and chemical hazards in the soil-water-landscape system. Special attention is paid to:

- Slope failure
- River and coastal flooding
- Soil degradation and dessication
- Chemical pollution of soil and water
- Ecotoxicology and risk assessment of chemicals

Learning outcomes:

- Acquire a broad overview of the essentials of theory and computational techniques to assess chemical and natural hazards, related to soil, water and landscape.
- Use these techniques in hazard assessment for selected case studies.

4.4. Environmental measuring techniques

6 ECTS

Contents:

In order to understand (biogeo)chemical and physical patterns and processes at the earth surface quantitative knowledge of soil and water properties is essential. Without quantitative data it is impossible to assess the impact of environmental changes on the functions of ecosystems and interpretation of environmental data requires profound knowledge of the methods which were applied. In this course you can choose your own focus on measuring techniques in the fields of environmental chemistry, soil (biogeo)chemistry, geomorphology or soil physics.

Learning outcomes:

- Acquire an overview of environmental measuring techniques in the fields of either soil (biogeo)chemistry, environmental chemistry or geomorphology
- Master the theory of some specific measuring techniques in one of the mentioned disciplines.
- Apply these techniques in small projects.
- Develop substantial insight into how these measurement techniques result in an improved understanding of processes at the earth surface.

4.5. Additional reading

Additional reading (TRUST deliverables) for this specialization are listed below:

- Quantitative UWCS Performance Model
- Flood mitigation by on-site stormwater management (SUDS)
- Source to Tap Urban Water Cycle Modeling
- Intervention concepts for energy saving, recovery and generation from the UWCS
- Guidance on evaluation and selection of sustainable water demand management technologies

5. SPECIALISATION 2: SOCIAL SCIENCES OF UWCS

Choose 14 up to 20 ECTS from the courses listed below (or additional courses in this topic domain available):

5.1. Water and health

4 ECTS

Contents:

Framework of water and health; human diseases related to water and sanitation: which diseases? How are they transmitted in our urban environment? How can sanitary engineers help to prevent this?
Insight is given in pathogenic microbes and toxic chemicals and the diseases they cause, how these contaminants behave in the water environment and how they can be transmitted through water systems and cause disease. The contribution of civil engineers to the present excellent state of health was and is enormous. Civil engineers in water are also health engineers. Their options for improvement of health in developing countries are discussed. Water is central: the medical dangers connected with it, but also the benefits of good water supply and sanitation. Much attention is paid to "new" water related health issues like legionellosis, SARS, enteric viruses, arsenic, pharmaceuticals, nanomaterials etc.

Learning outcomes:

- The overall study goal is to make you able to critically evaluate the health risks associated with engineered water systems.
- You will learn which health risks can be associated with engineered water systems, how they occur and how you can intervene.
- You will get knowledge about the agents that cause disease, how they are transmitted through the environment and how this can be prevented.
- You will be able to design safe water systems and be able to communicate with health authorities.

5.2. Quantitative research methodology and statistics

6 ECTS

Contents:

Hypothesis testing. Simple and og multiple linear regression. Model choices. Test planning with two-level factorial exercises. Law of propagation of errors Analysis of variance Process control. Tables of contingency. Non-parametric methods. Use of software tool for statistical analysis.

Learning outcomes:

- Knowledge: The student has good understanding of basic statistical models and methods that are being used in natural science and technology. This includes hypothesis testing, linear regression, test planning, analysis of variance, law of propagation of errors, process control, analysis of tables of contingency and non-parametric methods.
- Skills: The student is able to plan research experiments to collect informative data of high quality and analyse the collected data by using statistical software tool and bring forth information that can support decisions.

5.3. Social and behavioural aspects of water management

4 ECTS

Contents:

There is increasing emphasis in the water industry on demand management, ensuring water requirements for communities are met in the face of fixed or declining water supply. This has emphasised the need for understanding the social and behavioural aspects of water use. Topics in this course include behavioural influences on water consumption within the various socio economic segments, risk perception and consumer acceptance of recycled water, public trust in the authorities to ensure quality control, addressing public perceptions and public concerns, communication strategies and community engagement.

Learning outcomes:

After this course the student have a better understanding of:

- How social aspects such as public perception influence water demand
- How water organisations can better address the behaviour of communities through engagement and communication strategies.

5.4. Decision making in networks

5 ECTS

Contents:

This course introduces students to theoretical perspectives and models that help to describe how decisions are made in practice, i.e. what decision-makers really do, and explain why decisions are made in such a way, i.e. why decision makers actually do what they do. Beyond description and explanation, this course then acquaints students with how networks are structured and what strategies may be used in managing a variety of actors and interests. During the lectures students apply the theoretical perspectives and models to real-life examples of decision making. In parallel students analyze a case study in more depth, which evaluates past decision making processes to formulate recommendations to actors about future decision making processes. At the end of the course students are not only able to analyze decision making processes in networks, but are also able to design (strategies for) decision making processes that enable change in a multi-actor context.

Learning outcomes:

At the end of this course students will be able to:

- Understand and apply rational and political perspectives on decision making.
- Contrast the characteristics of networks with the characteristics of hierarchies, and recognize these in real life cases.
- Independently reconstruct and evaluate decision-making processes about complex problems in multi-actor settings, i.e. in networks and organizations.
- Recognize and design strategies for decision-making processes in networks and organizations.

5.5. Additional reading

Additional reading (TRUST deliverables) for this specialization are listed below:

- Customer perspectives on new urban water services
- Web based self-audit adaptive potential tool for urban water stakeholders
- Risk, vulnerability, resilience and adaptive management in the water sector

6. SPECIALIZATION 3: ECONOMICS OF UWCS

Choose 10 up to 20 ECTS from the courses listed below (or additional courses in this topic domain available):

6.1. Spatial and regional economics

4 ECTS

Contents:

Location is an important feature of economic activities. In this course two aspects of spatial and regional economics are studied: location theory and regional development. Location theory deals with land economics, and the location of the firms and households. The regional development part deals with differences in economic development between regions, both in developed as well as in developing countries.

Learning outcomes:

After successful completion of this course students are expected to be able to:

- explain and analyse the spatial aspects of economic theory;
- construct, use and analyse a number of regional economic models used for assessing economic situations and to analyse policy options;
- report on assignments related to the models.

6.2. Financial management of water services

5 ECTS

Contents:

Finance for urban water supply and sewerage: types of costs; cost and fixed asset accounting; financial statements, balance sheet and income and expenses statement; profitability and financial ratio analysis; affordability and willingness to pa;.
Economics: supply and demand curves; marginal costing, price and income elasticity; tariffs: average historical costs, long run marginal costing; metering, billing and collection; budgeting; sources of finance for capital investment; project finance.

Learning outcomes:

After successful completion of this course students are expected to be able to:

- Recognize the need for commercial accounting and identify the components of standard financial statements in water organisations.
- Analyze the financial position of a water organisation through an analysis of financial statements.
- Apply simple financial and economic modelling to optimize production and improve financial performance.

6.3. Economics and management of natural resources

6 ECTS

Contents:

This course deals with the efficient and sustainable use of natural resources. The key question is how intensely a resource should be exploited, considering the typical properties of the resource, possible externalities, and future generations. The course deals with nonrenewable resources (e.g. minerals and fossil fuels), as well as renewable resources such as forests, fisheries, water, and ecosystems. The course also pays attention to the economic theory of different policy instruments, such as individual transferable quota, days-at-sea, and tradable water use rights.

Learning outcomes:

After successful completing this course students are expected to be able to:

- apply dynamic optimization techniques to management of non-renewable resources (such as fossil fuels and phosphate) and renewable resources (such as forestry, fisheries, and ecosystems);
- analyse economic problems of natural resource use, taking into account dynamics and sustainability;
- evaluate economic problems of natural resource use, taking into account concerns of intergenerational equity, sustainability, and discounting;

6.4. Integrated ecosystem assessment in regional management

6 ECTS

Contents:

In regional planning and management many, often conflicting interests have to be taken into account in the decision-making process. In this process the importance of natural ecosystems is often neglected. For balanced decision-making, it is necessary to analyse all effects of human interventions in a given ecosystem or region in an integrated way (including ecological, socio-cultural and economic aspects), taking due account of the interests and perceptions of the involved stakeholders.
The course starts with an introduction of integrated ecosystem assessment concepts and tools with special emphasis on ecosystem services. Students will practice with these tools in a case study situation and apply them to selected regional environmental policy issues.

Learning outcomes:

After the course, the students are expected to:

- be able to explain and critically discuss the main ecosystem assessment tools and know how to apply them in analysing regional environmental problems;
- understand the different approaches to ecosystem service valuation and know how to involve stakeholders in the assessment process;
- explain the various trade-off instruments in regional planning and be aware of the importance of uncertainties;
- understand the main environmental policy instruments and how they are used to address regional environmental problems;
- be able to work with regional ecosystem assessment tools within a multidisciplinary project team.

6.5. Additional reading

Additional reading (TRUST deliverables) for this specialization are listed below:

- Contemporary market structure and regulatory framework
- Advice to water management practitioners on competition, efficiency and new business opportunities
- Financial Sustainability Rating Tool

7. SPECIALIZATION 4: ASSET MANAGEMENT OF UWCS

Choose 10 up to 20 ECTS from the courses listed below (or additional courses in this topic domain available):

7.1. Urban drainage and water management

4 ECTS

Contents:

Plenary lectures by various lecturers and scientists in the field of urban drainage. The lectures will discuss characteristics of urban water flows, hydraulics, hydrology and how to apply knowledge of these phenomena to the design and analysis of urban water systems. Integration of various scientific disciplines and technological and practical approaches is a central theme in this course.

Group project: students will design an urban drainage system for a case of new development or a redevelopment area. They will prepare a written report of their data, design choices and results and present main results in a plenary session that concludes the lecture series.

Learning outcomes:

- After successful finishing of this course, the student should be able to design an urban drainage system for the collection and transport of wastewater and rainwater, taking into account environmental, social and economic requirements.

7.2. Spatial tools in water resource management

4 ECTS

Contents:

The course discusses several Geopgraphical Information System (GIS) and Remote Sensing (RS) tools relevant for analysis of (problems in and aspects of) water systems. Within the course, several applications are introduced. These applications include GIS tools to determine mapping of surface water systems (catchment delineation, reservoirs and canal systems). The RS tolos include determination of evaporation and soil moisture patterns, and measurement of water levels in surface water systems. In exercises and lectures, different tools and applications are offered. For each application, assignments are given to allow students to acquire relevant skills. The course structure combines assignments and introductory lectures. Each week participants work on one assignment. These assignments

are discussed in the next lecture and graded. Each week a new assignment is introduced, together with supporting materials (an article discussing the relevant application) and lectures (introducing theoretical issues). The study material of the course consists of a study guide, assignments, lecture material and articles. The final mark is the average of the grades of the individual assignments.

Learning outcomes:

After this course a student can:

- Describe and evaluate major GIS and RS applications in water resources management;
- Select relevant GIS and/or RS applications given a water resources management case;
- Apply several major GS and RS techniques.

7.3. Integrated infrastructure asset management

5 ECTS

Contents:

This course introduces urban environmental infrastructure in the context of rapid urbanization on the one hand, and technological innovation on the other. Its main focus is on urban environmental infrastructure, i.e. the systems to provide urban households and offices with energy, drinking water, sanitation and waste (water) services.

The course begins with an introduction of the different physical and organizational elements describing the existing systems to handle urban energy and water services. The development of these systems is given a historical perspective, highlighting the processes and key drivers of their development for different urban typologies (developing, transition and developed countries). A major challenge for managing urban environmental infrastructures that is addressed is the asset management of the ageing existing urban infrastructures in the context of the crowded subsurface in which many stakeholders claim room for their cables and pipes. The transition towards multi-asset management is placed in the perspective of building new infrastructures in developing areas.

In this course students will carry out a group work in which the development of the infrastructure of the city of the future is explored and presented. The assignment concentrates on the development of one infrastructure (clean water, waste water or energy) in two possible surroundings (newly built city or transition from present to future situation).

The course includes an excursion to an infrastructure company that manages multiple assets, like drinking water production and distribution in combination with a sewer network.

Learning outcomes:

After successful completion of this course students are expected to be able to:

- Explain the importance of urban energy, water, sanitation and waste services for the urban environment;
- Recognize the historical evolution and current and future trends in the management of energy, water, sanitation and wastes in developing, transition and developed countries;
- Explain how the organizational performance of infrastructure services can be measured and compared (e.g. by benchmarking) and what the balance of economics and technology is;
- Understand the organization of (utility) companies and evaluate how strategic and operational decisions may affect the performance of utility companies;
- Explain the interaction between various infrastructures, both on technical and governance level and indicate what consequences this has on asset management;
- Design a blue print for urban service infrastructures (energy, water, sanitation and waste) for a new city and a city in transition from present solutions to future blue print;
- Explain the difference between New Public Management and Public Value Management and indicate the consequences for the asset management system.

7.4. Assessing water infrastructure performance and conditioning

6 ECTS

Content

This course presents the principles and procedures involved in the introduction of an infrastructure performance and conditional assessment within an infrastructure asset management context. It will provide participants with a broad understanding of how organizations can benefit from infrastructure asset management systems. It focuses on the infrastructure asset management preparation steps, continuous improvement, and implementation. It also covers issues such as levels of service, condition assessment, performance /reliability analysis and risk management.

The course is addressed to individuals interested in learning the fundamentals of Sustainable Water Infrastructure Asset Management and main focus is on water and wastewater networks,. Students will also learn the methodologies and tools that use knowledge of these fundamental processes for infrastructure engineering and management.

Specific topics:

1. Fundamentals of Asset Management
2. Infrastructure sustainability and risk management
3. Condition monitoring of infrastructure and smart networks
4. Strengthening the Asset Reinvestment Decision

Learning outcomes

The objective of this program is to broaden and deepen the knowledge for practicing engineers on the approaches of infrastructure asset management. The program is developed to improve the practice, elevate the standards and advance the profession of water infrastructure management.

7.5. Additional reading

Additional reading (TRUST deliverables) for this specialization are listed below:

- System Development, Method Applicability and Pipeline Condition Data for Modelling Purposes
- Infrastructure asset management and planning of urban water systems

8. SPECIALIZATION 5: GOVERNANCE OF UWCS

Choose 10 up to 20 ECTS from the courses listed below (or additional courses in this topic domain available):

8.1. Water law, policy and governance

7 ECTS

Contents:

Generally, the course consists out of two parts. First, there will be a general introduction on governance, normative aspects of water management, policy design and water governance assessment, actors, regulations and agreements, enforcement and financing water management. Subsequently, specific water issues will be discussed. These issues are water quality, water safety, urban water management, fresh water and drinking water supply, sanitation and protection of the marine environment. The focus of the course lies on the European and Dutch context. Besides regular lectures, guest speakers will elaborate on the subject matter by going deeper into a legal or governance aspect in which they are a specialist or by providing insight into the practice of water management. An integrated water governance assessment method will be used to get a better understanding of success and failure mechanisms in water management. Students use this method to assess a specific case study in groups of 2 or 3 students. Subjects that will be addressed in the course are:

- The right to water as defined in European law;
- The normative principles grounded in law and their influence on water management;
- The influence of EU water policy and law on national water law;
- Legal and alternative instruments in water management and their relation with other fields as land use planning and environmental and nature conservation law;
- The evolution and integration of European and national water laws: from multi-sector governance to a comprehensive approach and the role of the Water Framework Directive;
- The interplay between European and national water management (multi-level governance) and the division of responsibilities within water management;
- The relationship between stakeholders (both governments and private parties) and their role in water management (multi-actor governance);
- Different modes of governance in the field of water and shifts in the dominant modes (private responsibility, public participation);
- The administrative organization of water management in the EU and institutional capacities of the different authorities involved in water management;

- Financing of water management; and
- Cooperation and shared responsibilities within river basin districts: the management of river basins that cross jurisdictional borders.

Learning outcomes:

The core objective of the course is to provide insight into the policy, governance and legal aspects of water management. After completion of the course, students should be able to:

- Understand the interplay between international, European and national water policy (governance and law) and the influence of supranational policy and law on national policy and law;
- Have insight in the administrative organization of water management in the EU, the historical context of water management and actual developments and the current law and policies (normative principles, legal instruments, plans and programs and conflict management) as well as the evolution in water management regarding the different governance modes;
- Understand the complexity of water issues and the current challenges in water management by developing an integrated view on water management and governance;
- Recognize stakeholders in water management processes, identify their role in these processes and explain their influence on water management processes and their outcomes;
- Analyse water governance practices as a series of interlinked features; and
- Conduct research on the complexity of water management in a specific area and to report on this in clear language.

8.2. Planning and design of urban space

6 ECTS

Contents:

This course introduces concepts, principles and methods for the planning and design of sustainable urban environments. The mix of concepts, case studies and simulation exercises offered in this module provides students with theoretical and practical understanding of the key issues that urban planners and infrastructure managers are facing when developing sustainable urban communities.

The course is built around real world planning challenges and brings together urban planning and urban design. In the group assignment students work on a case study, where they apply water-sensitive design, passive solar design and urban form concepts. In the individual paper students contrast current planning methods with selected literature. In a

small, one week assignment, students practice the use of planning tools e.g. Environmental Impact Assessment, evaluation matrixes and Net Present Valuation. Finally, students are introduced to spatial planning software tools like touch tables and Google Sketch up. The course is facilitated through lectures, but interactive hands-on workshops are a key element of this course. The analysis of real cases during the lectures, the group assignment and the individual assignment is another specific feature of the course.

Learning outcomes:

At the end of the course the student is able to:

- recognize how different elements of the urban form (spatial organization of urban area) interact with energy, water, sanitation, transport and social parameters;
- practice the use of software tools that are employed by planners to make decisions about the spatial organization, design and technology implementation (e.g. design tables, google sketch up, Monte Carlo simulations);
- understand different concepts of urban planning paradigms and how they will influence processes of urban change and technology implementation;
- apply methods to engage with stakeholders and to support their planning decisions, such methods include stakeholder analysis, multi-criteria decision analysis;
- design sustainable urban areas using concepts of water-sensitive urban design, passive solar design and urban form.

8.3. Planning of urban water systems

6 ECTS

Contents:

Service life assessment for water and wastewater networks, forecasting performance, reliability of water and wastewater services, selection of materials and methods to obtain sustainability, use of modelling tools.

Learning outcomes:

The candidate should have knowledge of life cycle assessment for water and wastewater networks and forecasting performance, reliability of water and wastewater services. The candidate should be able to consider the application of various analytical methods in the field, and to contribute to the development of new theories and methods in the field.

The candidate should master selection of materials for assessment and the use of relevant methods to obtain sustainability, and be able to make use of modelling tools.

The candidate should be able to use these skills to perform research at a high international level. The candidate should be able to assess the work of others on the same level.

The candidate should be able to use knowledge from the discipline for scientific assignments and projects, and to publish research and development results in recognized national and international channels.

8.4. Governance for sustainable cities

6 ECTS

Contents:

This course focuses on both general concepts of sustainable cities and the analysis of specific areas of sustainability. Questions of sustainability are approached from an international perspective. Conceptually, the course is based on general theories and models that have been developed in political science, public policy, public management and public administration, but it also focuses on specific policies such as urban air pollution and urban climate policy. The course consists of four topics:

- Introduction to the governance of sustainable cities and city-regions, including an overview on the - economic, political, and social dynamics that influence the growth and development of cities:
    - international and national context of local sustainability;
    - institutionalization of environmental policy and sustainable development at the local level;
- General concepts and debates relevant for the analysis of urban sustainability:
    - basic concepts and theories on governance, transition management, stakeholder and citizen participation, etc.;
    - forms of horizontal collaboration such as the cooperation between public and private actors, and the emergence of transnational city networks;
    - forms of vertical collaboration such as the cooperation between local, national and international institutions;
- Specific issues related to environmental policy in urban environments:
    - air quality and city climate;
    - mechanisms of urban air pollution;
    - local climate change policies, including energy policies.
- Scenarios and alternatives for the city of the future and the development of cities in ways which reduce environmental damage, reduce the natural resources consumed by cities, and improve the citizens' quality of life.

Learning outcomes:

After successful completion of this course students are expected to be able to:

- understand the economic, political, and social dynamics that determine the way cities develop;
- understand urban climate and air pollution problems, processes and effects on environment and public health;
- identify the major theories and models which contribute to the concept of local sustainability and its social, economic, and environmental dimensions;
- apply these theories and models to climate and air pollution problems and to specific cities - analyse sustainable solutions to complex problems in a specific urban context;
  understand as to how policies for local sustainability are formulated and implemented and how the development of urban sustainability strategies is influenced by governmental and non-governmental actors at different levels;
- analyse ways how sustainable cities can be created and developed.

8.5. Additional reading

Additional reading (TRUST deliverables) for this specialization are listed below:

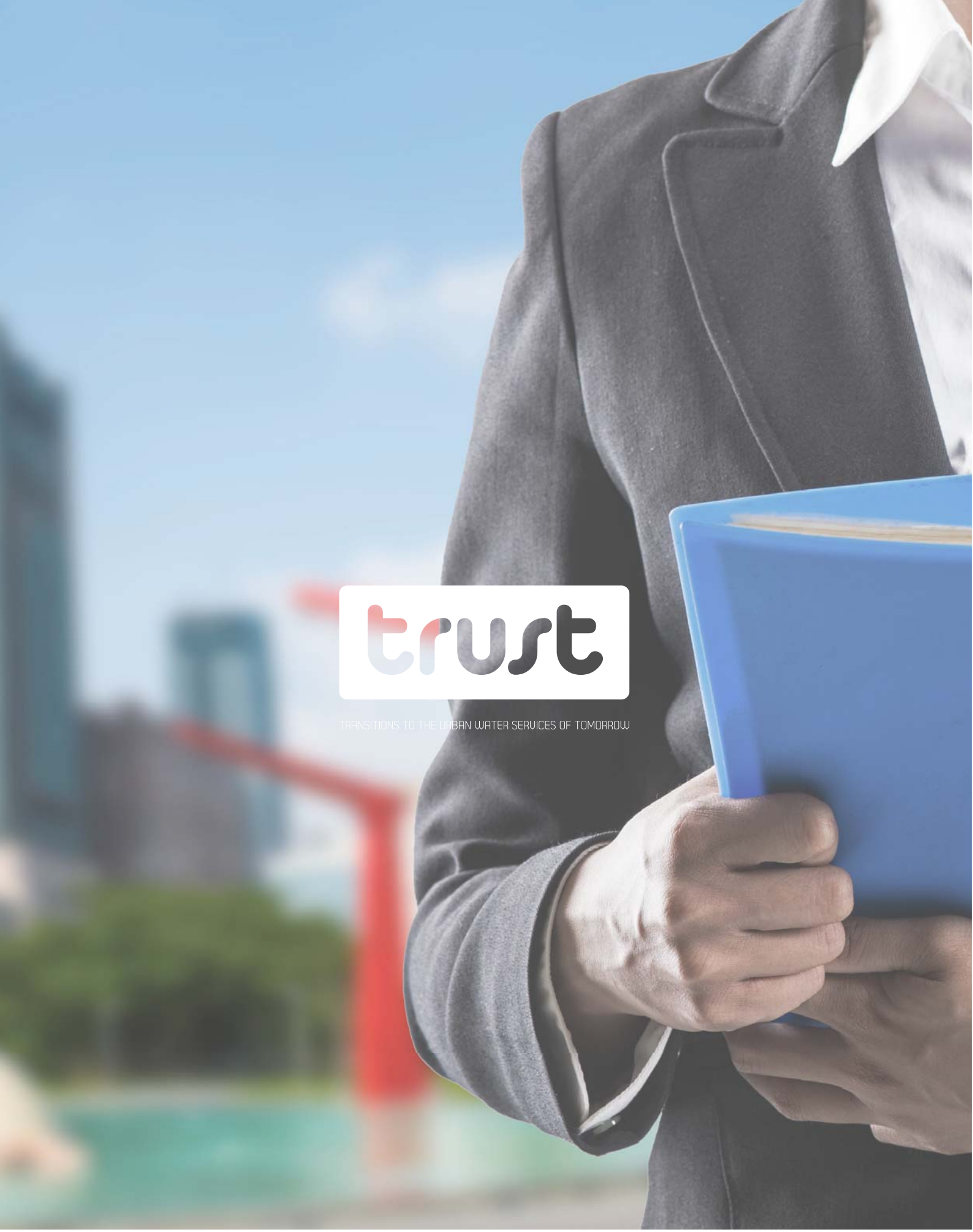
- Integrated Decision Support System Framework
- Scenario 2040 for Oslo as model city
- Policy brief on carbon sensitive urban water futures
- Set of policy briefs for water management practitioners
- Integrated planning guidance material for example UWCS development

9. TRUST DELIVERABLES

The following TRUST deliverables (available on www.trust-i.net) could be used as additional reading:

- A Master Framework for UWCS Sustainability
- Framework for Sustainability Assessment of UWCS and development of a Self-Assessment Tool
- Baseline assessment and best practices in urban water cycle services in the city of Hamburg
- City Blueprints: Baseline Assessment of Sustainable Water Management in 11 Cities of the Future
- Development of an on-line self-assessment tool based on UWCS performance measures
- Best practices for sustainable urban water cycle systems
- Roadmap guideline: A manual to organise transition planning in Urban Water Cycle Systems
- Flood mitigation by on-site stormwater management (SUDS) – Preparing of SUDS in Sandnes City
- Source to Tap Urban Water Cycle Modeling
- Intervention concepts for energy saving, recovery and generation from the UWCS
- Quantitative UWCS Performance Model
- System Development, Method Applicability and Pipeline Condition Data for Modeling Purposes
- Guidance on evaluation and selection of sustainable water demand management technologies
- Customer perspectives on new urban water services
- Web based self-audit adaptive potential tool for urban water stakeholders
- Risk, vulnerability, resilience and adaptive management in the water sector
- Contemporary market structure and regulatory framework
- Advice to water management practitioners on competition, efficiency and new business opportunities
- Financial Sustainability Rating Tool
- ADAPT, a drainage analysis planning tool
- Infrastructure asset management and planning of urban water systems
- Integrated Decision Support System Framework
- Scenario 2040 for Oslo as model city

- Policy brief on carbon sensitive urban water futures
- Set of policy briefs for water management practitioners
- Integrated planning guidance material for example UWCS development
- Transition to Sustainable Urban Water Services of Tomorrow; a handbook for policy makers.



One-year post-graduate course curriculum

Sustainable Management of Urban Water Cycle Services

D 53.4

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