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IHE DELFT
Institute for
Water Education
in partnership with UNESCO

Study Guide

Academic Programme 2018-2020

(fieldwork France with HERBD, HWR, and GroundwatCH student groups, 2016)

Programme Information: **Water Science and Engineering MSc Programme**

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Introduction

The Water Science & Engineering Programme focuses on the understanding, management and development of water resources and water flows and quality in the natural and human-influenced environment, while addressing the multidisciplinary character of human activities dealing with water.
The specializations within this programme explore natural and anthropogenic influences on the water cycle, from the perspectives of civil engineering, technology and earth system sciences. They are of direct relevance to sustainable development because they prepare graduates to improve the sustainable management of human impacts on water resources, design simulation models for various phases of the water cycle, and contribute to the development of integrated solutions for reducing the impact of water-related natural hazards and other water issues.
The programme aims to deepen the knowledge, insights and skills for Hydraulic Engineering (part of Civil Engineering and covering the disciplines River Basin Development, Land and Water Development for Food Security and Coastal Engineering and Port Development), Hydroinformatics (a technology oriented discipline) and Hydrology (an earth system science). These different fields are complementary and ensure exposure of the student to a large variety of water issues from different perspectives, and the ability to develop sustainable solutions for complex water problems.

Graduates are able to work in professional water sector environments that require academic skills.
Graduates who obtain very good study results are eligible to undertake a PhD in an appropriate water science or engineering field.

In particular, this programme provides the education to:

- improve the management of water resources through assessing and monitoring their condition and vulnerability to hazards;
- sustain economic development by better flood and drought protection, risk management and hazard reduction, in an era of global climate change;
- improve environmental and public health through pollution prevention;
- sustain and improve water supply, power generation and agriculture through integrated water resources management;
- improve food production by developing, operating, maintaining and optimising water-related infrastructure;
- sustain economic growth through the development of coastal and riparian zones; and
- manage and control water systems in an integrated and sustainable way, with stakeholders, through the development of technologies to simulate such systems.

The programme focuses mainly on emerging and least developed countries and is especially suitable for midcareer professionals.

Domain specific framework

The concept of Water Science & Engineering

The concept of Water Science & Engineering is born out of the recognition that the technical and scientific problems related to water are increasingly multidisciplinary and graduates can no longer rely on spending their future working within only one of the traditional disciplines; rather, dealing with even the more technical aspects of water problems requires a mix of disciplines that:

- deal with water fluxes and quality in the natural and human-influenced environment;
- are concerned with different aspects of water resources management and development ;
- explore the natural and anthropogenic influences on the water cycle at various spatial and temporal scales;
- investigate the management and optimization of the human impact on water resources through structural and non-structural measures;
- develop and apply various simulation and predictive models for different phases of the water cycle;
- consider physical and logistical aspects of transport over water; and
- are concerned with protection against water-related natural hazards.

The academic field of Water Science & Engineering

Water Science & Engineering includes a range of science and engineering disciplines related to the aquatic environment. Each discipline represents an established and well-defined academic field for which the objectives are readily obtained from international consensus. Hydrology for example is defined by the International Association of Hydrological Sciences (IAHS); and the fields of Hydraulic Engineering and Hydroinformatics by the International Association of Hydro-environment Engineering and Research (IAHR) and the International Water Association (IWA).

In short, the disciplines comprise:

- Hydrology: an earth system science that deals with the occurrence, circulation and distribution of water and the chemical and physical properties of water in the environment. In addition, it is the science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the earth, and various phases of the hydrological cycle;

- Hydroinformatics: a discipline which deals with applications of information and communication technologies, advanced risk-based modelling and forecasting tools, system analysis and optimization to all areas of integrated water management and especially to river basins, aquifers, urban water systems, estuaries, and coastal waters; and

- Hydraulic Engineering: a part of Civil Engineering that deals with the application of engineering principles and methods to the control, conservation and utilization of water. This discipline is further divided into Land and Water Development for Food Security, River Basin Development and Coastal Engineering and Port Development.

Objectives of the Water Science & Engineering Programme and intended learning outcomes

The overall objective of the Water Science & Engineering Masters Programme is as follows:
"By the end of the course, students will be able to work in a complex environment, and, by using interdisciplinary approaches, will be able to improve the management of human impacts on water resources, to develop simulation models for various phases of the water cycle, and to develop methods to reduce the impacts of water-related natural hazards".

To be able to work in this complex environment of water resources and to explore natural and anthropogenic influences on the water cycle as well as to develop solutions, scientific knowledge and academic skills are needed from the perspective of civil engineering (Hydraulic Engineering), technology (Hydroinformatics) and earth sciences (Hydrology). Therefore, these fields form the foundation for the Water Science & Engineering Masters Programme. In line with this overall objective, the Water Science & Engineering Masters Programme has the following intended learning outcomes.

Upon successful completion of the Water Science & Engineering Programme, graduates will be able to:

Knowledge and understanding
A. demonstrate knowledge and understanding of hydrological, hydraulic, morphological and environmental processes and phenomena and their inter-relationships;
B. identify and characterize the causes and impacts of water-related problems on society, the economy and the environment;
C. explain the need for integration of monitoring, modelling and information systems to support safe and reliable decision making;
D. demonstrate critical thinking skills, the ability of both independent and team problem-solving and the sense of engineering creativity and design;

Applying knowledge and understanding
E. apply modelling and data management related to hydrological, hydraulic, morphological and environmental processes;
F. conduct research, independently or in a multidisciplinary team, including the formulation of research questions and hypotheses, the selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations
G. support planning, design, implementation, operation and maintenance, and management of engineered measures, of both a constructive and an operational character, aimed at the solution of problems arising from the multiple uses of water;

Making judgements
H. co-operate within a multidisciplinary and interdisciplinary framework with due consideration of ethical and social aspects related to the application of their knowledge and skills;
I. critically judge and evaluate their own work and results, as well as prior research carried out by others;

Communication
J. communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences, making use of appropriate information and communication technologies;

Learning skills

K. demonstrate academic attitude and learning skills (including thinking in multidisciplinary dimensions) to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner; and

L. integrate ethical issues encountered in engineering practice and in relation to working in emerging and least developed countries and countries in transition.

The table below shows how the various programme components contribute to the relation between the programme level learning objectives.

Table 1: Relation between programme level learning objectives and programme components

	A	B	C	D	E	F	G	H	I	J	K	L
1. Introduction to water science and engineering	▒	■	▒						■			■
2. Hydraulics and hydrology	■	▒	▒									
3.-7. Specialization modules	■	▒	▒	▒	▒		▒		▒			▒
8. Programme-wide electives	■	▒			▒		▒	▒	▒			▒
9. Fieldtrip/fieldwork	■						▒					
10. Programme-wide electives	■	▒			▒		▒	▒	▒			▒
11. Institute-wide electives	▒	■			▒			▒	▒			
12. Summer courses	■	▒	■		■							▒
13. Groupwork		■	■	▒		▒	▒	■	■	▒		▒
14. MSc proposal preparation				■		■	■	■				■
15. MSc research	■	■	▒	■	■	■	■	■	■	■	■	▒

Key: ■ - objectives of primary focus; ▒ - objectives of secondary fcus

Skills development

Skills development is an integral part of the programme’s core learning objectives and activities. The academic and research skills are nurtured throughout the programme. These include, but are not limited to oral expression, reading comprehension, written expression, critical thinking, self monitoring, coordinating with others, scientific ethics, research skills and information literacy. These activities are well embedded within the core contents of the entire program (Tables 2 and 3), which helps to maintain a strong link between skills and knowledge (theory and application).

Table 2: Relation between skills development and programme components

	Oral expression	Reading comprehension	Written expression	Critical thinking	Monitoring self	Coordinating with others	Scientific ethics	Research skills	Information literacy
1. Introduction to Water Science and Engineering		somehow		somehow					
2. Hydraulics and Hydrology		well	somehow	well		somehow			well
3.-7. Specialization modules	somehow	well	somehow	well		somehow	somehow	somehow	somehow
8. Programme-wide electives	somehow	well	somehow	somehow		well	somehow	somehow	well
9. Fieldtrip/fieldwork	somehow	somehow	somehow	well	well	well		well	somehow
10. Programme-wide electives	somehow	somehow	somehow	somehow		somehow		somehow	somehow
11. Institute-wide electives	somehow		somehow			well		somehow	
12. Summer courses	well	well	well						well
13. Groupwork	well	well	well	well	well	well			well
14. MSc proposal preparation	well	well	well	well			somehow	somehow	well
15. MSc research		well	well	well			well	well	well

Key: covered well; covered somehow; not covered

Table 3: Explanation and definition of skills used in Table 2

Oral expression	Giving presentations, involvement in discussions, explaining concepts in own words
Reading comprehension	Carrying out exercises, assignments, reading lecture notes, reports, theses, articles
Written expression	Carrying out exercises, assignments, drafting reports, notes, thesis
Critical thinking	Being able to evaluate your work and that of others, making judgments about the value of information and drawing conclusions from data;
Monitoring self	Being able to change behavior to fit a situation;
Coordinating with others	Capacity to follow up tasks, follow through on undertakings, capacity to maintain, balance or restore workflow;
Scientific ethics	- Exercising honest research practices; - Responsible for the activities, subject matter and method of his or her research, as well as for the quality of the results; - Respect the contributions of other researchers and follow standards for authorship and cooperation; - Follow national and international regulations on ethics and safety;
Research skills	Independence – being able to work without close supervision, managing your own time and projects Critical thinking – being able to evaluate your work and that of others, making judgments about the value of information and drawing conclusions from data. Problem solving – working without "a right answer" and devising strategies to work towards a solution Contributing as a professional – presenting work to your peers, managing discussions and defending your position, having the confidence to put forwards ideas to senior staff Initiative – having the confidence to make decisions and act on them, not waiting for approval to do basic tasks, but reporting back responsibly at appropriate times
Information literacy	How to use scholarly information effectively and responsibly? More in particular, an information literate person: - Determines the nature and extent of information needed; - Accesses the needed information effectively and efficiently; - Evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system; - Uses information effectively to accomplish a specific purpose; - Understands many of the economic, legal, and social issues surrounding the use of information, and accesses and uses information ethically and legally;

Curriculum and structure of the Water Science & Engineering Programme

The overall emphasis of the programme is on water sciences, engineering and technology placed in the contemporary context of society, economy and environment. The specializations are structured in a sequential build-up of educational components (incremental learning approach), which allow some interchange of topics and other educational activities among groups of students following one chosen specialization. The programme provides an excellent opportunity for students – although mainly devoted to their selected specialization – to interact with colleagues of other specializations and to share information and learning activities in a multidisciplinary context. Time constraints have required careful choice of compulsory subjects that form the main skeleton of each specialization programme and common subjects and electives to promote interspecialization thinking and development. The Water Science & Engineering Masters Programme incorporates eight specializations:

- Hydrology and Water Resources (HWR);
- Hydraulic Engineering and River Basin Development (HERBD);
- Coastal Engineering and Port Development (CEPD);
- Land and Water Development for Food Security (LWDFS);
- Hydroinformatics: Modelling and Information Systems for Water Management (HI);
- Sustainable Urban Water Management (SUWM);
- Erasmus Mundus Programme on Flood Risk Management (FRM); and
- Erasmus+ Programme on Groundwater and Global Change (GroundwatCH).

Several tracks of these specializations have been developed as part of educational programmes that lead to a double degree (from IHE DELFT and partner organisation). The figure below gives an overview of the different specializations and double degree programmes. The specializations GroundwatCH and FRM are offered as Erasmus Mundus and Erasmus+ programmes. The LWDFS specialization is, in addition to the track offered in Delft, also organised as a double degree programme with three other partners, i.e. UNL in the USA, and Sriwijaya in Indonesia. HI offers the possibility to start at Universidad del Valle in Colombia. The SUWM specialization in IHE-Delft will work in close collaboration with the Southeast University, Nanjing, China.

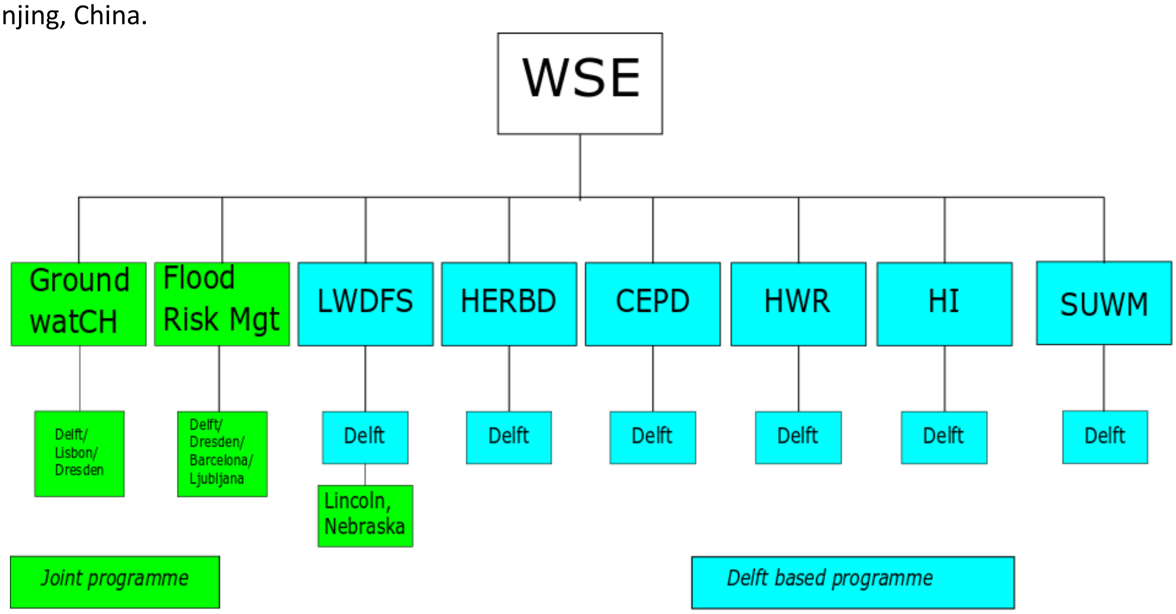

Figure 1: Water Science & Engineering Masters Programme: specializations and double degree programmes

The six Delft-based specializations have four distinct phases:

- a *foundation phase* – in which the foundation to build on is laid, fundamental principles and system understanding as well as key methodologies are introduced, students learn to understand their field of study (Water Science & Engineering) and neighbouring disciplines in a broader context;
- a *deepening phase* – when each student deepens his or her advanced knowledge and skills in their chosen specialization through an incremental learning approach;
- a *broadening phase* – when the student further learns to appreciate the inter-relationship between his or her specialization and the other specializations and programmes through (a) choosing electives offered by the other specializations and programmes, and (b) working collaboratively with his or her fellow students from those specializations and programmes on joint problems; and
- a *research phase* – when the student experiences doing his or her own independent research on a topic that may involve supervision from staff in more than one specialization. This is based on research experiences gained in the earlier parts of the curriculum (modules 1-13). Preparation for this phase begins early in the programme.

The programme has a modular structure with teaching organised into three-week blocks; sometimes two modules are scheduled in parallel for six weeks for didactical and logistical reasons. After a period of two blocks there is a week for examinations. This structure is generally reflected in the Academic Calendar.

Didactical concept

Generally, IHE DELFT follows the T-shape model as a generic competency profile guiding the design of its curricula (see Uhlenbrook and de Jong, 2012, for further details). This model differentiates between cognitive competencies in a certain specialization of Water Science & Engineering (e.g. hydrology; vertical leg of the T) and other cognitive/knowledge competencies in neighbouring fields (e.g. hydraulics, aquatic ecology, land use management etc.) and functional, personal and values competencies and meta-competencies (horizontal bar of the T). It is based on the holistic model of professional competencies by Cheetham and Chivers (1996) and related studies (Oskam, 2009), and proved effective in the water sector (Kaspersma et al., 2012). For the effectiveness of graduates from the Water Science & Engineering Masters Programme as professionals, a variable mix of competencies is required that are developed throughout the curriculum and facilitated by the applied variety of didactical approaches and assessment methods (section 3.2).

The Water Science & Engineering Programme is particularly designed to stimulate active learning within a framework of incremental learning. Each module therefore comprises a balance of formal lectures, supervised and unsupervised workshops, case studies, field trips, field work, individual studies, etc. and self study by the student. That establishes a foundation for addressing scientific and practical problems in the later stages of the programme. The knowledge and abilities of students are thereby gradually developed, so that both disciplinary knowledge and insights in problem analysis and problem solving, and general academic skills can be deployed to good effect in subsequent groupwork and research thesis studies. The MSc research provides a vehicle through which integration of the programme material is achieved. The MSc thesis part is the culmination of the study, the part where independent thinking and problem-solving is further developed. Students typically take one of the following types of topics:

- a research topic from their own home environment, often in a sandwich programme, where field research and/or data collection is carried out for 2-3 months out of the six months period. Almost by definition these are quite development relevant contributions, and quality is ensured by supervision throughout the project;
- a research topic related to a (larger) research project at IHE DELFT and/or partner organisation (usually in cooperation with PhD or post-doctoral research studies). This allows a close link with the latest research in a certain field; or
- a topic as part of ongoing research or development project at a knowledge institute like Deltares, or at a consultancy or a company, where the student works in a team and gets a unique experience of working in a professional research and/or consultancy environment. Sufficient academic orientation is ensured through co-supervision of IHE DELFT supervisor/mentor throughout the project.

Hydrology and Water Resources (HWR)

Hydrology is the science dealing with the occurrence, transport, and properties of water on the earth, in which the principal attention is directed to continental fresh water resources. Hydrologists are involved in solving numerous problems arising in society and generally work as specialised scientists and professionals within a multidisciplinary setting. Given the broad scope of the subject matter, hydrologists often focus on specific fields but need to have a good foundation in the overall aspects of the discipline itself, as well as a basic overview of concepts and principles of related disciplines. Typical issues and themes that are therefore dealt within the hydrology programme are:

- water cycle and water balances
- hydrological and hydrogeological systems, physical and chemical processes
- relationships with vegetation, landforms, geology, land use and infrastructure
- runoff formation and anthropogenic influences
- water resources assessment, planning and development
- environmental impact assessment
- water quality assessment
- water resources management
- hydro- and geo-informatics
- modelling and simulation of rivers, catchments and groundwater systems
- effects of landuse, urbanisation
- flood risk, drought, groundwater over-exploitation analysis
- pollution vulnerability and remediation
- statistical methods for rainfall, runoff and groundwater characterisation
- methods and techniques for measurements and data collection, processing and analysis
- reporting and presentation
- independent research, literature study

Short outline of the curriculum

Modules 1 and 2 are combined for all specializations in the WSE programme. The initial specialization modules 3 and 4 introduce the major concepts and principles of hydrology and hydrogeology while moving towards an advanced level of understanding. The important relations and underlying concepts of earth sciences used in hydrology, and the relation of hydrology with the atmosphere and climate are also outlined. Modules 5 and onward deal with specialist issues, including methodologies relating to water quality, data collection, processing and analysis methods, modelling tools and multidisciplinary application aspects in water resources management. Students can, according to their preference, focus on either surface water hydrology (module 7A), or groundwater hydrology (module 7B). During the summer, the fieldwork provides the opportunity for real-terrain experience. The fieldtrips expose students to a wide range of applications and problems involving hydrology. The group work is aimed at making a comprehensive hydrological assessment using a variety of data from real situations within a team framework. With permission of the professors involved, students can also choose the corresponding module 8, 10 or 11 from other WSE specializations. Module 14 deals with research methodology and approach, and offers the students to choose a selected topic on contemporary issues in current research related to hydrology, which are to be reviewed in an in-depth study. Finally, students will prepare a thesis proposal and carry out their thesis research under the guidance of an individual supervisor.

Hydroinformatics – Modelling and Information Systems (HI)

Hydroinformatics uses simulation modelling and information and communication technology to help in solving problems of hydraulics, hydrology and environmental engineering for better management of water-based systems. It provides the computer-based decision-support systems that now enter increasingly into the offices of engineers, water authorities and government agencies. The Hydroinformatics course aims at enriching traditional engineering practice by introducing innovative approaches in order to open up for the participants much broader perspectives.

To achieve these objectives the Hydroinformatics specialization provides:

- Academic education in fundamental Hydroinformatics. The basic hydraulic, hydrologic, water quality and environmental processes and the fundamentals of computer sciences and software engineering. The ways of combining both fields for design and development of software tools.
- Education for understanding the two modelling paradigms of 'physically-based (process) modelling' and 'data-driven modelling'. Training in analysis and modelling techniques from both paradigms, including their complementary applications.
- Education for understanding systems analysis, and training in use of optimisation and decision support tools and techniques.
- Hands-on training in using software tools in several application areas: river and flood management, urban water systems, coastal systems, environmental systems, groundwater and catchments hydrology and water quality.
- Education for understanding the integrative nature of Hydroinformatics and its broader role in society.

Overview of the study programme

The study programme is structured in such a way that several different and interrelated themes are being covered through the introduction, and the extensive use of various modelling, information technology, and decision support tools (Figure 2).

The *Fundamentals, hydraulic, hydrologic and environmental processes* theme groups all the subjects that should be mastered in order to be able to fully assimilate and benefit from the subjects given in the other blocks. A strong emphasis is put on the basic notions of hydraulic and hydrologic processes, water quality and environmental processes, as well as appropriate mathematical techniques and computer manipulation.

The *Information systems, GIS, communications and Internet* theme groups the fundamentals of computer science and software engineering. It includes database and data analysis systems, Geographical Information Systems (such as GIS), and technologies for Internet based communications.

The *Physically-based simulation modelling* theme comprises subjects concerned with the modelling approaches that are based on the description of the various physical water-related processes. It also includes a reasonable understanding of the numerical techniques used in most commercially available models, and the precautions that should be taken in order to ensure good quality modelling solutions.

The *Data-driven modelling and computational intelligence* theme groups all the subjects related to modelling techniques that do not rely on a physical description of the processes involved in the system under study. This includes in particular artificial neural networks, genetic algorithms as well as more classical statistical techniques.

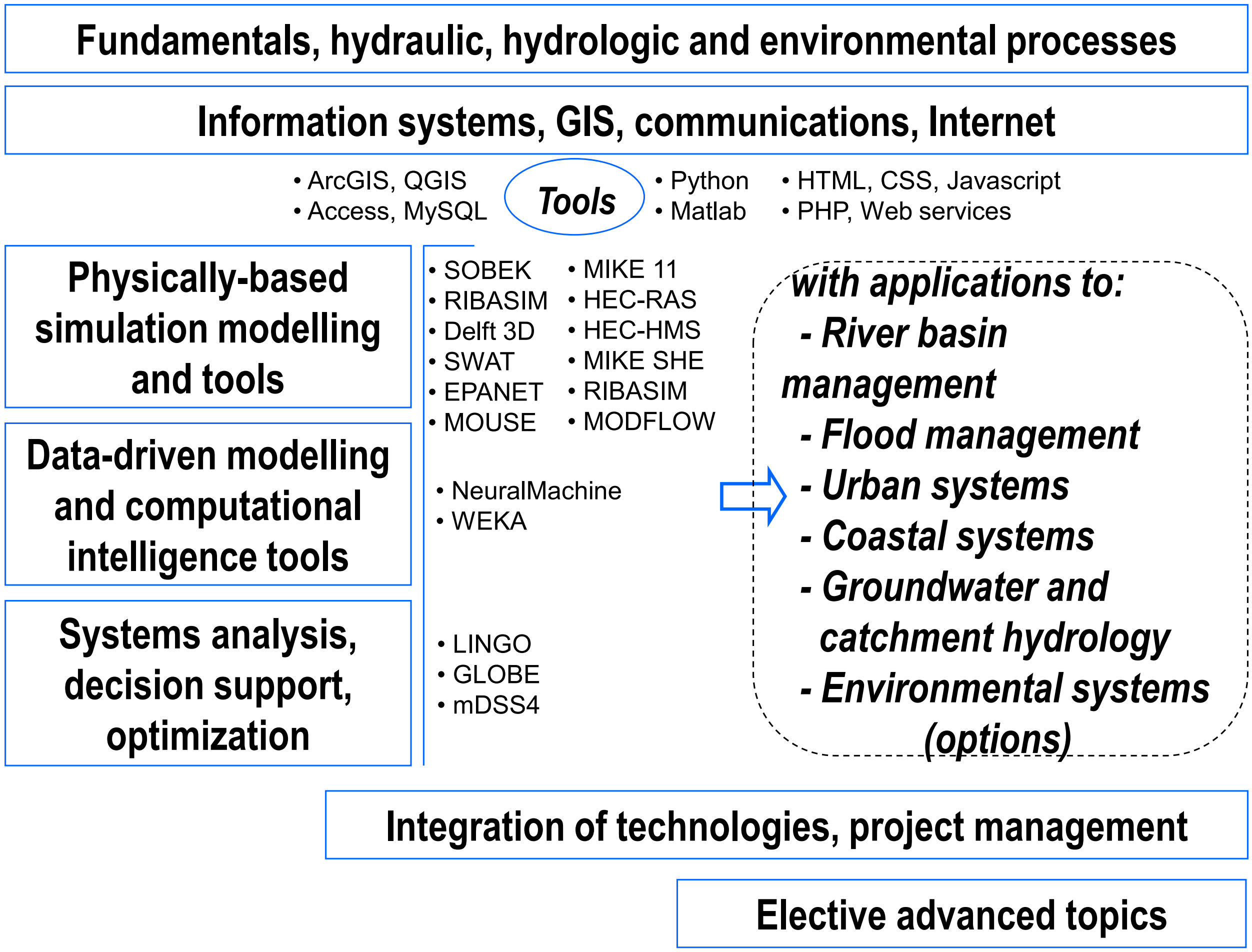

Figure 2: The general thematic structure of the Hydroinformatics specialization

The *Systems analysis, decision support and optimisation* theme combines subjects in basic optimisation techniques, with those on understanding the nature and role of systems analysis in water resources. The concepts of control- and decision support systems are introduced with applications to different kinds of problems in water resources planning and management.
The *Applications* theme includes subjects in which different modelling techniques, and Information and Communication Technologies (ICT) are being applied in a variety of water related areas such as: river basin and flood management, coastal systems, urban systems, groundwater and catchment hydrology and applications dealing with water quality and the aquatic environment. Most of the subjects from this theme are common to all participants.

The participants need to choose however between specialization modules:

- **River flood modelling and risk management**
- **Hydroinformatics for urban systems**
- **Hydroinformatics for environmental applications**

The *Integration subjects* theme includes subjects where the participants are expected to combine and synthesise the notions acquired in all the other themes. This includes in particular the groupwork that plays a very important role in the Hydroinformatics programme.
The programme also includes several elective subjects on *special topics*, which can be chosen by the participants depending on their particular interest.

Hydraulic Engineering and River Basin Development (HERBD)

The Hydraulic Engineering and River Basin Development specialization educates engineers involved in design and implementation of projects for sustainable use of river systems and their resources (fresh water, floodplain space and sediments) and further develops the scientific and engineering knowledge in this field of interest through independent research. Nowadays, fresh water resources and floodplain space are limited and therefore of significant value. The pressing need for food, energy, flood protection and domestic and industrial water supply require an efficient use and management of water resources. Traditional river engineering has had serious consequences for riverine ecosystems and land-use, causing damage to flora and fauna and sometimes exacerbating floods and droughts. Based on the sound understanding of physical aspects of river behaviour, planning, design, construction, operation and maintenance, water resources are critically assessed for implementing sustainable water-related infrastructure, tools and management strategies in river basins.

Aims and learning objectives

The aim of the programme is to convey knowledge, concepts, insights and skills that are required for students to function as independent professionals within the field of hydraulic engineering and river basin development and to prepare candidates for further study as part of a research career. This aim has been developed into a set of objectives, which have been transformed to final qualifications that are formulated within a more generic context for the entire Water Sciences and Engineering programme.

The development and management of water resources in a river basin requires a broad approach in which full integration takes place over the entire spectrum of socio-economic and environmental interests. The challenge for water users, planners, policy and decision-makers and engineers is to contribute effectively to meet social and economic goals, maintaining and managing water resources on a sustainable basis and avoiding the physical and social degradation of the environment.

The success of these activities depends on the ability to design river structures for different purposes and on the correct understanding of dynamic river processes. Emphasis will be laid on different scales of water projects (catchments, river stretch and floodplains), river defence works and river management and their environmental compatibility and sustainability. The student has to acquire sufficient knowledge to integrate different relevant interest in hydraulic engineering projects as well as to optimise their multiple uses, operation and maintenance.

The focus of the specialization is on the following main fields of interest:

- *River Dynamics* , this encompasses the study of the way in which water flows in rivers and the consequent transport of sediment and morphological change. The impact of measures to enhance the environment and mitigate damage is considered throughout. In an engineering context the role and design of river intakes and river training works are considered.
- *River Structures* , which is mainly directed to the design of hydraulic structures, by defining sites and designs of reservoirs, dams, intakes, hydropower plants, conveyance systems, etc. Emphasis is given not only to technical aspects but also, in a broader context to managerial, social and environmental questions associated with these engineering works.
- *Flood Risk Management* , which is mainly concerned with the engineering issues, planning, policies and structural/non-structural measures and approaches to cope with floods and mitigate their impacts and consequences.
- *Modelling,* all the above make use of conceptual models which are often computer-based. Modelling is taught both throughout the course and in specific modules. The aim is to allow students to develop as intelligent and discerning users of models in river basin management.

Coastal Engineering and Port Development (CEPD)

The management of resources in coastal areas of the world and the hydraulic engineering works required for their development, operation and maintenance have gained an increasing importance and complexity with time. They often require -in addition to well-proven experiences and technologies adapted to local conditions- innovative solutions. Based on considerable experience accumulated in The Netherlands and under inclusion of modern approaches, IHE DELFT offers a well-balanced and updated curriculum in the areas of Hydraulic Engineering - Coastal Engineering and Port Development.

Background

Several large hydraulic engineering projects have made the Netherlands famous all over the world. Examples are the enclosing and partially reclaiming of the former Zuyder Zee (1927- 1968), the large multi-purpose project for damming the delta of the rivers Rhine and Meuse, known as the Delta Plan (1958-1986) with the construction of the storm surge barrier in the Eastern Scheldt estuary; a masterpiece of today's hydraulic engineering both servicing the protection against flooding and the environment. The port of Rotterdam is one of the largest ports in the world and is still expanding today. Europort, the outer port of Rotterdam, has been built on newly reclaimed land from the sea, while a new extension by reclamation is under construction. A storm flood barrier in the New Waterway, the entrance to Rotterdam, protects the banks of the tidal branches of the Rhine River. Coastal Zone management and the conservation of the natural sea defences in The Netherlands are political foci and demand much attention. All of these hydraulic engineering works, as well as a wealth of overseas experience by various Dutch firms well known for their expertise in hydraulic engineering, have created a concentration of know-how in The Netherlands. The main objective of this course is to transfer this knowledge available in The Netherlands and to demonstrate the applicability of the Dutch experience to solve the hydraulic engineering problems of, in particular, developing countries.

Organisation

In the modules of the specialization Coastal Engineering and Port Development attention is paid to basic topics such as the design of coastal and port structures (dikes, closure dams, breakwaters, mooring facilities. The physical phenomena of the sea and the coast, in particular coastal morphology, are emphasised. The study of coastal defence works forms an important element of the study package. Major exercises are conducted on coastline management and coastal zone management. The design of a coastal structure is worked out in detail.

The Port Development modules concentrate on the planning, design and construction of ports and harbours. A seminar on port management forms part of the programme. Also special attention is paid to foundations of port structures. The design of the layout of a new port is a core element of the programme. Furthermore the execution of coastal and port works and environmental aspects are discussed.

Aim

The overall aim of the Coastal Engineering and Port Development programme is to train engineers such that after the programme they are able to solve practical technical problems in coastal and port engineering. These problems are of relevance for the *future* needs of their countries. Given the need for practical professionals (like designers at a high academic level), this programme is practically oriented.

Approach

In general there are three levels of problems:

I: those that have to be solved by the engineer (or his staff) fully independently;

II: those for which the help of an outside advice (like a consulting engineer) is required;

III: those for which the help of a specialist is required.
Type I problems are the every-day problems of the engineer, for which problems tools are available (like handbooks and simple PC programs). The engineer should be able to define the problem, analyse the problem, solve the problem, completely without any help from other departments, consultants, etc.
Type II problems are the problems at a larger scale, or for which special designs have to be made. These designs or studies are usually made by outside consultants. For these type of problems, the engineer should be able to define the problem, define the terms of reference for a consultant, supervise the study and assess the final report.
Type III problems are the very unusual problems, which cannot be solved by an average consultant. Only a few specialised organisations in the world can do the job. The engineer should know that these advanced techniques exist, which specialised organisations can solve the problem, and how to set-up a supervising structure to supervise this work by a more specialised expert.
Alumni of IHE DELFT master's course are engineers, who can address these three types of problems as outlined above. It should be mentioned that the course is *practically oriented.*

Land and Water Development for Food Security (LWDFS)

Academic domain and normative activities

Central to the educational and research domain of the Land and Water Development for Food Security (LWDFS) specialisation of the Master Programme in Water Science and Engineering (WSE) is the conceptual and practical understanding for sustainable development and management of irrigation and drainage systems and protection of flood prone areas. Developing a multidisciplinary and comprehensive perspective including various institutional, socio-economic, infrastructural and environmental issues is key to addressing the current and foreseen issues in the field of land and water development and management. In line with the above premise, the LWDFS specialisation has defined two major normative domains:

- *Irrigation, drainage and flood protection:* measures to improve water management, to enhance crop production and water use efficiency;
- *Interaction land use, water management and flood protection in flood prone areas: optimization of* measures related to man induced changes in land use and climate changes.

Aim

In keeping with the academic domain and normative activities, the overall aim of the LWDFS Programme is to generate new and advance current knowledge and skills with regard to development, management and adaptation of land and water resources for different types of use, with a focus on land use for agriculture. The guiding principle is the development of irrigation, drainage and flood protection infrastructure to meet an agreed level of service for an optimal balance between costs and benefits.

Approach

Given the importance of both technical and non-technical aspects in land and water development and management, the LWDFS Programme courses and research works integrate:

- technology and management capacity;
- technology and society, economy and environment;
- agricultural and civil engineering aspects of development and management.

Content and description

The LWDFS Specialisation consists of a total of 15 modules - most modules have a duration of three weeks. These are categorized as:

- three common WSE modules (modules 1, 2 and 13);
- five specialisation specific modules (modules 3 to 7);
- three elective WSE/IHE-wide modules (modules 8, 10 and 11);
- three Institute-wide modules (modules 12, 14 and 15).

Module 9 consists of two weeks of international field trip, and this might be undertaken together with one or more of the other WSE specialisations; and a one-week field work, which is specialisation specific. Modules 8 and 10 are WSE elective modules while Module 11 is an Institute-wide elective module.
In Module 12 the participant can chose a summer course from different specialisations (institute-wide).
In module 13 (common WSE), the participants engage in the group work and identify alternative solutions to various land and water development related issues in an integrated manner from the systems perspective in close collaboration with the other WSE specialisation participants.

After successful completion of the above common, specialisation specific and elective modules, the participants undertake individual MSc thesis research for 6 months during modules 14 (preparation and proposal) and 15 (field work and analysis).

The MSc thesis research (modules 14 and 15) is driven by the following two key objectives:

- To advance the horizon of science and current knowledge and expertise in various technical, socio-economical, environmental and institutional aspects of land and water development and management;
- To investigate pragmatic solutions to challenges related to water scarcity, food insecurity, flood risks and fragility of the environment, particularly in the least developed and emerging countries.

Prior to embarking on their field work (module 15), the participants follow Module 14 in which they become acquainted with the main drivers and incumbent research priorities as identified, but not limited to, by the WSE Master Programme in general and the LWDFS specialisation in particular. They also acquire valuable skills in problem description, formulating scientific research questions, articulating related research methodologies, literature review, data collection and analyses using pertinent techniques including modelling and presentation of the research findings.
The MSc thesis topics and contents are aligned with the following main research lines under the LWDFS Specialisation:

- **Hydraulic structures and hydraulic systems:**

o *Hydraulic performance evaluation and modernization of irrigation and drainage systems:* Research focused on various technical approaches and methods for analysing the performance of irrigation and drainage systems and optimising crop, land and water productivities as well as the development of improvised approaches and techniques for modernising irrigation and drainage systems.

o *Sediment transport in irrigation canals.* Research focused on the analysis of sediment movement in irrigation canals under different conditions and operation rules.

o *Lessons to learn from historical approach:* As the importance of projects aiming at rehabilitation and/or transformation of existing water infrastructure is increasing, knowing, understanding and learning lessons from the history of such systems and their management are prerequisites for quality design and planning.

- **Environmental impacts of hydraulic works:**

o *Water saving in irrigation.* Research is focused on improvements in water use in irrigation in light of prevention of environmental degradation.

o *Interaction between irrigation, drainage and sustainable development.* Research on sustainable exploitation of water resources (surface water and groundwater).

- **Institutional and socio-economic aspects of system management:**

o *Performance analysis and accountability mechanisms.* Research on institutional and socio-economic aspects of irrigation and drainage system management.

o *Global future irrigation and drainage needs.* Research on the needs for and potentials of irrigation and drainage in light of food production, sustainable rural development and the development of flood prone areas under the influence of various drivers for global change.

- **Integrated lowland development and management:**

o *Interaction between land use and flood management.* Research on interaction between land use and flood management in flood prone areas. Economic optimisation in the design, operation and maintenance of water management and flood protection schemes.

o *Land and water management in tidal lowlands.* Long-lasting research cooperation with various Dutch and Indonesian institutions with a focus on integrated development of tidal lowlands in Indonesia.

Sustainable Urban Water Management (SUWM)

The SUWM specialization aims at fostering academic excellence relevant to the Sponge City program (initiation-preparation-implementation-evaluation). It draws upon modern insights on the urban water cycle and sustainable urbanization (such as IWA principles for Water Wise Cities, Water Sensitive Cities and Water Sensitive Urban Design, Sustainable Drainage Systems, etc.) from around the world.

While the sole responsibility of conducting the specialization remains with IHE-Delft, it will work in close collaboration in China with Prof. Dafang Fu of the Southeast University, Nanjing. It will be an 18 month master's programme where students start at IHE, complete the taught part of the masters (year 1) at IHE. The students will select their MSc thesis topic (with close consultation with the Chinese professors (to be selected) as well) at IHE and develop and defence the thesis proposal. At this point, they will return to China (Jiangsu) and will continue the thesis research there with supervision from both IHE-Delft and Chinese professors (to be selected). Ultimate supervisory responsibility will be with IHE-Delft. Upon conclusion of the research (six month period) the students will defend their thesis while in China (Jiangsu), in front of an examination committee appointed by IHE-Delft, according to IHE-Delft rules. The graduation ceremony will be held in Jiangsu with representations of IHE-Delft.

Scope

The essential feature of the SUWM specialization is its focus on the total urban water cycle requiring an integration of multiple disciplines of engineering and environmental sciences. Managing the urban water cycle involves managing water scarcity and water excess concurrently and in an integrated way including water quantity and quality and system resilience. It aims the provision of water services (water security and safety) including the protection of aquatic environments in urban areas. Strong emphasis will be set on integrative elements of the urban water cycle and sustainable interventions spanning across different sub-sectors (e.g. drinking water, wastewater and surface water) and creating synergy and co-benefits.

Following are some salient features of the SUWM

- At the start of the master's course, each student is provided with a personal 'mentor' (IHE staff member) who will guide the student on the various subject choices etc.
- At the start, students will enrol an ongoing, online course titled "Integrative skills for total Urban Water Cycle management". This course provides the integrative elements of the master's programme, throughout the period of the masters. When the senior-batch is doing their master's thesis work, they will still be engaged in this course together with the corresponding junior-batch. This will help the beginner students to be exposed to advance integrative thinking at an early stage.
- The master's thesis will always have two supervisors: one from IHE another from a Chinese university (to be selected). The students are required to provide monthly written progress reports and bi-monthly progress presentations in front of all supervisors (online).

Erasmus Mundus + Programme GroundwatCH (www.groundwatermaster.eu)

The GroundwatCH programme is organized around the following thematic areas:

- General Hydrogeology;
- Groundwater Data Collection, Interpretation and Modelling;
- Climate Processes and Modelling;
- Integrated River Basin and Water Resource Management;
- Groundwater and Environmental Impacts;
- Groundwater, Society and Policies; and
- Groundwater, Climate and Global Change Impacts and Adaptation.

The students will start the academic year in September at Instituto Superior Técnico in Lisbon, where during the first semester they receive courses addressing core competences in Thematic Areas 1-6, totalling 30 ECTS.

In March of the following year, the students will move to IHE Delft, where they acquire 30 ECTS in the second semester, taking advanced courses within Thematic Areas 2 and 4-7.

Following conclusion of the second semester and the summer break, the students then move to the Technical University of Dresden, where they study during the third semester, obtaining advanced training (30 ECTS) in Thematic Areas 3 and 7, through compulsory teaching modules in climate modelling and groundwater-soil-land-climate feedback mechanisms, as well as a study project. Here the students will also have a number of optional modules from which they can choose two, specialising in a certain direction, depending on their thesis subject.

In March of the second academic year the students will start their thesis study (30 ECTS). Students can conduct dissertation research at any private or public institution, under promotership of a lecturer of a consortium partner institution. Lecturers of both the consortium and associated partner institutions can act as co-promoters.

Balance for MSc dissertation projects amongst partner institutions will be achieved by means of promoting the establishment of joint projects between different members of the consortium.

Flood Risk Management (www.floodriskmaster.org)

Semester 1
TU Dresden, Germany
The programme starts with the first semester at TUD, where students take either non-engineering or engineering subjects to complement their background and build a solid foundation for everyone. A fieldtrip to flood-prone areas is organised.

Semester 2
IHE Delft, Netherlands
At IHE Delft the students join IHE's Hydroinformatics programme, focussing on different types of modelling. On real case studies students learn how to apply and integrate various types of modelling and decision support systems. An international fieldtrip is offered as well.

Semester 3
UPC, Spain and University of Ljubljana, Slovenia
During the third semester the students take more specialised modules, such as Debris Flow and Coastal Flooding (including fieldtrips). The last part of the third semester is conducted at University of Ljubljana where the students study spatial planning and socio-economic and institutional frameworks for flood risk management.

Semester 4
Research thesis
During the thesis phase the students, while remaining associated with one partner, may occasionally carry out the research together with an industrial partner (which may be an Associated Member or not).

Double Degree Programme on Advanced Water Management for Food Production (DD-AMWFP)

The first 9 modules of the programme are identical to the LWDFS programme. Then, until the end of year 1, the student follows coursework at University of Nebraska-Lincoln (UNL), aimed to deepen knowledge on plant-water relations, remote sensing, and advanced irrigation and drainage systems followed by a final exam week and Christmas Holidays. .From then on the student will write a thesis, and, at the same time, will do more coursework on the human dimensions of Global Water and Food.

Table of Contents

1. IHE Delft

1.1 Introduction

IHE Delft continues the work that was started in 1957 when IHE first offered a postgraduate diploma course in hydraulic engineering to practicing professionals from developing countries. Over the years, IHE has developed into an international education institute providing a host of postgraduate courses and tailor-made training programmes in the fields of water, environment and infrastructure; conducting applied research, implementing institutional capacity building and human resources development programmes, participating in policy development, and offering advisory services world-wide.

The Institute has gradually expanded its academic base to include disciplines such as sociology, economics, and environmental and management sciences. The range of activities has broadened accordingly, from identifying solutions to engineering problems to designing holistic and integrated approaches in the development and management of water and environmental resources, and urban infrastructure systems. The services of the Institute now also include integrated water resources management, effective service delivery and institutional reform, all of which aim to enhance full stakeholder involvement, equity, accountability and efficiency in water sector development and management.

The mission of the Institute is to contribute to the education and training of professionals and to build the capacity of sector organisations, knowledge centres and other institutions active in the fields of water, the environment and infrastructure, in developing countries and countries in transition.

IHE is located in Delft, an internationally renowned centre of excellence in civil engineering and in water related sciences. The Delft University of Technology, the laboratories of Deltares, and The Netherlands Organisation for Applied Scientific Research are situated nearby. IHE Delft maintains intensive relations with national and international institutions to ensure a continuous exchange of knowledge and experience.

1.2 MSc Degree Programmes

The backbone of the Institute are the postgraduate programmes in the fields of:

- Environmental Science
- Urban Water and Sanitation
- Water Management and Governance
- Water Science and Engineering

Each year, these programmes are attended by hundreds of engineers, chemists, biologists, earth scientists, and other professionals from all over the world. The graduates are awarded a Master of Science degree. The programmes are subject to accreditation under Dutch law.

1.3 Research and PhD Programmes

IHE Delft carries out scientific research, often in co-operation with universities and research institutes in developing countries. A number of positions are available for PhD research.

The PhD programme has a nominal duration of 4 years and can be carried out either in Delft or in a sandwich construction. The PhD degrees are awarded by IHE Delft together with a Dutch university. Candidates should preferably hold an IHE Delft MSc degree, but an equivalent degree from another reputed university may also be acceptable.

1.4 Organisation

The Rectorate of the Institute consists of a Rector, a vice rector Academic Affairs and a Business Director.

There are three academic departments:

- Water Science and Engineering
- Environmental Engineering and Water Technology
- Integrated Water Systems and Governance

These departments have one or more chair groups in major fields, led by a professor, who is assisted by academic staff and research fellows.

Process management support units and an education bureau provide administrative support.

Besides the academic staff of IHE Delft, education is provided by selected guest lecturers, who are experts employed by universities, research institutes, government agencies, consulting firms, international organisations, etc. in the Netherlands and abroad.

2 Programme framework

2.1 Introduction

The Institute offers the following Master of Science degree programmes:

- the master programme in Environmental Science;
- the master programme in Urban Water and Sanitation;
- the master programme in Water Management and Governance; and
- the master programme in Water Science and Engineering.

Each programme has several distinct specialisations, in which students follow a curriculum best suited to their preference. Some specialisations are offered jointly with one or more partner institutes in the world. Details of each programme and its (joint) specialisations are given in the programme descriptions of the study guide.

2.2 Academic Regulations

The *Examination Regulations* describe the precise details of how examinations are assessed and marked, the procedures and rules for re-examinations, procedures for appeal, and which results are required for awarding the Master of Science degree.
Special examination regulations are drafted for the joint specialisations.

Students are strongly advised to familiarise themselves with these procedures at an early stage during their study.

2.3 Structure of the Programmes

All Delft based curricula follow a modular structure.
The Delft-based curricula of the MSc Programmes have a duration of 18 months, and consist of 106 ECTS credit points divided between a Taught Part (61 ECTS credit points) and a Thesis Research Part (45 ECTS credit points).

The Taught Part consists of 13 modules.
A module consists of a teaching period (usually 3 weeks) and an exam period (within the exam week following each two consecutive modules). Modules may be shared between or among specializations and/or programmes.

The Thesis Research Part consists of two modules on research methodology and MSc proposal drafting and defence, followed by a period of six months of individual research and writing of the thesis. The MSc thesis is defended publically at the end.

The curricula of the joint specialisations consist of modules offered at IHE Delft and courses at the partner institutes.

2.4 Final Qualifications

Each programme specialisation has a set of final qualifications that state the knowledge, insight and skills achieved by students who successfully complete the programme. A distinction is made between discipline-specific qualifications, which are required by the field of study, and general academic skills, which are expected from university education graduates.
Similarly, each module of the curriculum has a set of learning objectives, which detail the specific outcomes if the student completes that part of the programme. The individual topics in the modules usually aim to achieve a further detailed subset of the module learning objectives.

2.5 Curriculum Information

All components of the curriculum are described in the module plans of the study guide providing the following information:
the name and code of the module;
the learning objectives;
the pre-requisite knowledge or skills;
the study load hours and credit points;
the lecture, exercise and examination contact hours;
the nature and weights of the examination parts;
the responsible lecturers/examiners;
a concise description of the contents and working methods; and
the required and recommended literature, and other materials.

2.6 Teaching Methods

All education activities are conducted using a combination of lectures, exercises, assignments and assessments.
Lectures serve one or more of the following functions:

- to impart information;
- to introduce and explore a topic;
- to build-up complex structures step-by-step;
- to clarify and illustrate concepts and ideas detailed in the literature or lecture notes; and
- to provide a framework for further independent study and reading.

An exercise takes one of the following forms:

- a design or practical exercise;
- a computer or other workshop;
- a laboratory session;
- a fieldwork or fieldtrip; and
- a group work discussion.

Assignments are carried out independently by the students and consist of all required activity to:

- study or practice the lecture material;
- prepare a report, thesis or presentation;
- work out the results of an exercise;
- conduct an experiment or test;
- prepare for an examination; and
- conduct a research or other study.

2.7 Assessments

Assessments serve to test if and how far students have achieved the learning objectives of a module, and ultimately those of the programme itself. The assessment for a module may consist of multiple parts. For example, a combination of a written or oral test and one or more assignments to be handed in separately. Examination work can also be produced by (small) groups of students working together on an assignment, e.g. the group work report.
Assessment of examination material is carried out by appropriate examiners, which are usually the involved lecturers. Students who successfully complete a module will be granted the credit points for that module. Fieldtrips may require active participation instead of an examination in order to receive the credit points.

For each assessment, students are informed about the results via e-mail. When all assessments have been passed, the student has successfully completed the so-called programme examination and will be awarded the degree.

2.8 Study Load

All scheduled education activity taking place in the presence of a lecturer or an assistant is designated as contact time. All other time spent by students in relation to the study programme is designated as independent study time. The study load for (a part of) a programme is the cumulative contact time and independent study time that is nominally required to successfully complete that (part of the) programme. Study load is expressed in whole ECTS credit points, where one ECTS credit point is equivalent to 28 working hours.

The study load credits for a curricular activity indicate the notional time spent by an average learner to achieve the required outcomes for that activity, as specified by the learning objectives. The nominal time expenditure for a 5 ECTS credit points module is therefore 140 hours.

Where study load involves scheduled class-based activity, one lecture period is taken equal to two hours of contact time.

2.9 Planning and Scheduling

Education activities taking place inside the Institute are, in principle, scheduled into 'periods' of two hours each, for which the following times are available:

Period 1 08:45 – 09:30 and 09:45 – 10:30
Period 2 10:45 – 11:30 and 11:45 – 12:30
Period 3 13:45 – 14:30 and 14:45 – 15:30
Period 4 15:45 – 16:30 and 16:45 – 17:30

Throughout the academic year, the student will receive the following information and materials:

- schedules of the education activities;
- required lecture notes, textbooks and other course-related material;
- announcements of assessment planning details; and
- statements on assessment results and study progress.

2.10 Participation in coursework and lunch seminars

Active participation and attendance by students is required for all curricular activities on the schedule. Special attention is required for lunch seminars. During the academic programme lunch seminars are organised focussing on a specific topic. Participants are required to attend these seminars as well Students have to inform their programme coordinator as early as possible when they are not able to attend a scheduled programme activity.

2.11 Evaluation of the Programme by Students

As part of the quality assurance procedures of the Institute the programmes are routinely evaluated in order to obtain feedback from the students regarding the quality of the content and the performance of the lecturers. The evaluations are based on a module questionnaire, which the students complete in separate class sessions. The questionnaire asks the students to provide a rating for achievement of the learning objectives, the study load feasibility, the contents of the subject matter, the balance between the various working and examination methods, the quality of the lecture materials, and the presentation by the lecturers. Furthermore, additional written comments and an overall rating for the module may be provided.

The module evaluations are carried after the examination, but before the results have been announced. Students can also request to address specific programme related issues in a group or individual discussion with the involved coordinator or lecturers.

Feedback on the programmes from the students is much appreciated. The Institute uses the results of the evaluations to improve the academic programmes where necessary, in order to maintain high standards of education.

3 Regulations

3.1 Examination regulations

See for the Examination regulations the separate part of the study guide.

3.2 Library regulations

Fair use of on-line information resources at the IHE Delft Library.

The IHE Delft Library Services provides access to a large number of on-line information resources and databases. Access to these resources is provided to all computer users within the premises at Westvest and through remote authentication via the IHE Delft portal. By using these on-line resources you agree with the following conditions:

1) Systematic downloading of electronic journals articles using manual means is permitted only within reasonable amounts; no more than 50 downloads per user within 24 hours.

2) Programmatic downloading / 'web crawling' is not allowed. In addition to systematic downloading of files manually, the use of a spider (web crawler), the intention of which is to programmatically download data within a specific website, is prohibited.

3) Copyright/reproduction. It is prohibited to reproduce entire or parts of publications in your own publication without the consent of the publisher. You are obliged to provide a correct source reference of all of the material at all times.

4) Selling and providing material to third parties is strictly forbidden. The re-sale of material purchased subject to license to third parties is prohibited; this applies both within and outside of the Institute for which the materials have been purchased.

5) Permanent archiving. Large-scale archiving is not permitted on the local servers or your hostel personal computer nor is the continued use of these servers as an archive, in collaboration with third parties or otherwise. The temporary storage of archive material for personal use is permitted for a period not longer than 120 days.

6) Making changes to an original work. Infringing upon an original work by merging various original texts into a document or by amending original texts is prohibited. Processing materials in such a way is an infringement upon the copyright that is held by the publisher or the author him/herself.

Infringement of one or all of the above mentioned stipulations will be considered as academic misconduct and will result in disciplinary measures, which will be proportionate to the seriousness of the infraction. The Rector will decide upon the disciplinary measures which will be taken. These measures may include temporary or permanent suspension from attending class.

3.3 Code of conduct

THE RECTORATE OF IHE Delft

- In consideration of the need for rules and regulations concerning the safety and the proper use of the buildings, grounds and facilities of IHE Delft by students and visitors;
- In accordance with article 7.57h and article 9.2, first paragraph, of the Higher Education and Scientific Research Act of the Netherlands;
- Having heard the Student Association Board;

RESOLVES to establish the following Regulations:

Article 1 Definitions

1.1 WHW	Higher Education and Scientific Research Act of the Netherlands (Staatsblad Bulletin of Acts and Decrees 1992, 593);
1.2 the Rector:	the rector of IHE Delft
1.3 the Rectorate:	the rector, the deputy rector Academic affairs and the business director
1.4 Central services department	the central services department of IHE Delft
1.5 Facilities	the institute buildings, the interior and equipment as well as rented office and accommodation facilities
1.6 Buildings	the buildings of IHE Delft, located at Westvest, Delft
1.7 Student	anyone who is enrolled at IHE Delft for the purpose of education provided by IHE Delft and who uses the educational and examination facilities of IHE Delft for this purpose;
1.8 Visitor	anyone who is not a student nor is employed by IHE-Delft as referred to in article 1.1 of the Collective Labour Agreement (CAO) for Dutch Universities.

Article 2 Compliance requirement for rules, guidelines and instructions

2.1 Any student or visitor making use of the grounds, buildings or facilities of IHE Delft is required to comply with all rules, instructions and/or directions issued by the Rectorate and delegated staff with regard to maintaining order and proper social conventions of the host country within the buildings and on the grounds. According to the in the institutes code of undesirable behaviour the following is considered to be undesirable behaviour: sexual harassment, aggression, or violence, both verbal and non-verbal towards course participants, staff, visitors or contracted staff. Furthermore all participants, staff, visitors and contracted staff are to observe and comply with the rules and regulations with regard to appropriate and legitimate use of the facilities of IHE Delft scrupulously and without delay, and is required to deport him or herself such that:

a. he or she does not cause direct or indirect damage to IHE Delft or to other persons who are present on the grounds or in the buildings of IHE Delft or who make use of the facilities of IHE Delft, nor that he or she causes nuisance or annoyance;

b. he or she does not infringe on the rights of IHE Delft or of other persons who are present on the grounds or in the buildings of IHE Delft or who make use of the facilities of IHE Delft;

c. he or she does not act contrary to statutory obligations;

d. he or she does not act contrary to appropriate and proper social conventions with regard to people or property.

2.2 It is prohibited to wear clothing that covers the face or to wear other clothing and/or accessories that severely interfere with communication between teaching staff and students or between students themselves or between members of the teaching staff. When sitting an examination it is prohibited to wear clothing that covers the face or to wear other clothing and/or accessories that severely limit the ability to establish the identity of the person in question.

2.3 The Head of the Central Services department may, on behalf of the Rectorate, issue instructions and directions for the purpose of ensuring the smooth and proper use and functioning of buildings and grounds of IHE Delft entrusted to him/her.

Article 3 Disciplinary Measures

The Rectorate may take the following measures against any student or visitor who fails to comply with the contents of these Regulations, with due observance of the procedure described in these Regulations:

a. excluding the student or visitor from the buildings and grounds of IHE Delft or from one or more parts of IHE Delft, with the provision that a student may only be excluded from buildings or grounds in whole or in part for a period not to exceed one year;

b. excluding the student or visitor from the use of the facilities of IHE Delft;

c. fining the student if such fine has been agreed on or follows from the statute;

d. issuing a written reprimand;

e. retribution for damages to properties and or facilities.

Article 4 Exclusion Order by the Rectorate

4.1 The Rectorate may immediately issue an exclusion order for the buildings or grounds, or for parts of those buildings or grounds, to a student or visitor who commits an infringement on these Regulations or the rules referred to in article 2, or it may issue an exclusion order for the institute facilities.

4.2 Anyone who is subjected to measures as referred to in the first paragraph will be given the opportunity for a subsequent hearing as soon as possible by or on behalf of the Rectorate if this was not previously possible due to the urgent nature of the matter at hand.

4.3 The exclusion order will contain at least the following:

a. an indication of the buildings and/or grounds or the parts of the buildings and/or grounds of IHE Delft and/or the facilities or use of the facilities of IHE Delft to which the exclusion order applies;

b. the duration of the exclusion order;

c. the reasons for the exclusion order;

d. any conditions which will result in the effectuation of the exclusion order in case of noncompliance.

Article 5 Termination of the exclusion order

5.1 The Rectorate may, of its own accord or in response to a request by a person who is subject to a disciplinary measure in the form of an exclusion order as referred to in these Regulations, choose to terminate the exclusion order or alter its scope before it has elapsed if there is sound reason to do so according to the judgement of the Rectorate.

5.2 The Rectorate may attach special conditions to the termination or alteration of the exclusion order.

5.3 If in the judgment of the Rectorate the person subject to the exclusion order, and on behalf of whom a proposal to terminate said order has been forwarded, has not met the special conditions set by the Rectorate, then the original exclusion order will once again be put into force; the period of time that has passed since the termination or alteration of the exclusion order will not be deducted from the originally specified period in this case.

Article 6 Entry into force

These Regulations enter into force on October 1st 2007

Article 7 Method of Citation

These Regulations may be cited as “Regulations for the use of buildings, grounds and facilities by students and visitors of IHE Delft”. Approved in the rectorate meeting of September 25th 2007

3.4 Plagiarism

NOTE: FAILURE TO COMPLY WITH THE TERMS OF THIS SECTION COULD JEOPARDISE YOUR DEGREE. PLEASE READ AND DIGEST CAREFULLY.

It is very important that all students understand IHE Delft rules about plagiarism.

Students sometimes break these rules unintentionally because they do not realise that some of the ways in which they have incorporated other people's work into their own, before they came to IHE Delft, may be against the rules here.

At the beginning of the programme, and before submitting any assessments, you will be required to agree to an 'own work declaration'. You will also be invited to give consent for the scanning of your work by plagiarism detection software. Work cannot be submitted unless these conditions are agreed to.

What is plagiarism?

Plagiarism is the practice of taking someone else's work or ideas and passing them off as one's own. This act is considered as academic fraud. When there is a strong presumption of plagiarism, whether occurring during the course of the study or after the completion of the study, cases will be investigated by the Examination Board. The Examination Board shall examine the cases of alleged plagiarism on their individual merits. After examining all the evidence, the Examination Board shall establish whether plagiarism and implicitly fraud has been committed. When fraud has been established the offender will be given the mark of 1.0 for the examination work.

Plagiarism detection

IHE Delft uses a computer program called Turnitin ® to assist with the detection of plagiarism. The plagiarism detection service is an online service that enables IHE Delft and its staff to carry out electronic comparison of students' work against electronic sources including other students' work. Turnitin ® works by executing searches of the World Wide Web, and extensive databases of reference material, as well as content previously submitted by other IHE Delft students.

Each new submission is compared with all the existing information. The software makes no decisions as to whether a student has plagiarised, it simply highlights sections of text that are duplicated in other sources. All work will continue to be reviewed by the course coordinator.

Once work has been submitted to the system it becomes part of the ever growing database of material against which subsequent submissions are checked.

The software is used as a tool to highlight any instance where there is a possible case of plagiarism. Passages copied directly or very closely from existing sources will be identified by the software and both the original and the potential copy will be displayed for the examiner to view. Where any direct quotations are relevant and appropriately referenced, the examiner will be able to see this and will continue to consider the next highlighted case.

Citing references

The key to avoiding plagiarism is to make sure that you give correct references for anything that you have taken from other sources to include in your academic work. This might include, for example, any ideas, theories, findings, images, diagrams or direct quotations that you have used. At IHE Delft the house style for references is based on the Hydrogeology Journal output. If you take any material word for word from another source, it is essential that you make it clear to your reader that this is what you have done.

If you take material from another source, change a few words and then include the reference you may still have committed a plagiarism offence because you have not made it clear to your reader that you have essentially reproduced part of the original source. You should either express the ideas fully in your own words and give the reference or else use clearly labelled direct quotes. Bear in mind that if you include too many direct quotes in your work this may reduce your grade, as the marker will find it difficult to see evidence of your own understanding of the topic. You must also include a bibliography and references section at the end of your work that provides the full details of all of the sources cited within the text. You should be aware that, for work done in other subject areas, you might be expected to use a different referencing system.

The process of referencing may seem rather complicated and arbitrary, if it is new to you, but it should begin to make more sense as you progress through your studies. In order to assess your work and to give you useful feedback your marker needs to have a clear sense of what ideas you have developed for yourself and what comes from elsewhere. To be fair to all of the students on the course it is important that each student is given grades that accurately reflect their own efforts. As you learn to produce work at a Master standard, you are developing the skills that will allow you to participate within wider communities of scholars. In these communities new knowledge and understanding is often developed by building on the work of others. By properly acknowledging earlier work you give credit where it is due and help to maintain the integrity and credibility of academic research in this area. Clear referencing also allows readers to learn about the wider literature through your work. It is often the case that understanding the ways in which particular scholars have contributed to the development of the literature makes it much easier to make sense of the current state of play.

Team work, accidental and self-plagiarism plagiarism

Students sometimes wonder where to draw the line between discussing their ideas with their peers (which can be an excellent learning experience) and unacceptable collusion. The time to be particularly careful is when you are preparing work for assessment. You need to be certain that the work you submit represents your own process of engagement with the task set. You may get into difficulty if, for example, reading another student's plan for their work influences you, or if you show them your plan. Assisting another student to plagiarise is a cheating offence.

In addition to giving references for all of the materials that you have actually included within your assignments, it is important to appropriately acknowledge other sources of guidance you have used when preparing your work.

Accidental plagiarism is sometimes a result of a student not yet having fully come to terms with how to study effectively at university. For example, the ways in which students take their notes sometimes makes it difficult for them to later distinguish between verbatim quotes, paraphrased material and their own ideas. A student may also plagiarise unintentionally because they have been feeling daunted by a piece of work and so have put it off for so long that they have had to rush to meet the deadline. If you think these kinds of wider issues may be relevant to you then you should contact your module coordinator.

Plagiarism guide's references

The following sources were used in the development of the plagiarism guide:

Blum, S. D. (2009). My word! : plagiarism and college culture. Ithaca: Cornell University Press.

Carroll, J. and Appleton, J. (2001). Plagiarism: A Good Practice Guide. Oxford: Oxford Brookes University and Joint Information Systems Committee

Eisner, C., & Vicinus, M. (2008). Originality, imitation, and plagiarism : teaching writing in the digital age. Ann Arbor: University of Michigan Press.

Sutherland-Smith, W. (2008). Plagiarism, the Internet and student learning : improving academic integrity. New York: Routledge.

Harvard University Guide to Plagiarism
http://isites.harvard.edu/icb/icb.do?keyword=k70847&pageid=icb.page355322

Purdue University Writing Lab
http://owl.english.purdue.edu/

University of Princeton Academic Integrity
Site http://www.princeton.edu/pr/pub/integrity/pages/plagiarism/

University of Teesside Plagiarism Guidance http://dissc.tees.ac.uk/Plagiarism/Plag-4.htm

4 Facilities

4.1 Location

The IHE Delft buildings and facilities are located on a single compound at the Westvest 7 in the centre of Delft. The buildings provide an efficient atmosphere for optimal learning and creativity, direct communication with lecturers and other staff, as well as meeting with fellow students. The building is open during the following times:
Monday to Friday 07:30 – 20:00
Saturday 08:00 – 12:30

4.2 Student Affairs (office)

The Student Affairs office provides non-academic support to students. The SA office takes care of student applications and student registration. The new students are also assisted with formalities such as applications for residence permits, insurance, bank accounts, and fellowship issues. Housing arrangements in one of the hostels are being made immediately upon arrival.
Throughout their study period, students can contact the staff during office hours for information or questions related to health, religion or other issues related to the student's wellbeing. Personal matters can be discussed with the student counsellor and will be dealt with strictly confidential.
During the entire academic year, SA organizes a number of social and cultural activities including the weekly movie night, social evenings and the annual Christmas dinner. Other activities include cultural excursions to interesting cities and places in the Netherlands and other countries in Europe. Furthermore, the students are given opportunity to actively practice sports on a regular basis. From October to May, the Institute arranges accommodation in Delft for such sports as soccer, volleyball, basketball and badminton. The SA office organizes sports events and tournaments, in which the teams can compete internally, but also against players from other international institutes.

4.3 Student Association Board

The Student Association Board (SAB) is composed of representatives who are elected by the students in annual elections that take place several weeks after the opening of the academic year.
The SAB provides a forum through which students can share their experiences, problems and general issues on study-related matters. If necessary, the SAB will bring these matters forward in discussions with the executive levels of the Institute. The board can be contacted directly via its members or the general e-mail address sab@unesco-ihe.org. The SAB closely co-operates with the Student Affairs office in organizing social and sporting events.

4.4 ICT services

IHE Delft provides modern computing (IT) facilities for education and research. A local wired- and wireless network is available in the building. Through the network all computers have access to a fast Internet connection. Besides that, participants have unlimited access to Internet in all hostels provided by IHE Delft.
All desktop and laptop PCs are Intel based with Microsoft Windows operating system. The laptop PC will be provided in order to get access to the IT facilities.
The laptop is on loan for use during studying at IHE Delft. At the end of the study, the institute offers the possibility to buy the laptop. The contract given clearly states the terms and conditions for borrowing the laptop. Bringing one's own laptop is allowed; however, laptops other than the IHE Delft laptop might not give access to all the required IT-facilities and might not be supported by IT-service desk.
A wide range of software packages is available, ranging from standard PC-software, like Microsoft Office (Word, Excel, etc.) to special modelling software used for the education programmes. Upon registration you will receive an IHE Delft e-mail account which enables you to make use of all relevant

computing facilities at the Institute.. A web-based E-learning and collaborative system is accessible for all participants to exchange learning information and documents.
For specific applications during the thesis study, it may be possible to use specialist software packages on the laptop PCs. This is, however, dependent on the particular type of licence agreement that the Institute has with the supplier. Enquiries for specific software should be made at the computer helpdesk.

4.5 General Facilities in the Building

In the reception area of the building, students have their own locker for the distribution of schedules, lecture notes and other study-related papers, and private mail. Two monitor screens opposite the reception desk are regularly updated with news or information on events taking place at IHE Delft.
The restaurant provides a wide variety of reasonable-priced multicultural meals and beverages during lunchtime. The meals can be paid using the bank-card or cash. Coffee, tea and soft drinks can be obtained from machines throughout the day.
The building houses a number of fully-equipped lecture rooms and theatres, which can accommodate groups of all sizes from 15 to 300 persons. Rooms for facilitating computer classes and workshops are present and can be used freely by students outside class hours.
Furthermore, the Institute has its own printing and reproduction facilities and also contains an in-house distance learning and video conferencing centre. Photocopy services are available to students. In the building also a meditation room is available, which is located on the third floor.

4.6 IHE Delft Library and Information Services

IHE Delft's Library provides access to over 35,000 printed titles, among which the complete collection of IHE Delft Master thesis and PHD dissertations. Furthermore the collection contains over 8.000 online journals. The online journals collection is accessible on the network at the Westvest premises or through remote authentication through the portal. For more information please visit the Library's Internet page http://www.unesco-ihe.org/library
The library is open to all IHE Delft participants and staff, and to visitors by appointment.
The services provided by the library include lending out books, requesting articles and other materials through the inter-library loan system and providing assistance in searching the electronic catalogue.

Membership
Upon registration participants receive a registration card which can also be used to borrow items from the library collection.

The catalogue
The library collection is accessible through an electronic catalogue, which is searchable by author, title (word) and subject, as well as by Boolean operators. Please visit http://www.unesco-ihe.org/library for more information.

Borrowing library items
A maximum of ten items may be borrowed from the library at any one time. The maximum loan period is 21 days, renewable up to a maximum of 42 days. Renewals can be made online, http://www.unesco-ihe.org/library by using the borrower information function within the catalogue or by email (library@unesco-ihe.org). Please note that the loan period can be extended only if the items have not already been reserved by another person.
Reference works, MSc theses, bound and non-bound periodicals and materials bearing a green sticker may not be borrowed. By using their library card to borrow items from the library, borrowers agree to be responsible for those items, including the cost of replacing lost or damaged items.

Opening Hours
Monday 09:00–18.30
Tuesday-Friday 09:00–19.00
Saturday 09:30–12:30
Please note that the Library opening hours are subject to change. Visit the Library webpage for regular updates. For further information please contact the library reference desk.
Email: library@unesco-ihe.org
Tel: +31 (0)15 215 1714
Fax: +31 (0)15 212 2921

4.7 Laboratories

Modern educational and research laboratories are available in the fields of chemistry, process technology, microbiology, aquatic ecology and soil science. A wide range of standard analytical tests can be performed for chemical, physical and microbiological water, air and soil quality analyses.
Elemental analyses, various kinds of microscopy and analytical techniques such as spectrophotometry, gas- and ion chromatography, and atomic absorption can be carried out. A wide range of laboratory and bench-scale reactors, temperature and light controlled growth chambers, and various constant temperature rooms are available for research in one of the departmental research programs, including waste water management using aquatic macrophytes and wetlands, the adsorption and/or (an-)aerobic degradation of micropollutants, self-purification in drains and filtration. Through close co-operation with the DelftUniversity of Technology and other educational and research institutions, researchpossibilities are quite extensive.
In addition to the in-house facilities, the laboratory has a range of instrumentation and equipment available for field instruction and for conducting hydrological or environmentalfield experiments and measurements.

4.8 Study Materials

Study materials such as textbooks, lecture notes and hand-outs are provided by the Institute.
Students receive the lecture notes either on paper in their personal locker or via the electronic repository 'eCampusXL', before the start of the involved lecture series. Additional material (on paper or electronically) can be provided by the lecturers in the form of hand-outs. Also other materials, such as for example PowerPoint presentations or exercise materials used by the lecturers, can be accessed or downloaded from the electronic repository. Reference works are available from the Institute library or the library of the Delft University of Technology (see above).
Students can login to the electronic repository from any location via the Internet web page located at http://ecampusxl.unesco-ihe.org
Students are expected to bring in other materials, such as electronic calculators and language dictionaries on their own account.

4.9 English support courses

Introduction
A variety of academic writing courses are offered to students during the first 12 months of study. Students are allocated a place on these courses according to their language level, not their specialization. Writing courses are available from ‘lower-intermediate’ to ‘advanced’ level, consisting of about 20 hours contact time. These courses run parallel to scheduled lectures, and are not limited to one programme specialization or module.

Placement Test for everyone
Every student must take the English Placement Test. Based on the result, the student may be required to follow an academic writing course. Placement tests are held in October and January. Participants

with weakest English skills are strongly advised to take the test in October, as they will receive support courses first. All remaining participants will be tested in January. Places on writing courses are allocated according to the student's placement test score. A student cannot join a writing course unless s/he has taken the placement test.

Students whose test score is at A1, A2 or B1 level CEFR (The Council of Europe's *Common European Framework* of Reference for Languages is a basis for recognising language qualifications. A1-A2 = Basic; B1-B2 = Intermediate; C1-C2 = Advanced), are obliged to attend a support course: attendance is required. Students whose test score is B2 are strongly recommended to attend a course. If students who score B2choose to take a support course, regular attendance is required. Those with score levels C1 and C2 are exempt from academic writing courses.

Scheduling and attendance

Academic Writing courses are given throughout the year, with the first courses starting in October and the last courses ending in August/September. Students are assigned a course based on their Placement Test performance.

English support courses usually consist of about 20 hours contact time, approximately 13 or 14 lectures. English support courses are always scheduled at the following times:

Tuesdays 3.45pm-5.30pm

Thursdays 8.45am-10.30am

Occasionally classes are given on Saturday mornings. In special cases, evening classes may be necessary.

A Certificate of Attendance will be provided on completion of an academic writing course, provided attendance requirements have been met. If a student does not turn up for the allocated course without giving notification of absence, s/he forfeits their place on the course. An alternative course is not provided.

Summary descriptions of writing courses:

1.First Steps in Academic Writing: lower intermediate

Based on textbook '*First Steps in Academic Writing*', Longman

This course provides low-intermediate students with essential tools to master basic academic writing. It focuses on paragraph organization, sentence structure, and grammar. Students are guided through the writing process to produce well-organized, clearly developed paragraphs.

Simple explanations are supported by clear examples to help students through typical rough spots, and numerous practices help students assimilate each skill.

2.New Headway Academic Skills: intermediate

Based on textbook *'New Headway Academic Skills',* Oxford University Press

This course combines reading, writing, and study skills, and is suited to those who have reasonable English but have not studied for a while. It aims to refresh and consolidate existing language through practice, as well as to learn new language. There is guided writing practice and relevant grammatical structures are explained. In addition, skills and strategies which develop good vocabulary learning and recording are included.

3.Academic Writing: upper intermediate

Based on textbook '*Focus on Academic Skills for IELTS'*, Pearson-Longman

· Focuses on academic writing skills

· Includes vocabulary building and reading techniques relevant to research.

· Specific writing skills include: collocations; useful phrases and language of research; the language of change (increase, decrease, etc); interpreting and comparing information from diagrams; presenting arguments and opinions; justifying solutions (modal verbs, conditionals) and much more to improve academic writing.

· Life-long learning. This textbook offers systematic preparation for the IELTS exam, hence it can help any student who wishes to gain this internationally-recognised certificate, or improve their existing score.

4.Advanced Academic Writing: advanced
Based on textbook '*Academic Writing, A Handbook for International Students*' Routledge
Specifically aimed at improving key academic writing skills, this is a very practical and thorough course. Three main areas are covered:
The Writing Process – from making an outline to proofreading;
Elements of Writing – writing skills such as making comparisons, describing results and paraphrasing;
Accuracy in Writing – to improve common problems, e.g. articles, passives, prepositions.

The above courses follow a workshop approach and are designed to provide maximum hands-on practice. There is a strong emphasis on collaborative writing activities for students, with the lecturer adopting the role of facilitator.

5.MSc Thesis Writing: for all participants. A reader is provided.
In August/September a series of lectures is given, open to all MSc participants, on thesis writing. The lectures aim to make participants aware of the conventions and structures used to write a proposal, literature review and thesis, and how to present their judgements in a persuasive and reasoned argument. Topics will include proposal writing, literature review, thesis chapters, argument structure, paragraph writing, editing skills, etc.

United Nations Educational, Scientific and Cultural Organization

IHE DELFT
Institute for Water Education under the auspices of UNESCO

Education and Examination Regulations 2018– 2020

For:

- the Master Programmes in
    a. Urban Water and Sanitation
    b. Environmental Science
    c. Water Management and Governance
    d. Water Science and Engineering
- short and online courses which are part of these programmes (starting between 1 Sep 2018 and 31 Aug 2019)
- Graduate professional diploma programmes

Approved by the Rectorate of IHE Delft, 11 September 2018

Table of Contents

Chapter 1. Definition of terms

The following terms are defined in the context of these regulations:

Act: the Higher Education and Scientific Research Act (*Wet op Hoger Onderwijs en Wetenschappelijk Onderzoek*);

Assessment: is the evaluation of a student's achievement on a course or topic. Assessments can have different formats, such as (written and oral) examinations, assignments, presentations etc.

Blind marking: the student information is hidden from the examiner while they are marking the examination;

Co- mentor: a staff member from an external institute or different chair group within IHE Delft involved in the daily direction of a student during the MSc thesis research phase;

Degree: a degree as stipulated in article 7.10a. of the Act;

Double (multiple) degree programme: a master programme offered by multiple institutes of higher education leading to multiple degrees;

Diploma: a written proof of evidence as stipulated in art 7.11 of the Act that a student has passed all programme requirements;

Diploma supplement: a written document as stipulated in art 7.11/4 giving information about nature and content of the programme and the results obtained by the student for each component of the programme;

ECTS: the European Credit Transfer and Accumulation System: a standard for comparing the study attainment and performance of students of higher education across the European Union and other collaborating European countries;

Examination: an assessment for a part of the module as stipulated in art 7.10/1 of the Act;

Examination Board: the committee as stipulated in article 7.12 of the Act;

Academic Appeals Board: the committee as stipulated in article 7.60 of the Act;

(External) Examiner: a person who sets and marks examinations to test students knowledge or proficiency

Fraud: a deception deliberately practiced in order to secure unfair or unlawful gain;

Joint programme: a master programme offered by two or more institutes of higher education leading to a joint or multiple degree(s);

Mentor: staff member involved in the daily direction of a student during the MSc thesis research phase;

Module: a self-contained programme unit with specified learning objectives, as stipulated in article 7.3 of the Act; can also be offered as a short- or online course.

Module plan: a document describing a.o. the learning objectives, content, didactic methods and assessments. Modules plans are part of the study guide;

Observer: a person who is present at an oral examination in order to monitor and listen to what happens;

Online short course: a module offered as an online certificate course;

Peer review: is the evaluation of work by one or more people of similar competence to the producers of the work (peers);

Plagiarism: the practice of taking someone else’s work and passing them off as one’s own;

Practical: a practical educational activity as stipulated in article 7.13, paragraph 2, clause d of the Act, taking one of the following forms:

- the writing of a report or thesis;
- producing a report, study assignment or design;
- conducting a test or experiment;
- performing an oral presentation;
- participating in groupwork, fieldwork or a fieldtrip;
- conducting a research assignment; or
- participation in other educational activities that aim to develop specific skills;

Programme evaluation: the formal evaluation of the student performance before graduation (in the Act: *examen*);

Study Guide: a reference document for a specific programme containing generic and programme specific information, which students need to know throughout their programme;

Short course: a module offered as a face-to face certificate course;

Student: a person who is registered in a study programme and sits for assessments;

Supervisor: professor responsible for the work of student during the MSc thesis research phase.

Taught part: part of the study programme consisting of taught modules and courses (modules 1 – 13);

Transfer of credit points: the procedure of granting credits to a student for studies completed at another institute;

Research part: part of the study programme consisting of an individual research work by the student leading to a MSc thesis, based on an approved research proposal (modules 14 and 15).

Chapter 2. General Information

Article 1 Scope of the regulations

1.1 The present regulations apply to the education offerings and examinations within:

I. the Master programmes in:
   i. Urban Water and Sanitation
   ii. Environmental Science
   iii. Water Management and Governance
   iv. Water Science and Engineering

II. Short and online courses which are part of these master programmes
III. Graduate Professional Diploma Programmes (GPDP)

referred to hereafter as 'the programmes'.

The programmes are executed by the IHE Delft Institute for Water Education, Delft, the Netherlands, referred to hereafter as 'the Institute' and several partner institutes in various countries.

1.2 For the following 3 specialisations, leading to a joint degree, separate examination regulations apply:
- Urban Water Engineering and Management (UWEM);
- Limnology and Wetland Management (LWM);
- International Master of Science in Environmental Technology and Engineering (IMETE);

1.3 In case a joint specialisation (see art. 1.4) leads to a double or multiple degrees, the rules and regulations of the partner institute will be applicable for those parts of the programme organised and implemented by the partner.

1.4 These regulations apply to the following Master of Science programmes and specialisations:

1. Urban Water and Sanitation programme:

Specialisation	Offered by	Type of degree
1. Water Supply Engineering	IHE Delft	IHE Delft degree
2. Sanitary Engineering	IHE Delft	IHE Delft degree
	• IHE Delft • Universidad de Valle, Cali, Colombia	Double degree
3. Urban Water Engineering and Management	• IHE Delft • Asian Institute of Technology, Thailand	Joint degree

2. Environmental Science programme:

Specialisation	Offered by	Type of degree
1. Environmental Science and Technology	IHE Delft	IHE Delft degree
2. Environmental Planning and Management	IHE Delft	IHE Delft degree
3. Applied Aquatic Ecology for Sustainability	IHE Delft	IHE Delft degree
4. Limnology and Wetland Management	• IHE Delft • BOKU - University of Natural Resources and Life Sciences, Vienna, Austria	Joint degree

	• Egerton University, Egerton, Kenya	
5. Environmental Technology and Engineering (Erasmus Mundus programme)	• IHE Delft • Ghent University, Belgium, • ICTP, Prague, Czech Republic	Joint degree

3. Water Management and Governance programme:

Specialisation	Offered by	Type of degree
1. Water Management and Governance	IHE Delft	IHE Delft degree
2. Water Cooperation and Diplomacy	• IHE Delft • Oregon State University, USA • UPEACE, Costa Rica	Triple degree

4. Water Science and Engineering programme:

Specialisation	Offered by	Type of degree
1. Hydrology and Water Resources	IHE Delft	IHE Delft degree
2. Hydraulic Engineering - River Basin Development	IHE Delft	IHE Delft degree
3. Coastal Engineering and Port Development	IHE Delft	IHE Delft degree
4. Land and Water development	IHE Delft	IHE Delft degree
	• IHE Delft • Asian Institute of Technology Thailand	Double degree
	• IHE Delft • University of Nebraska -Lincoln, USA	Double degree
5. Hydroinformatics- Modelling and information systems for water management	IHE Delft	IHE Delft degree
6. Flood Risk Management (Erasmus Mundus programme).	• IHE Delft • Technische Universität Dresden, Germany • Universitat Politècnica de Catalunya, Spain • University of Ljubljana, Slovenia	Multiple degree
7. Groundwater and Global Change - Impacts and Adaptation (Erasmus Mundus programme).	• IHE Delft • TU Dresden, Germany • University of Lisbon, Portugal	Multiple degree
8. Sustainable Urban Water Management	IHE Delft	IHE Delft degree

5. **Graduate professional diploma programmes**:

Name	Offered by	
Sanitation and Sanitary Engineering	• IHE Delft	Diploma

Article 2 Aim of the programmes and courses

2.1 The aim of the master programmes is for students to acquire knowledge, insight and skills that are required for them to function as independent professionals within their field of study and to be appropriate candidates for further study towards a research career.

2.2 The final qualifications of the master programme graduates are listed in Appendix A.

2.3 The aim of a short course or an online course is for students to acquire knowledge, insight and skills of a particular field of study.

2.4 The aim of the GPDP is to convey to the students the knowledge, insight and skills of a particular field of study and consists of a number of online modules, regular master modules or a combination of both.

Article 3 Full-time/part-time

3.1 The master programmes and short courses are offered on a full-time basis.

3.2 Online courses are offered on a part-time basis.

3.3 The GPDP is executed on a part-time basis.

Chapter 3. Content of the Programme

Article 4 Constitution of the specializations and joint specializations

4.1 The constitution of each programme specialization and diploma programme is described in the study guides of IHE Delft (and the partner institutes in case of joint or double / multiple degree programmes)

4.2 The learning objectives of all modules (face to face and online), the content and assessment methods are described in the module plans.

Article 5 Participation

5.1 The attendance and active participation of students is required for all scheduled curricular activities, examinations and the practicals of the programme in which they are registered.

Chapter 4. Assessments

Article 6 Timing, formats and duration of assessments

6.1 Assessments tests whether a student has met the learning objectives.

6.2 A module is assessed through (a combination of) written and/or oral examinations, assignments and presentations as described in the module plans of the study guide.

6.3 The sequence of the modules and its assessments will take place according to the order described in the study guide.

6.4 During the taught part of the first academic year, students in the MSc programmes have 3 attempts to pass all modules. A 4th attempt is allowed for maximum 1 module, to be taken before the end of January during the second academic year,

6.5 The date and time of the written and oral assessments are announced in the programme schedules. Written and oral assessments take place during the examination periods indicated in the academic calendar.

6.6 Written and oral assessments for short and online course participants (NB: This applies to participants who paid for doing assessments) are held at the end of the short course or within two weeks after the end of the module. Dates are determined in consultation between the module/course coordinator and the students

6.7 The format for the final assessment of a short course can deviate from the assessment format for the corresponding module.

6.8 The duration of a written examination may not exceed three hours and is scheduled to take place in a morning or afternoon session. In case the examination consists of two or more different parts, a break of 15 minutes is allowed, provided that all examination work of the first part(s) is collected by the invigilators before the break.

6.9 In the case of a combination of oral and written assessments of a module during the examination week, the maximum total duration of the combined examination shall not exceed three hours.

6.10 Deadlines for submission of assignments are set by the examiner. The latest moment is the examination week following the module.

Article 7 Re- assessments

7.1 Re-assessment consists of re-taking one or more failed assessments as described in the assessment part of the module plan, as is required to achieve a successful module result.

Taking part in re-assessments is required if:

- one of the assessments is ≤ 4.9 or marked as a 'fail';
- the module mark is a fail (≤ 5.9). In this case one or more assessments for which a mark < 6.0 has been obtained can be re-taken.

Taking part in re-assessments is not allowed if:

- the module mark is a pass (≥ 6.0) and all assessments are ≥ 5.0.

7.2 The first written and oral re- assessments take place in the examination period immediately following the examination period of the first attempt, except for the re-examinations of modules 10 and 11 which take place on the first Friday of module 14. The second written and oral re-assessments take place in a dedicated week during module 14.
Dates and times of written re-examinations are announced in the programme schedules.

7.3 Students of short courses or online courses (including GPDP) are eligible to sit for one (1) re-assessment within 3 months after the end date of the course they are registered for (NB: This applies to participants who paid for doing assessments).

7.4 Re-submission of failed assignments has to take place before the end of the examination period immediately following the examination period of the first attempt.

7.5 Students are not allowed to sit for further assessments during the programme period they are registered for, if they failed 14 or more credits (after the first re-assessments) of the taught part of the programme (this does not include the MSc proposal defence).

7.6 The format of a re- assessment may deviate from that of the first assessments for the same module.

7.7

Article 8 The organisation of the assessments

8.1 Assessments are carried out according to the Examination Procedures as described in annex B of these regulations.

8.2 In the case of oral or written assessments for an online course, the student has to provide proof of identity (e.g. passport) to the examiner.

8.3 Students are expected to be in the examination room 10 minutes before the scheduled start of the exam. They will not be allowed to enter the examination room after the scheduled start of the examination.

8.4 Misreading the date, time or room allocation are not accepted as legitimate reasons for absence from an examination or for arriving too late.

8.5 Students who suffer from a physical or sensory impairment are offered the opportunity to take examinations such that, as much as possible, account is taken of their disability. If required, an expert will be consulted for advice.

Article 9 Oral assessments

9.1 Oral assessments are taken individually (only one student at a time). During oral assessments, a second staff member is present as an observer. In case of absence of a second staff member, the oral assessment is recorded for reference purposes and kept on file for 12 weeks.

9.2 During oral assessments for online courses a second staff member as observer is not required. The oral assessment has to be digitally recorded and kept on file for 12 weeks.

9.3 Oral assessments are non-public, unless stated otherwise in the module plan or current regulations.

Article 10 MSc proposal defence

10.1 The MSc thesis proposal examination is an oral examination during the examination period indicated in the academic calendar. The examination consists of a presentation of the proposal, and a discussion with the examining committee. The examining committee consists of the supervisor and the mentor of the student. The examination is open to public attendance and discussion.

10.2 To be allowed to sit for the MSc proposal defence, students must have successfully completed all but maximum 1 module.

10.3 The MSc thesis proposal defence is assessed as a pass or a fail. In the case of a fail, the student may defend his/her thesis proposal one more time within one month after the first attempt before the same examining committee as stipulated in article 10.1. In the case of an unsuccessful second attempt the student is not allowed to embark on the MSc thesis work.

Article 11 Replacement of modules and transfer of credit points

11.1 Replacement of a module by a course followed elsewhere and transfer of credit points is generally not granted. In exceptional cases, the Examination Board may evaluate a request and conclude to grant a transfer of credit points, after receiving a favourable recommendation from the programme committee.

11.2 For joint specializations credits obtained at the partner institute are accepted on the basis of the credit transfer agreements made in the cooperation documents.

Article 12 Absence from examinations and late submission of assignments

12.1 Absence from an examination or late submission of an assignment must be reported by the student to the programme coordinator as early as possible. Absence is only allowed if the student missed a substantial part of the education relevant for the examination due to:

a. medical reasons, to be confirmed by student counsellor or a statement by a doctor;
b. serious personal circumstances beyond control of the student which should be supported by written evidence as far as possible.

12.2 For cases in which the programme coordinator, in agreement with the module coordinator, decides that the absence from an examination or the late submission of the assignment is justified, the student shall sit the examination or submit the assignments as soon as is reasonably possible.

12.3 For cases in which the programme coordinator, in agreement with the module coordinator, decides that the absence from an examination or the late submission of the assignment is not justified, a mark of 1.0 will be recorded.

Article 13 Fraud

13.1 If a student is caught in an attempt to take unfair advantage during an examination, the invigilators or examiners inform the Academic Registrar who submits a written report to the Examination Board after investigation of the incident, and after having had a discussion with the student.

13.2 Plagiarism is an act of fraud.

13.3 An examiner who observes or suspects fraud during the marking of examination work is required to submit a substantiating report to the Examination Board via the module coordinator.

13.4 If the Examination Board, after investigation of the incident as described in articles 13.1-13.3, concludes that there has been a case of fraud, the offender will be given a mark of 1.0 for the examination work.

13.5 If a student commits severe or repeated fraud, the Examination Board may decide to withdraw the student the right to sit for one or more examinations for a determined period with a maximum period of one year.

13.6 In case of severe or repeated fraud the rectorate, upon advice of the Examination Board, may also decide to permanently terminate the registration of the student concerned.

Chapter 5. Results of Assessments

Article 14 Assessment and notice of assessment results

14.1 Assessment results (including the thesis examination) are represented on a scale of 1.0 to 10.0, with one decimal of accuracy, unless the assessment is a pass or non-pass. Marks 6.0 and higher indicate a pass.
The following grading scale is used:

9.0 - 10.0	Excellent
8.0 - 8.9	Very good
7.0 - 7.9	Good
6.0 - 6.9	Sufficient
5.9 and below	Fail

14.2 Assessment results (including the thesis examination) obtained at partner institutes are represented according to the descriptions in annex C of these regulations.

14.3 The mark for a module is determined by the weighted average of the results of the various assessments. The weights for each assessment are stated in the module plan. The minimum mark that should be obtained for each assessment is 5.0.
Marks between 5.0 and 5.9 can be compensated by higher marks of other assessments in the same module.

14.4 After a successful re-sit of an assessment, the mark for the module is recalculated according to the weighted average of the assessment results. The highest mark obtained (first assessment or re-sit) for an assessment will be used. However, the maximum module mark which can be awarded when there has been a re-assessment is 7.0.

14.5 Students will be informed on the outcome of their module mark and assessments as soon as possible, at least three weeks before the planned re-assessments.

14.6 Students will be informed on the outcome of their module mark and re-assessments as soon as possible, but maximum three weeks after the re-assessments.

14.7 The examination committee for the thesis examination shall determine the result immediately after the defence. The mark and distinction recommendation remain conditional until confirmed by the Examination Board.

Article 15 Period of validity

15.1 The result of a module, if successful, is valid for an unlimited period of time.

15.2 Notwithstanding paragraph 1 of this article, the period of validity for which the Examination Board takes module results into account for the programme evaluation is four years.

Article 16 Right to inspection of assessments

16.1 Students may, upon their own request, peruse their assessment work within ten working days after they were notified of the result.

16.2 Where a practical is part of a module, the work for that part may be returned to the students when all assessments of the module are fully completed.

16.3 Written examination work is archived for a minimum of 7 years.

Article 17 Study progress and study advice

17.1 All study results that are required for evaluating the performance of the students, are recorded by the Education Bureau on behalf of the Examination Board.

17.2 Students can view their individual study progress in the electronic study information system.

Chapter 6. Thesis Examination

Article 18 The organisation of the thesis examination

18.1 Students can sit the thesis examination only if all other modules required to obtain the degree have been successfully completed.

18.2 All students have to submit the examination version of the thesis report on or before the date announced by the Examination Board, and defend their thesis in the designated period.

18.3 The thesis will be assessed by a thesis examination committee consisting of three members: a professor as the chairperson, the mentor and one independent examiner.

In special circumstances the committee may consist of more than three members:

a) If the IHE Delft mentor is a PhD fellow, an additional staff member has to be appointed in the committee.

b) If the research work is carried out outside IHE Delft a co-mentor from that institute may be appointed.

c) If the research work is co-mentored by a staff member from another chair group at IHE Delft;

d) In the case of a double degree or joint degree programme, where the MSc research work is carried out under co-supervision of staff members of the partnering institutes.

Independent examiners:

a) are not involved in the preparation of the thesis work
b) must be capable of reaching an independent judgement of the quality of the MSc thesis and the student without having any personal interest in this judgement and that of the other members of the examination committee.
c) are from outside the institute or are in exceptional cases from another department within the institute, and are not involved in the supervision of the research work.
d) have to possess at least a Master degree.

18.4 After submission, the thesis will be assessed by the members of the examination committee, including a check on plagiarism. If the examination committee concludes that the thesis is unfit to be successfully defended, they may propose to the student to accept a fail without the thesis defence. The student is given the opportunity to re-sit as per Article 18.5. The student can also decline the offer and ask for the thesis defence to be organised anyhow.

18.5 If the outcome of the thesis examination, including the defence, is a fail, the examination can be repeated once. The examination committee will detail the reasons for the failure in writing and clarify what is required to pass the exam. The student is not entitled to receive further supervision.
The thesis shall be re-submitted and the defence shall be done within three months after the date of the first defence session and will, in principle, be done in front of the

same MSc Examination Committee as for the first attempt. The examination can take place via videoconference.

18.6 The maximum recorded mark for a re-sit of the thesis examination is 6.0.

18.7 The MSc thesis work shall be assessed according to the MSc thesis assessment criteria as outlined in appendix E.

18.8 The mark for the thesis examination is based on the following components: written MSc thesis report, oral presentation, and examination. The latter includes the ability of the student to satisfactorily answer questions from the examination committee. The oral presentation of the thesis research has a maximum duration of 30 minutes and is followed by a maximum 30 minutes examination discussion with the examining committee.
The oral presentation is open to public attendance and discussion.

18.9 The decision on a final mark for the thesis examination in principle will be based on a consensus of the examining committee. In the case of insurmountable disagreements the chair of the examining committee takes a decision.

18.10 The maximum duration of the MSc research phase is six months for full-time study. In the case of a *force majeure,* as supported by substantiating documents, extension of this period may be granted by the Examination Board on request by the student through his/her mentor.

Chapter 7. Criteria, degrees and certificates

Article 19 Evaluation of the programme

19.1 The student has fulfilled the requirements for the programme evaluation if s/he has met the following criteria:

1. Urban Water and Sanitation programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Water Supply Engineering	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Sanitary Engineering	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
	• IHE Delft • Universidad de Valle, Cali, Colombia	Double degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 113.36 ECTS.	GPA of 3.5 or higher for the course work done at Univalle	Achieved a mark '6' or higher for the thesis examination
3. Urban Water Engineering and Management	• IHE Delft • Asian Institute of Technology, Thailand	Joint degree	Successfully completed all modules at IHE Delft	48 AIT credits or 120 ECTS	minimum CGPA of 2,75 for courses at AIT	Has obtained a grade 'fair' or higher for the Master thesis at AIT

2. Environmental Science programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Environmental Science and Technology	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Environmental Planning and Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
3. Applied Aquatic Ecology for Sustainability	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
4. Limnology and Wetland Management	• IHE Delft • BOKU - University of Natural Resources and Life Sciences, Vienna, Austria • Egerton University, Egerton, Kenya	Joint degree	Successfully completed all modules at IHE Delft, BOKU, and Egerton	Obtained a minimum of 120 ECTS		
5. Environmental Technology and Engineering Programme (IMETE)	• IHE Delft • Ghent University • Prague University	Joint degree	Successfully completed all modules at IHE Delft, Ghent and Prague	Obtained a minimum of 120 ECTS		

3. Water Management and Governance programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Water Management and Governance	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Water Cooperation and Diplomacy	IHE Delft Oregon State University U-Peace	Triple degree				

4. Water Science and Engineering programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Hydrology and Water Resources	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Hydraulic Engineering - River Basin Development	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
3. Coastal Engineering and Port Development	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
4. Land and Water development	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
	• IHE Delft • University of Nebraska -Lincoln, USA	Double degree	Successfully completed all modules at IHE Delft and at Nebraska	Obtained a minimum of 112 ECTS		
	• IHE Delft • Asian Institute of Technology,Thailand	Joint degree	Successfully completed all modules at IHE Delft	48 AIT credits or 120 ECTS	minimum CGPA of 2,75 for courses at AIT	Has obtained a grade 'fair' or higher for the Master thesis at AIT

5. Hydroinformatics-Modelling and information systems for water management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
6. Flood Risk Management (Erasmus Mundus programme).	• IHE Delft • Technische Universität Dresden, Germany • Universitat Politècnica de Catalunya, Spain • University of Ljubljana, Slovenia	Multiple degree	Successfully completed all modules of the programme, according to the grading rules of TU-Dresden, University of Ljublijana, TU-Catalonia and IHE Delft	Obtained a minimum of 120 ECTS		
7. Groundwater and Global Change - Impacts and Adaptation (Erasmus Mundus programme).	• IHE Delft • TU Dresden, Germany • University of Lisbon, Portugal	Multiple degree	Successfully completed all modules of the programme, according to the grading rules of the University of Lisbon, Technical University Dresden, and IHE Delft	Obtained a minimum of 120 ECTS		
8. Sustainable Urban Water Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		

5. **Graduate professional diploma programmes**:

Name	Offered by		Criteria for diploma awarding			
Sanitation and Sanitary Engineering	• IHE Delft	Diploma	Successfully completed all modules at IHE Delft	Obtained a minimum of 20 ECTS for the programme		

19.2 The student has fulfilled the requirements for the short or online course if s/he successfully completed all assessments of the course.

19.3 The student has successfully completed the programme evaluation or short / online course evaluation if the Examination Board takes a decision to that effect.

Article 20 Awarding of degrees and certificates

20.1 Master of Science degree.
Students who have successfully completed the programme evaluation requirements will be awarded the Master of Science degree. The degree is signed by the Chair of the Examination Board, the Rector of the Institute and the Academic Registrar. In addition to the degree certificate, the graduate receives a degree supplement stating the results achieved and credit points for each component of the programme.

20.2 Certificate of Graduate Study.
Students who fail to meet the master programme evaluation requirements and have accumulated a minimum of 45 credits will be awarded a certificate of graduate study in the programme for which they are registered. Registration as student will be terminated.

20.3 Certificate of attendance.
Students who fail to meet the master programme evaluation requirements, or who suspend or terminate their registration, will be issued a certificate stating the result achieved and credit points for each successfully completed component of the programme, and the period of registration. The Certificate of Attendance is signed by the Course coordinator and the Academic Registrar.

20.4 If a student re-registers within 4 years after termination and meets (after assessment(s)) the requirements of an MSc degree, s/he is obliged to return the certificate as mentioned under art 20.2 and art 20.3.

20.5 With reference to art 20.4, if a student re-registers within 4 years with the aim to obtain an MSc degree, s/he has to re-take in full all failed and missed modules. Re-registration is only possible for a subsequent academic period.

20.6 Certificate for short or online course.
Students who have successfully completed a credited short or online course including all its assessments, will be awarded a certificate. The certificate is signed by the Course coordinator and the Academic Registrar. In addition to this certificate, the graduate receives an academic transcript stating the result achieved and credit points awarded.

20.7 Certificate of Attendance.
Students who have successfully completed the short or online course without assessments, and who have demonstrated an active participation in the course throughout the whole study period, verified by the course coordinator, will be awarded a Certificate of Attendance.
The Certificate of Attendance is signed by the Course coordinator and the Academic Registrar.

20.8 GPDP diploma
Students who have successfully collected a minimum of 20 ECTS for the programme will be awarded a Postgraduate Professional Diploma in Sanitation and Sanitary Engineering.
The diploma is signed by the Rector of the Institute, the Chair of the Examination Board and the Academic Registrar. In addition to this diploma the graduate receives a diploma supplement stating the learning objectives, the composition of the programme, the results achieved and the associated credit points.

20.9 Students who fail to meet the requirements for the awarding of the GPDP diploma will receive a Certificate (art 20.4) for those courses which were successfully completed.

Article 21 Criteria for MSc degree with distinction

21.1 An MSc degree with distinction can be awarded upon recommendation of the examination committee. The recommendation is made in recognition of the exceptional performance by the student and is submitted with motivation to the Examination Board for consideration. Recommendations are admissible if the following minimum criteria have been met:

For single degree programmes:

- the candidate obtained a mark of 8.5 or higher for the thesis examination, and
- an arithmetic average mark at IHE Delft of 8.0 or higher for all modules in the taught part of the programme that are assessed on a numerical scale, conform article 14.1,
- and

For double / multiple degree programmes where student sits for the thesis examination at IHE Delft:

- the candidate obtained a mark of 8.5 or higher for the thesis examination, and
- an arithmetic average mark at IHE Delft of 8.0 or higher for all modules that are assessed on a numerical scale, conform article 14.1.

The recommendation should also be based on the results for the courses obtained at the partner institute(s).

For double / multiple degree programmes where the student sits for the thesis examination at a partner institute no recommendation for a MSc degree with distinction can be made.

21.2 The student will be awarded an MSc degree with distinction if the Examination Board takes a decision to that effect.

Chapter 8. Appeals

Article 22 Grounds for appeal

22.1 Students have the right to appeal against an assessment result, if
- a. the performance of the student suffered through illness or other factors;
- b. a material administrative error in the conduct of an assessment occurred;
- c. the assessment or evaluation was not conducted in accordance with the regulations;
- d. some other material irregularity occurred;
- e. there is a serious unsolved conflict with the supervisor or the mentor.

Article 23 Procedure for appeal

23.1 A student shall first attempt to resolve the problem with the decision making body or person that has taken the disputed decision. If mediation is required, the role of mediator will be assigned to the programme coordinator.

23.2 If the appeal concerns a decision taken by an Examiner or an MSc Examination Committee, the appeal shall be submitted to the Examination Board within 3 weeks following the date on which the decision was made known. It should be submitted by the student in writing, stating the grounds for appeal and enclosing appropriate documentation, including an account of the attempt to resolve the case amicably.

23.3 If the appeal concerns a decision taken by the Examination Board - not being an appeal as referred to in Article 23.2 - or a decision taken by the Academic Registrar, the appeal shall be submitted to the Academic Appeals Board within 3 weeks following the date on which the decision was made known. It should be submitted by the student in writing, stating the grounds for appeal and enclosing appropriate documentation, including an account of the attempt to resolve the case amicably.

23.4 Pending the outcome of the appeal procedure, the initial (contested as per appeal) decision will remain in force and will be implemented

23.5 Reference is made to Appendix F for a detailed description of the appeal procedure.

Chapter 9. Final Articles

Article 24 Amendments

24.1 Amendments to these regulations are made by separate decision of the Rectorate.

24.2 No amendments shall be made in relation to the ongoing academic year, unless there is reasonable expectation that the amendment will not disadvantage the students.

Article 25 Unforeseen situations

25.1 Situations which are not foreseen by the present regulations will be decided on by the Examination Board, where necessary after consultation with the programme committee concerned.

Article 26 Publication

26.1 The Rectorate is responsible for the timely publication of these Examination Regulations, and any amendments thereof.

Article 27 Period of application

27.1 These regulations take effect for the cohort 2018 – 2020. Approved by the Rectorate of IHE Delft on 11 September 2018.

Appendix A Qualifications of Graduates

UWS - Water Supply Engineering

Knowledge and understanding	1. Place the specialized knowledge gained into a broader understanding of water issues, challenges, debates and developments. 2. Understand the required basic chemical, physical and (micro)biological principles commonly applied in the field of water supply and sanitation. 3. Understand the engineering- and socio-economic aspects of urban water systems 4. Understand different international practices and approaches in wider urban water systems. 5. Understand the configuration of drinking water supply systems, including treatment, water transport, and distribution. 6. Understand water quality criteria and their standards, and their relation to public health, environment and urban water cycle. 7. Explain physical, chemical and biological processes that take place within water supply systems. 8. Identify how water quality affects selection of water treatment process. 9. Explain hydraulic concepts and their relationship to water transport within treatment plants and distribution networks. 10. Recognize and understand the importance and methods for operation and maintenance of water supply systems. 11. Identify options for centralized and urban systems versus decentralized and rural systems.
Applying knowledge and understanding	1. Draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques. 2. Conduct research independently in a scientifically sound and ethically responsible manner. 3. Contribute to interdisciplinary and evidence-based knowledge development and problem solving. 4. Integrate disciplinary knowledge and skills in a broader urban water system problem solving context. 5. Collect, process and analyse field/lab data related to water supply and sanitation systems. 6. Design and rehabilitate raw water abstraction, transport, treatment and distribution processes and systems. 7. Select treatment processes depending on the nature of impurities to be removed and the intended use of the treated water. 8. Apply modelling tools for simulation, prediction of performance and operation of water supply system components.
Making judgements	1. Identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems. 2. Critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches. 3. Interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations. 4. Define, evaluate and select water supply technology alternatives on the basis of chosen selection criteria.
Communication	1. Communicate and present effectively, both in writing and orally, employing the appropriate information and communication technologies. 2. Debate and defend findings and insights, in a clear, systematic and convincing manner. 3. Communicate effectively across disciplines and cultures to enhance collaborations in teams.
Learning Skills	1. Develop competencies required to further develop and expand their knowledge and skills on their own initiative

UWS - Sanitary Engineering

Knowledge and understanding	1. Place the specialized knowledge gained into a broader understanding of water issues, challenges, debates and developments. 2. Understand the required basic chemical, physical and (micro) biological principles commonly applied in the field of water supply and sanitation. 3. Understand the engineering- and socio-economic aspects of urban water systems. 4. Understand different international practices and approaches in wider urban water systems. 5. Understand and explain the role of sanitation in urban water cycle and its relation to public health and environment. 6. Develop rational approaches towards sustainable waste (water) management via pollution prevention, appropriate treatment, resources recovery and re-use on both centralized and decentralized level. 7. Understand in-depth relevant physical, chemical and biological processes, and their mutual relationships within various sanitation components.
Applying knowledge and understanding	1. Draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques. 2. Conduct research independently in a scientifically sound and ethically responsible manner. 3. Contribute to interdisciplinary and evidence-based knowledge development and problem solving. 4. Integrate disciplinary knowledge and skills in a broader urban water system problem solving context. 5. Collect, process and analyze field/lab data related to water supply and sanitation systems. 6. Apply gained knowledge and skills in practice; 7. Prepare conceptual engineering and process design of sanitation components; 8. Apply modern tools for technology selection and carry out modelling of sanitation components. 9. Identify, develop and conduct independent research including formulation of hypotheses selection and application of research methodologies, and the formulation of conclusions and recommendations. 10. Carry out desk studies, field work, and laboratory based research. 11. Contribute to the development of innovative approaches to the provision of adequate and sustainable sanitation services in developing countries and countries in transition.
Making judgements	1. Identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems. 2. Critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches. 3. Interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations. 4. Define and critically analyze, assess and evaluate various urban drainage and sewerage schemes, and wastewater, sludge and solid waste treatment process technologies. 5. Analyze, synthesize, integrate, interpret, and discuss both scientific and practical information in the context of various research and engineering projects including preparation of Master plans, feasibility studies and preliminary designs.
Communication	1. Communicate and present effectively, both in writing and orally, employing the appropriate information and communication technologies. 2. Debate and defend findings and insights, in a clear, systematic and convincing manner. 3. Communicate effectively across disciplines and cultures to enhance collaborations in teams.
Learning Skills	1. Develop competencies required to further develop and expand their knowledge and skills on their own initiative.

UWS - Urban Water Engineering and Management

Knowledge and understanding	1. Place the specialized knowledge gained into a broader understanding of water issues, challenges, debates and developments. 2. Understand the required basic chemical, physical and (micro) biological principles commonly applied in the field of water supply and sanitation. 3. Understand the engineering- and socio-economic aspects of urban water systems. 4. Understand different international practices and approaches in wider urban water systems. 5. Understand the urban water cycle and its water system components, their characteristics and functioning within greater urban infrastructure systems. 6. Understand urban water management problems including ability to: identify water systems' demand; deal with climatic and hydrologic uncertainties and/or extremes (e.g., flooding); institutional limitations; and work within a data-constrained environment. 7. Understand water infrastructure/asset planning, financing and management, and utility management. 8. Familiarize with the concept of integrated water resources management (IWRM) and its application to a variety of water management problems at the urban catchment scale.
Applying knowledge and understanding	1. Draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques. 2. Conduct research independently in a scientifically sound and ethically responsible manner. 3. Contribute to interdisciplinary and evidence-based knowledge development and problem solving. 4. Integrate disciplinary knowledge and skills in a broader urban water system problem solving context. 5. Collect, process and analyze field/lab data related to water supply and sanitation systems. 6. Make appropriate and critical use of methods, techniques and tools necessary to monitor, analyze and design urban water systems including: water supply infrastructure; drinking water treatment and distribution; wastewater collection, treatment, transport and disposal systems; drainage and flood protection systems. 7. Identify, articulate, analyze and solve problems of the urban water cycle and systems, integrating theory and applications. 8. Collect, summarize, analyze and interpret technical data/materials in a structured form to gain knowledge on urban water system design and operation and maintenance. 9. Work with a range of information technology tools (e.g., GIS tools) available for solving urban water management problems and for effectively communicating with fellow water managers, researchers, scientists, planners, and policy-makers.
Making judgements	1. Identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems. 2. Critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches. 3. Interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations. 4. Critically analyze and assess the need for continued-education and research on planning, design, maintenance and management of urban water systems.
Communication	1. Communicate and present effectively, both in writing and orally, employing the appropriate information and communication technologies. 2. Debate and defend findings and insights, in a clear, systematic and convincing manner. 3. Communicate effectively across disciplines and cultures to enhance collaborations in teams.
Learning Skills	1. Develop competencies required to further develop and expand their knowledge and skills on their own initiative.

Water Management and Governance

Knowledge and understanding	1. Place the specialized knowledge gained into a broader understanding of water issues, challenges, debates and developments. 2. Analyse biophysical and social processes and appraise principles and approaches relevant to water management and governance. 3. Recognize and distinguish different ways of knowing and framing water questions and problems in order to analyse water management and governance processes from an interdisciplinary perspective.
Applying knowledge and understanding	1. Draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques. 2. Conduct research independently in a scientifically sound and ethically responsible manner. 3. Contribute to interdisciplinary and evidence-based knowledge development and problem solving. 4. Analyse and contextualize governance arrangements and (integrated) management approaches to address water issues in socially inclusive and ecologically sustainable ways.
Making judgements	1. Identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems. 2. Critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches. 3. Interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations. 4. Reflect critically on the implications of water management and governance interventions on society and nature and formulate and defend own standpoint.
Communication	1. Communicate and present effectively, both in writing and orally, making use of information and communication technologies suited for the audience and the purpose. 2. Debate and defend findings and insights, in a clear, systematic and convincing manner. 3. Communicate effectively across disciplines and cultures to enhance collaborations in teams.
Learning Skills	1. Develop competencies required to further expand their knowledge and skills on their own initiative. 2. Reflect on own professional and educational background in order to identify a personal learning trajectory to realize career objectives and professional development goals.

WMG - Water Conflict and Diplomacy

Knowledge and understanding	1. Place the specialized knowledge gained into a broader understanding of water issues, challenges, debates and developments. 2. Analyse biophysical and social processes and appraise principles and approaches relevant to water management and governance. 3. Recognize and distinguish different ways of knowing and framing water questions and problems in order to analyse water management and governance processes from an interdisciplinary perspective. 4. Discuss and compare theories and concepts that relate to water conflict, cooperation and diplomacy.
Applying knowledge and understanding	1. Draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques. 2. Conduct research independently in a scientifically sound and ethically responsible manner. 3. Contribute to interdisciplinary and evidence-based knowledge development and problem solving. 4. Analyse and contextualize governance arrangements and (integrated) management approaches to address water issues in socially inclusive and ecologically sustainable ways. 5. Critically analyze latent and actual water disputes including key elements of conflict analysis and key contextual elements. 6. Critically analyze different dispute resolution mechanisms and participatory processes. 7. Select and use conflict management tools to develop water cooperation and diplomacy processes and arrangements to mitigate and resolve water disputes in socially inclusive and ecologically sustainable ways.
Making judgements	1. Identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems. 2. Critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches. 3. Interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations. 4. Reflect critically on the implications of water management and governance interventions on society and nature and formulate and defend own standpoint. 5. Identify and reflect critically on issues, challenges and potential conflicts regarding competition and cooperation around water at different scales.
Communication	1. Communicate and present effectively, both in writing and orally, making use of information and communication technologies suited for the audience and the purpose. 2. Debate and defend findings and insights, in a clear, systematic and convincing manner. 3. Communicate effectively across disciplines and cultures to enhance collaborations in teams.
Learning Skills	1. Develop competencies required to further expand their knowledge and skills on their own initiative. 2. Reflect on own professional and educational background in order to identify a personal learning trajectory to realize career objectives and professional development goals.

ES - Environmental Science and Technology

Knowledge and Understanding	1	be able to place the knowledge gained through their own specialization into a broader understanding of contemporary global water issues, challenges, debates and developments.
	2	understand the required basic chemical, physical, (micro)biological and ecological principles commonly applied in the field of environmental science.
	3	understand the socio-economic dimensions of environmental systems.
	4	understand different common practices and approaches in river basin and environmental management.
	5	identify the way to prevent environmental pollution through resource management and application of re-use technologies.
	6	identify the way polluted water, waste, gas, soils and sediments can be treated to reduce environmental risk.
Applying Knowledge and Theory	1	formulate research questions and hypotheses, select and apply research methods, theories and techniques, and prepare a research plan.
	2	conduct independent research.
	3	contribute to multidisciplinary and creative problem solving.
	4	contribute to the development of knowledge and integrate it with knowledge from other field.
	5	integrate disciplinary knowledge and skills in an environmental science context.
	6	collect, process and analyse field data.
	7	develop, design and apply technologies for the prevention and remediation of environmental pollution by searching scientific information, conducting scientific research in the field of environmental technology and engineering, and reporting their findings by means of scientific reports and papers.
Making Judgements	1	identify relevant research, ideas and approaches from literature and other sources in view of their potential for helping understand or solve particular water-related problems.
	2	critically discuss, as well as comparatively evaluate and judge existing knowledge, ideas and approaches against each other, well as against own research approaches and outcomes.
	3	recognize and address ethical and sustainability dimensions in professional practice
	4	use research outcomes to inform well-founded, original conclusions, solutions or recommendations.
	5	critically analyse and evaluate a range of options for the prevention or remediation of environmental problems under prevailing socio-economic conditions.
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies.
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams.
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative.

ES - Environmental Policy Making

Knowledge and Understanding	1	be able to place the knowledge gained through their own specialization into a broader understanding of contemporary global water issues, challenges, debates and developments.
	2	understand the required basic chemical, physical, (micro)biological and ecological principles commonly applied in the field of environmental science.
	3	understand the socio-economic dimensions of environmental systems
	4	understand different common practices and approaches in river basin and environmental management.
	5	understand how the legal, cultural, technical, ethical, socio-economic, and/or political context influences environmental planning and management, and sustainable outcomes, from local to global levels.
	6	analyse policy and planning instruments to improve management of water and natural resources.
	7	analyse concepts, methods and tools for strategic decision-making such as policy analysis, planning and environmental and social impact assessment.
Applying Knowledge and Theory	1	formulate research questions and hypotheses, select and apply research methods, theories and techniques, and prepare a research plan.
	2	conduct independent research.
	3	contribute to multidisciplinary and creative problem solving.
	4	contribute to the development of knowledge and integrate it with knowledge from other field.
	5	integrate disciplinary knowledge and skills in an environmental science context.
	6	collect, process and analyse field data.
	7	apply and reflect upon concepts, methods and tools for strategic decision-making.
	8	design and implement water and environmental plans for various levels of decision-making.
Making Judgements	1	identify relevant research, ideas and approaches from literature and other sources in view of their potential for helping understand or solve particular water-related problems
	2	critically discuss, as well as comparatively evaluate and judge existing knowledge, ideas and approaches against each other, well as against own research approaches and outcomes.
	3	recognize and address ethical and sustainability dimensions in professional practice.
	4	use research outcomes to inform well-founded, original conclusions, solutions or recommendations.
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies.
	2	debate and defend findings and insights, in a clear, systematic and convincing manner.
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams.
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative.

ES - Applied Aquatic Ecology for Sustainability

Knowledge and Understanding	1	be able to place the knowledge gained through their own specialization into a broader understanding of contemporary global water issues, challenges, debates and developments.
	2	understand the required basic chemical, physical, (micro)biological and ecological principles commonly applied in the field of environmental science.
	3	understand the socio-economic dimensions of environmental systems.
	4	understand different common practices and approaches in river basin and environmental management.
	5	understand and evaluate the physical, biogeochemical, and ecological processes related to the functioning of natural and degraded aquatic ecosystems.
Applying Knowledge and Theory	1	formulate research questions and hypotheses, select and apply research methods, theories and techniques, and prepare a research plan.
	2	conduct independent research.
	3	contribute to multidisciplinary and creative problem solving.
	4	contribute to the development of knowledge and integrate it with knowledge from other field.
	5	integrate disciplinary knowledge and skills in an environmental science context.
	6	collect, process and analyse field data.
	7	integrate stakeholder objectives and scientific knowledge to create management objectives for the sustainable management, restoration, and conservation of aquatic ecosystems.
Making Judgements	1	identify relevant research, ideas and approaches from literature and other sources in view of their potential for helping understand or solve particular water-related problems.
	2	critically discuss, as well as comparatively evaluate and judge existing knowledge, ideas and approaches against each other, well as against own research approaches and outcomes.
	3	recognize and address ethical and sustainability dimensions in professional practice.
	4	use research outcomes to inform well-founded, original conclusions, solutions or recommendations.
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies.
	2	debate and defend findings and insights, in a clear, systematic and convincing manner.
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams.
	4	effectively communicate the responses of lakes, rivers, and wetlands to anthropogenic pressures to stakeholders and peers.
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative.

ES - Limnology and Wetland Management

Knowledge and Understanding	1	to demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex interrelationship between protection and wise use of environmental resources;
	2	to describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources
	3	to identify the impacts of human activities on freshwater ecosystems in different socio-economic contexts;
	4	to demonstrate knowledge and understanding of the international water quality guidelines;
	5	to name and explain concepts, instruments and technologies for protection and remedial actions of freshwater ecosystems.
Applying Knowledge and Theory	1	to design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;
	2	to design, optimise and interpret environmental monitoring and assessment schemes for freshwater ecosystems;
	3	to apply general scientific methods (including statistics and environmental modelling) for the development and application of scientific and technological approaches, concepts and interventions to address problems of freshwater ecosystems;
	4	to conduct research, independently/in multidisciplinary teams, incl. formulation of research questions and hypotheses, selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations.
Making Judgements	1	to critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions;
	2	to critically analyse and evaluate a range of options and alternatives for the prevention or remediation of problems related with freshwater ecosystems, under different socio-economic and legal contexts, and under often data-poor conditions;
	3	to contribute in interdisciplinary teams in developing solutions for prevention/remediation of aquatic ecosystem problems by linking scientific knowledge to engineering interventions and management decisions in different cultural/socio-economic contexts.
Communication	1	to communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences.
Learning Skills	1	to demonstrate academic attitude and learning skills (incl. thinking in multidisciplinary dimensions and distinguishing main issues from minor ones), to enhance and keep up-to-date the acquired knowledge and application skills in an independent manner.

ES - Environmental Technology and Engineering

Knowledge and Understanding	1	be able to place the knowledge gained through their own specialization into a broader understanding of contemporary global water issues, challenges, debates and developments
	2	understand the required basic chemical, physical, (micro)biological and ecological principles commonly applied in the field of environmental science
	3	understand the socio-economic dimensions of environmental systems
	4	understand different common practices and approaches in river basin and environmental management
	5	identify the way to prevent environmental pollution through resource management and application of re-use technologies
	6	identify the way polluted water, waste, gas, soils and sediments can be treated to reduce environmental risk
Applying Knowledge and Theory	1	formulate research questions and hypotheses, select and apply research methods, theories and techniques, and prepare a research plan
	2	conduct independent research
	3	contribute to multidisciplinary and creative problem solving
	4	contribute to the development of knowledge and integrate it with knowledge from other field
	5	integrate disciplinary knowledge and skills in an environmental science context
	6	collect, process and analyse field data
	7	develop, design and apply technologies for the prevention and remediation of environmental pollution by searching scientific information, conducting scientific research in the field of environmental technology and engineering, and reporting their findings by means of scientific reports and papers
Making Judgements	1	identify relevant research, ideas and approaches from literature and other sources in view of their potential for helping understand or solve particular water-related problems
	2	critically discuss, as well as comparatively evaluate and judge existing knowledge, ideas and approaches against each other, well as against own research approaches and outcomes
	3	recognize and address ethical and sustainability dimensions in professional practice
	4	use research outcomes to inform well-founded, original conclusions, solutions or recommendations
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
	4	effectively communicate the responses of lakes, rivers, and wetlands to anthropogenic pressures to stakeholders and peers
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE - Coastal Engineering and Port Development

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	have an understanding of the application of modern analysis and design techniques to coastal problems and the expertise necessary to make decisions on effective engineering interventions in the coastal environment
	4	have advanced level of knowledge and understanding of coastal processes, and nautical and logistic aspects and their interrelationship with the nearshore and offshore structures
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	the ability to contribute to interdisciplinary and evidence-based knowledge development and problem solving
	4	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	5	integrate monitoring, modelling and information to support safe and reliable decision making
	6	develop strategies to cope effectively with problems related to natural hazards (e.g. coastal floods) and shoreline erosion problems and understand the conflict between coastal developments and natural coastal processes
	7	apply sophisticated design techniques using theoretical concepts of coastal hydraulics and various principles and approaches of coastal engineering design to advance the needs of society for shelter, infrastructure and a safe environment
	8	evaluate and implement coastal engineering solutions in a multidisciplinary and interdisciplinary environment
	9	apply hydraulic and nautical, logistic and economic theories in the planning and design of coastal and ports layout and port logistics
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	place a coastal engineering and/or port project in its environment (social, ecological and physical environment), quantify and understand the interactions between the project and the environment
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE - River Basin Development

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	have knowledge and understanding of the latest concepts and theories that are required for independent professionals within the field of hydraulic engineering and river basin development
	4	have knowledge and understanding of the cross-sectoral linkages determinant for the design and planning of sustainable water infrastructures prepared for global change
	5	have an analytical understanding of physical mechanisms and processes in the natural and built environment that are determinant for the design and planning of sustainable water infrastructures prepared for global change
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	the ability to contribute to interdisciplinary and evidence-based knowledge development and problem solving
	4	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	5	integrate monitoring, modelling and information to support safe and reliable decision making
	6	apply and master tools like analytical solutions and numerical models for hydraulic and hydrological processes, remote sensing and GIS-based models for the design of water infrastructure at the project scale and for river basin scale planning
	7	estimate, predict and prepare the occurrence of hydrological extremes within and across river basins
	8	model and quantify fluvial processes involving the transport of water and sediments, which are determinant for the morphodynamics of rivers, safety of citizens, and for physical, chemical, and biological mechanisms in the river basin
	9	plan and design water infrastructures essential for food and energy production, domestic and industrial water supply, and protection against floods and geomorphological hazards
	10	initiate research and development activities, innovative solutions for the adequate management of water resources and for the sustainable development of water infrastructures within the river basin
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	to identify opportunities for innovative development of tools and strategies for water management at the river basin scale, and to identify research avenues regarding physical processes essential in the design of water infrastructures
	7	to assess the sustainability of water infrastructures and of tools and strategies for river basin water management, by critical assessment of their technical, socio-economic and environmental components
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE - Hydroinformatics

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	have understanding of the information cycle and systems approach in relation to the management of water based systems, and have a thorough awareness of the flow of information following the sequence "data - modelling - forecasting - optimization – decision support - management", aimed at sustainable development and stakeholder involvement
	4	have a good understanding of numerical methods for solving equations of water flow, and knowledge of their ranges of applicability in various contexts
	5	have an understanding of advanced and appropriate information and communication technologies, advances in computer science, computer programming, data science and applied mathematics, and their use in building technologies supporting water management in a wide sense
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	4	integrate monitoring, modelling and information to support safe and reliable decision making
	5	master the theory and practice of different modelling paradigms and systems analysis, and, in particular, physically based and data driven modelling, computational intelligence and multi-disciplinary optimization, and integrate these in hydroinformatics systems
	6	apply the knowledge of numerical methods for solving equations of water flow, computational intelligence and data analysis, be able to implement them in research computer codes and apply to various problems of water modelling and forecasting
	7	to select and apply available software and internet-based tools, integrate them, and critically assess their advantages and disadvantages in application to water resources management, hazard risk assessment and forecasting, environmental planning and asset management
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	make critical use of advanced theories, concepts and tools in hydroinformatics to search innovative solutions for new problems and situations, either independently or within a team
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE – Hydrology and Water Resources

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	be aware of the importance of hydrology to society and the relationship of hydrology with related disciplines
	4	have in-depth understanding of the current theories and concepts in both surface and subsurface hydrology, the relevant physical, chemical and biological process interactions between the hydrosphere, the lithosphere, the biosphere and the atmosphere
	5	master the major hydrological methodologies and applications with regard to both water quantity and water quality, including techniques for data collection, processing and analysis, and the application modelling techniques
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	the ability to contribute to interdisciplinary and evidence-based knowledge development and problem solving
	4	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	5	integrate monitoring, modelling and information to support safe and reliable decision making
	6	apply and integrate the relevant physical, chemical, applied mathematical, computational and earth-scientific principles and concepts, and to use information and communication technology relevant to hydrology
	7	design and conduct hydrological assessments and experiments for both application and scientific purposes, either independently or within a team-based framework
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	evaluate and analyse hydrological systems and processes at a wide range of scales in both space and time for the purpose of water resources assessment, natural hazards assessment and mitigation, and environmental planning and management
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE - Land and Water Development for Food Security

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	have knowledge and understanding of the latest concepts and theories of irrigation and drainage design, modernization and management, and land reclamation for sustainable development and food security
	4	have knowledge and understanding of the cross-sectoral linkages related to land and water development comprehending wider aspects of society, economy, human health and environment and its contributions to food security
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	the ability to contribute to interdisciplinary and evidence-based knowledge development and problem solving
	4	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	5	integrate monitoring, modelling and information to support safe and reliable decision making
	6	apply the latest hydraulic engineering and hydrological methods in planning, design and implementation of irrigation and drainage schemes, independently or in a multidisciplinary team
	7	apply innovative tools like Remote Sensing and GIS in planning and performance management of land and water development schemes for enhanced food security
	8	contribute to the development of innovative approaches for adequate and sustainable land and water development for food security
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	identify options for participatory land and water development, and critically assess their technical, socio-economic and environmental performance
	7	evaluate aspects of planning, design, modernization, operation & maintenance and financing of irrigation and drainage schemes
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE – Flood Risk Management

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	have a comprehensive knowledge base and understanding of the current theory and practice relating to flooding and flood management
	4	have an understanding of advanced and appropriate information and communication technologies and data science, and their use in building technologies supporting flood risk management
		have a broad scientific knowledge about conservation, restoration and management measures to overcome challenges imposed on water by humans and by climate change
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	the ability to contribute to interdisciplinary and evidence-based knowledge development and problem solving
	4	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	5	integrate monitoring, modelling and information to support safe and reliable decision making
	6	apply specific practical skills, such as identifying the major physical processes in a given river basin or coastal zone and their interaction with the associated assets and receptors
	7	apply sophisticated hydroinformatics and modelling tools, best practices and information and communication technology to address the problems of flood risk management
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	identify the links between all issues related to flooding in order to apply an integrated approach using the best tools to support decision making for the sustainable management of floods (
	7	advise on a basin-wide approach to flood risk management
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

WSE - Groundwater and Global Change - Impacts and Adaptation

Knowledge and Understanding	1	have knowledge of contemporary water issues, challenges, debates and developments
	2	demonstrate knowledge and understanding of hydrological, hydraulic and environmental processes and phenomena, and their inter-relationships, in natural and built environments
	3	have in-depth understanding of the current theories and concepts in both surface and subsurface hydrology, the relevant physical, chemical and biological process interactions between the hydrosphere, the lithosphere, the biosphere and the atmosphere
	4	be able to explain in depth how groundwater systems respond to climate variability and human activities in both an urban and rural context, and how this is dealt with in water resources management in adaptation to climate and global change
Applying Knowledge and Theory	1	the ability to draft a research plan, including the formulation of research questions and hypotheses and the selection of research methods, theories and techniques
	2	the ability to conduct research independently in a scientifically sound and ethically responsible manner
	3	the ability to contribute to interdisciplinary and evidence-based knowledge development and problem solving
	4	apply appropriate modelling and data management tools related to hydrological, hydraulic, morphological and environmental processes, to support management and engineering interventions
	5	integrate monitoring, modelling and information to support safe and reliable decision making
	6	apply and integrate the relevant physical, chemical, applied mathematical, computational and earth-scientific principles and concepts, and to use information and communication technology relevant to hydrology
	7	design and conduct hydrological assessments and experiments for both application and scientific purposes, either independently or within a team-based framework
	8	use field assessment and process understanding techniques in combination with modelling tools to study and simulate groundwater and climate processes and their interactions with each other, with the environment and with human activities, within identified and quantified levels of uncertainty, for the purpose of integrated water resources management
Making Judgements	1	the ability to identify and appraise relevant research, concepts and approaches in view of their potential for helping understand or solve water-related problems
	2	the ability to critically discuss and evaluate own research approaches and outcomes within the context of existing knowledge and approaches
	3	the ability to interpret research findings critically in order to formulate evidence-based conclusions, solutions and/or recommendations
	4	apply engineering creativity and design skills, both independently and in multidisciplinary teams
	5	have a sense of professionalism and an appreciation for the obligations of a professional and be aware of the professional and ethical issues encountered in scientific and engineering practice
	6	evaluate and analyse hydrological systems and processes at a wide range of scales in both space and time for the purpose of water resources assessment, natural hazards assessment and mitigation, and environmental planning and management
	7	identify and select the appropriate groundwater-related solutions to water scarcity under climate and global change in terms of technical, socio-economic and environmental
Communication	1	communicate and present effectively , both in writing and orally, employing the appropriate information and communication technologies
	2	debate and defend findings and insights, in a clear, systematic and convincing manner
	3	cooperate effectively in multi-/interdisciplinary and intercultural teams
Learning Skills	1	have the competencies to further develop and expand their knowledge and skills on their own initiative

Appendix B Examination Procedures

GENERAL RULES
Students taking part in an examination are expected to have taken notice of these procedures and are expected to understand the implied meaning of these procedures.

WRITTEN EXAMINATIONS
PROCESS:
1. the students brings his / her student card and displays it on the table;
2. the invigilator verifies the card and confirms attendance by the student by ticking the box of the student on the attendance list;
3. students hand in their exam papers at the end of the session; this is their own responsibility;
4. invigilators bring the exam papers to the Education Office (immediately after the exam);
5. Education Officers verify which exam papers have been received and record this on a list;
6. the list produced by the Education Officers serves as the evidence that the exam papers have been handed in;
   a. if exam papers get lost and they have been recorded on the list of Education Office, IHE Delft has the responsibility to propose an adequate alternative assessment to the student.
   b. if a student claims that an exam paper got lost and the exam paper is not recorded on the list of Education Office, then the Institute considers the exam paper not to have been handed in by the student. There will be no alternative assessment proposed.

Invigilators: The invigilators (examination supervisors) ensure proper conduct of the examination and maintain order in the examination room. They will announce the beginning and the duration of the examination, and will warn the students 10 minutes before the ending of the examination.

Communication: During the examination, students are not allowed to exchange materials or to communicate with other students. If something is unclear, students have to inform the invigilator, who will contact the programme coordinator, the examiner or education officer if necessary.

Attendance list: Students are considered to have taken part in an examination from the moment they receive the examination papers from the invigilators, whether or not they submit any answers.

Bags: Bags and carrying cases, including penholders, are to be placed along the side of the room before the start of the examination.

Exam paper: Answer and scratch paper will be provided to the students

Students provide the answers in clearly readable English, with proper indication of the question label. All answer papers must carry the student number and locker number of the student. Unreadable answers or unidentified answer papers may be discarded for assessment by the examiner.

Pen: Students are required to bring the necessary writing and drawing tools. The answer papers to be submitted must be written with a pen, a pencil is not allowed.

Dictionary: The use of a printed language dictionary without any additional written annotations is allowed (all languages are allowed). Invigilators are allowed to check the dictionaries for hand-written annotations during the exam (spot checks while they are walking around).
Electronic dictionaries are not allowed.

Calculators: Only self-contained calculators with a single-line display or dual-line display are allowed, provided that these devices are battery operated, that any audio functions are switched off, and that these devices are exclusively built for calculation purposes only and do not have internet access.

Cell phones: Use of cell phones is not allowed and must be switched off

Other materials: The use of materials other than listed above, including blank paper, texts, laptops, computing and communication devices, personal audio and video devices, of any kind, is not allowed.
Examiners may nevertheless allow students to use specified text matter or other effects in a so-called 'open book' examination. These materials shall not include previous or example examinations and solutions.

Toilet visit: Only one student at a time will be allowed by the invigilator to leave the examination room for a short visit to the lavatory, except during the first 15 and the last 15 minutes of the examination. Examination materials and requirements may not be taken outside the examination room. Before leaving the examination room, students have to hand over their cell phone to the invigilator.

Submission of exam papers: Students who finish the examination at least 15 minutes after the start and at least 15 minutes before the ending of the examination are allowed to submit their work to the invigilator and quietly leave the examination room.
Students have to ensure that all required papers are submitted to the invigilator. Papers cannot be submitted after the student has left the examination room.

ASSIGNMENT REPORTS AND INDIVIDUAL DISCUSSIONS

For designated subjects students have to submit an assignment report, which will be assessed as part of the subject examination. The examiner may discuss the assignment report with the student as part of the assessment.

The examiner will set a deadline for submitting assignment reports. The deadline cannot be set at a date after the examination period for the subject, as indicated in the academic calendar. Students submit assignments to either the lecturer or the responsible coordinator.

Appendix C GRADING SYSTEMS used by partner institutes

1. Asian Institute of Technology

Grade	Grade Points	Description
A	4	Excellent
B+	3.5	
B	3	Good
C+	2.5	
C	2	Fair
D	1	Deficient
F	0	Fail
I		Incomplete

2. Universidad del Valle

Grade	Description
0.0	Given when absent from the exam without valid reason, when blank exam is submitted, or when caught cheating.
1.0 – 2.9	Non-pass, resit needed
3.0	Acceptable
4.0	Good
5.0	Excellent

Degree is awarded when

- GPA for the taught part is 3.5 or higher, and
- a pass is obtained for the thesis. (pass / non-pass)

3. Egerton University

Grade	Grade Points	Description
A	70% and above	Excellent
B	60-69%	Good
C	50-59%	Average
F	0-49%	Fail

Grading systems approved by the University Senate, with 50% as the pass mark.

4. BOKU

Austrian grade	ECTS Grade	Description
1	A/B	excellent/very good
2	C	good
3	D	satisfactory
4	E	pass

5. TU Dresden:

Grade	Grade Points	Description
A	1	very good
B	2	good
C	3	satisfactory
D	4	sufficient
E	5	insufficient

All courses have to be lower than 4 for a degree.

6. University of Ljubljana

Grade	Description
10	excellent: outstanding results with negligible mistakes
9	very good: high pass with minor mistakes
8	very good: sound knowledge
7	good: sound knowledge with major mistakes
6	satisfactory: adequate knowledge suiting minimum criteria
5 - 1	insufficient: failure, poor knowledge below minimum criteria

Candidates with grades satisfactory (6) or more, have passed the examinations successfully.
The student has two grades per subject: separately theory and lab exercise (seminar work). For thesis there are also two grade: written report and presentation, both should be more than 6. Finally we have one grade for thesis and common final grade of study (special formula).

7. TU-Catalonia

Grade	Description
9.0 - 10.0	excellent
7.0 - 8.9	very good
5.0 - 6.9	satisfactory
4.0 - 4.9	marginal fail
0.0 - 3.9	fail
NP	not examined
R	recognition

MH Honors (is given on exceptional cases)

8. University of Lisbon

Grade	Grade Points	Description
A	20-18	excellent
B	17-16	very good, with few errors
C	15-14	good, with some errors
D	13-12	satisfactory, with many errors
E	11-10	sufficient

9. Oregon State University

Grade	Grade Points	Description
A	4	
A-	3.7	
B+	3.3	
B	3.0	
B-	2.7	
C+	2.3	
C	2.0	
C-	1.7	
D+	1.3	
D	1.0	
D-	0.7	
F	0.0	

Grade Requirement
A grade-point average of 3.00 (a B average) is required: 1) for all courses taken as a degree-seeking graduate student, and 2) for courses included in the graduate degree or graduate certificate program of study. Grades below C (2.00) cannot be used on a graduate program of study. A grade-point average of 3.00 is required before the final oral or written exam may be undertaken.

10. UPEACE
The University for Peace grades on a zero (0) to ten (10) scale
The minimum passing grade is 7.0
Some courses may be evaluated with pass/fail.
The general average on the final transcript is a weighted average

Grade	Grade Points	Description
A	9.5 -10	excellent
A-	9.0 – 9.4	excellent
B+	8.5 – 8.9	good
B	8.0 – 8.4	good
C+	7.5 – 7.9	satisfactory
C	7.0 – 7.4	satisfactory
F	Below 7.0	fail

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Appendix D MSc modules: names, credits & assessment methods

The tables on the next pages give an overview of the module in each specialisation, including the ways these modules are assessed.

1. Urban Water and Sanitation programme

Sanitary Engineering

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3346	Introduction to UWS 1	ssr	S.G. Salinas Rodríguez, PhD, MSc	4.5	125	50		10				40	
Compulsory	201819T02	M3347	Introduction to UWS 2	ssr	S.G. Salinas Rodríguez, PhD, MSc	4.5	118	60						40	
Compulsory	201819T03	M3345	Introduction to UWS 3	pvs	N.P. van der Steen, PhD, MSc	5	147	100							
Compulsory	201819T04	M3343	Urban Drainage and Sewerage	asa	A. Sanchez Torres, PhD, MSc	5	142	60						40	
Compulsory	201819T05	M1802	Conventional Wastewater Treatment	clo	C.M. Lopez Vazquez, PhD, MSc	5	140	80						20	
Compulsory	201819T06	M2384	Resource Oriented Wastewater Treatment and Sanitation	rubio2	F.J. Rubio Rincón, PhD, MSc	5	142	80						20	
Compulsory	201819T07	M2373	Wastewater Treatment Plants Design and Engineering	clo	C.M. Lopez Vazquez, PhD, MSc	5	140	50			25			25	
Compulsory	201819T08	M3054	Modelling of Wastewater Treatment Processes and Plants	cmh	C.M. Hooijmans, PhD, MSc	5	132	100							
Compulsory	201819T09	M3342	International Fieldtrip and Fieldwork UWS	ysl	Y.M. Slokar, PhD	5	150							100	
Elective	201819T10	M2371	Water Treatment Processes and Plants	roj	S.K. Sharma, PhD	5	141				60			40	
Elective	201819T10	M3102	Industrial Effluents Treatment and Residuals Management	hga	H.A. Garcia Hernandez, PhD, MSc	5	151						60	40	
Elective	201819T10	M3405	Urban Water Systems	zov	Dr. Z. Vojinovic	5	142	40						60	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3114	Groupwork Sint Maarten	bpt	B. Petrusevski, PhD, MSc	5	140		40					60	
Compulsory	201819T14	M3239	MSc research proposal development for UWS	ysl	Y.M. Slokar, PhD	9	40							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Water Supply Engineering

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3346	Introduction to UWS 1	ssr	S.G. Salinas Rodríguez, PhD, MSc	4.5	125	50		10				40	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3347	Introduction to UWS 2	ssr	S.G. Salinas Rodríguez, PhD, MSc	4.5	118	60						40	
Compulsory	201819T03	M3345	Introduction to UWS 3	pvs	N.P. van der Steen, PhD, MSc	5	147	100						0	
Compulsory	201819T04	M3338	Unit Operations in Water Treatment (coagulation, sedimentation, flotation	dhaka6	N. Dhakal, MSc	5	144	60		20				20	
Compulsory	201819T05	M3339	Disinfection, Adsorption and Natural Processes for Water Treatment	gfe	G. Ferrero, PhD, MSc	5	146	70		20				10	
Compulsory	201819T06	M3334	Groundwater Resources and Treatment	bpt	B. Petrusevski, PhD, MSc	5	140	70		15				15	
Compulsory	201819T07	M3437	Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	20					40	40	
Compulsory	201819T08	M3341	Desalination and Membrane Technology	ssr	S.G. Salinas Rodríguez, PhD, MSc	5	140	70		10				20	
Compulsory	201819T09	M3342	International Fieldtrip and Fieldwork UWS	ysl	Y.M. Slokar, PhD	5	150							100	
Elective	201819T10	M2371	Water Treatment Processes and Plants	roj	S.K. Sharma, PhD	5	141				60			40	
Elective	201819T10	M3102	Industrial Effluents Treatment and Residuals Management	hga	H.A. Garcia Hernandez, PhD, MSc	5	151						60	40	
Elective	201819T10	M3405	Urban Water Systems	zov	Dr. Z. Vojinovic	5	142	40						60	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140						0	100	
Compulsory	201819T13	M3114	Groupwork Sint Maarten	bpt	B. Petrusevski, PhD, MSc	5	140		40					60	
Compulsory	201819T14	M3239	MSc research proposal development for UWS	ysl	Y.M. Slokar, PhD	9	40							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Urban Water Engineering and Management

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T04	M3343	Urban Drainage and Sewerage	asa	A. Sanchez Torres, PhD, MSc	5	142	60						40	
Compulsory	201819T05	M3350	Asset Management	apa	P.D.A. Pathirana, PhD, MSc	5	129				50			50	
Compulsory	201819T06	M3432	Managing Water Organisations	mtu	M. Tutusaus Luque, MSc	5	148						60	40	
Compulsory	201819T07	M3437	Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	20					40	40	
Compulsory	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigation	zov	Dr. Z. Vojinovic	5	140	40						60	
Compulsory	201819T09	M3342	International Fieldtrip and Fieldwork UWS	ysl	Y.M. Slokar, PhD	5	150							100	
Elective	201819T10	M2371	Water Treatment Processes and Plants	roj	S.K. Sharma, PhD	5	141				60			40	
Elective	201819T10	M3102	Industrial Effluents Treatment and Residuals Management	hga	H.A. Garcia Hernandez, PhD, MSc	5	151						60	40	
Elective	201819T10	M3405	Urban Water Systems	zov	Dr. Z. Vojinovic	5	142	40						60	
Compulsory	201819T11	M3039	MSc Thesis Research Proposal for AIT	era	E.R. Raj, PhD, MSc	0									100

2. Environmental Science programme

Environmental Science and Technology

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3371	Introduction to Environmental Science 1	edr	E.D. de Ruijter van Steveninck, PhD, MSc	9	260	50						50	
Compulsory	201819T03	M3370	Introduction to Environmental Science 2	edr	E.D. de Ruijter van Steveninck, PhD, MSc	5	140	60						40	
Compulsory	201819T04	M3031	Integrated Project Environmental Science	pvs	N.P. van der Steen, PhD, MSc	5	140		30					70	
Compulsory	201819T05	M3373	Environmental Process Technology	pvs	N.P. van der Steen, PhD, MSc	5	142	65		35					
Compulsory	201819T06	M3399	Environmental Systems Analysis	kir	Prof. K.A. Irvine, PhD, BSc	5	140	40	10					50	
Compulsory	201819T07	M3349	Water Quality Assessment and Monitoring	azu	Dr. A.L. Zuijdgeest	5	140			15				85	
Compulsory	201819T08	M3413	Industrial Resource Management and Cleaner P	era	E.R. Raj, PhD, MSc	5	140						60	40	
Compulsory	201819T09	M3352	International Fieldtrip and Fieldwork ES	azu	Dr. A.L. Zuijdgeest	5	140							100	
Elective	201819T10	M3396	Ecotechnologies	jvo	J.L.C.M. van de Vossenberg, PhD, MSc	5	140	70		30					
Elective	201819T10	M3415	Environmental Assessment for Water-related P	ams	Dr. A. Mendoza - Sammet	5	140	50						50	
Elective	201819T10	M3430	Aquatic Ecosystems Processes and Applicatio	gge	G.M. Gettel, PhD, MSc	5	140		10					90	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Manage	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3445	Applied environmental management	azu	Dr. A.L. Zuijdgeest	5	140							100	
Compulsory	201819T14	M3424	Thesis Research Proposal Development for ES	ams	Dr. A. Mendoza - Sammet	9	233							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Environmental Planning and Management

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3371	Introduction to Environmental Science 1	edr	E.D. de Ruijter van Steveninck, PhD, MSc	9	260	50						50	
Compulsory	201819T03	M3370	Introduction to Environmental Science 2	edr	E.D. de Ruijter van Steveninck, PhD, MSc	5	140	60						40	
Compulsory	201819T04	M3031	Integrated Project Environmental Science	pvs	N.P. van der Steen, PhD, MSc	5	140		30					70	
Compulsory	201819T05	M3385	Water and Environmental Law	jas	F.G.W. Jaspers, MA, BSc	5	152	70						30	
Compulsory	201819T06	M3399	Environmental Systems Analysis	kir	Prof. K.A. Irvine, PhD, BSc	5	140	40	10					50	
Compulsory	201819T07	M3212	Water and Environmental Policy Analysis	ams	Dr. A. Mendoza - Sammet	5	140	50						50	
Compulsory	201819T08	M3421	Environmental Planning and Implementation	jev	J.G. Evers, PhD, MSc	5	138	40						60	
Compulsory	201819T09	M3352	International Fieldtrip and Fieldwork ES	azu	Dr. A.L. Zuijdgeest	5	140							100	
Elective	201819T10	M3396	Ecotechnologies	jvo	J.L.C.M. van de Vossenberg, PhD, MSc	5	140	70		30					
Elective	201819T10	M3415	Environmental Assessment for Water-related P	ams	Dr. A. Mendoza - Sammet	5	140	50						50	
Elective	201819T10	M3430	Aquatic Ecosystems Processes and Applicatio	gge	G.M. Gettel, PhD, MSc	5	140		10					90	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Manage	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3445	Applied environmental management	azu	Dr. A.L. Zuijdgeest	5	140							100	
Compulsory	201819T14	M3424	Thesis Research Proposal Development for ES	ams	Dr. A. Mendoza - Sammet	9	233							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Applied Aquatic Ecology for Sustainability

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3371	Introduction to Environmental Science 1	edr	E.D. de Ruijter van Steveninck, PhD, MSc	9	260	50						50	
Compulsory	201819T03	M3370	Introduction to Environmental Science 2	edr	E.D. de Ruijter van Steveninck, PhD, MSc	5	140	60						40	
Compulsory	201819T04	M3031	Integrated Project Environmental Science	pvs	N.P. van der Steen, PhD, MSc	5	140		30					70	
Compulsory	201819T05	M3398	Applied Ecology and Bioassessment	jsi001	Dr. J.P.E.H.B. Simaika	5	140							100	
Compulsory	201819T06	M3399	Environmental Systems Analysis	kir	Prof. K.A. Irvine, PhD, BSc	5	140	40	10					50	
Compulsory	201819T07	M3349	Water Quality Assessment and Monitoring	azu	Dr. A.L. Zuijdgeest	5	140			15				85	
Compulsory	201819T08	M3403	River and Floodplain Rehabilitation	avd	A.A. van Dam, PhD, MSc	5	140		20					80	
Compulsory	201819T09	M3352	International Fieldtrip and Fieldwork ES	azu	Dr. A.L. Zuijdgeest	5	140							100	
Elective	201819T10	M3396	Ecotechnologies	jvo	J.L.C.M. van de Vossenberg, PhD, MSc	5	140	70		30					
Elective	201819T10	M3415	Environmental Assessment for Water-related P	ams	Dr. A. Mendoza - Sammet	5	140	50						50	
Elective	201819T10	M3430	Aquatic Ecosystems Processes and Applicatio	gge	G.M. Gettel, PhD, MSc	5	140		10					90	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Manage	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3445	Applied environmental management	azu	Dr. A.L. Zuijdgeest	5	140							100	
Compulsory	201819T14	M3424	Thesis Research Proposal Development for ES	ams	Dr. A. Mendoza - Sammet	9	233							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Limnology and Wetland Management

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T09	M3273	Data Analysis and Modelling for Aquatic Ecosystems for LWM	avd	A.A. van Dam, PhD, MSc	5.6	140	40	20					40	
Compulsory	201819T10	M3431	Aquatic Ecosystems Processes and Applications for LWM	gge	G.M. Gettel, PhD, MSc	5.6	140		10					90	
Compulsory	201819T11	M3318	Wetlands for Livelihoods and Conservation for LWM	ehe	E.M.A. Hes, MSc	5.6	140		10					80	10
Compulsory	201819T13	M3446	Applied environmental management for LWM	azu	Dr. A.L. Zuijdgeest	5.6	140							100	
Elective	201819T14	M3424	Thesis Research Proposal Development for ES	ams	Dr. A. Mendoza - Sammet	9	233							100	
Elective	201819T15	M3319	MSc research, thesis and defence for LWM	edj	Drs. E.A. de Jong	30			100						
Compulsory		(LIWM714)	Ecology of Streams and Rivers												
Compulsory		(LIWM722)	Fisheries & Aquaculture												
Compulsory		(LIWM713)	Lake Ecology												
Compulsory		(LIWM721)	Wetlands for Water Quality												
Compulsory		(LWM1)	Basics in Limnology												
Compulsory		(LWM2)	Ecology of Aquatic Organisms												
Compulsory		(LWM3)	Basics in Applied Limnology												
Compulsory		(LWM4)	Aquatic Ecosystem Management												
Compulsory		(LWM5)	Scientific Methods												
Elective		(LIWM735)	MSc Proposal; Research Plan, logistics, site assessment, application & societal relevance												
Elective		(LIWM736)	MSc Thesis: Research and Thesis writing												

Environmental Technology and Engineering

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T05	M3373	Environmental Process Technology	pvs	N.P. van der Steen, PhD, MSc	5	142	65		35					
Compulsory	201819T06	M3394	Elective project II	cdu001	Dr. C.D.M. Dupont	2	56		30					70	
Compulsory	201819T06	M3395	Communication and writing skills for engineers II	era	E.R. Raj, PhD, MSc	3	84		50					50	
Elective	201819T07	M2373	Wastewater Treatment Plants Design and Engineering	clo	C.M. Lopez Vazquez, PhD, MSc	5	140	50			25			25	
Elective	201819T07	M3349	Water Quality Assessment and Monitoring	azu	Dr. A.L. Zuijdgeest	5	140			15				85	
Elective	201819T08	M3054	Modelling of Wastewater Treatment Processes and Plants	cmh	C.M. Hooijmans, PhD, MSc	5	132	100							
Elective	201819T08	M3413	Industrial Resource Management and Cleaner Production	era	E.R. Raj, PhD, MSc	5	140						60	40	
Elective	201819T09	M3352	International Fieldtrip and Fieldwork ES	azu	Dr. A.L. Zuijdgeest	5	140							100	
Elective	201819T09	M3342	International Fieldtrip and Fieldwork UWS	ysl	Y.M. Slokar, PhD	5	150							100	
Elective	201819T10	M3102	Industrial Effluents Treatment and Residuals Management	hga	H.A. Garcia Hernandez, PhD, MSc	5	151						6	4	
Elective	201819T10	M3396	Ecotechnologies	jvo	J.L.C.M. van de Vossenberg, PhD, MSc	5	140	70		30					
Compulsory	201819T15	M3231	MSc research, thesis and defence	edj	Drs. E.A. de Jong	30			100						
			Environmental Microbiology (UCT Prague)												
			Environmental Engineering (UCT Prague)												
			Wastewater Treatment (UCT Prague)												
			Waste Management and Treatment (UCT Prague)												
			Atmosphere Protection Technology (UCT Prague)												
			Environmental Engineering-Laboratory (UCT Prague)												
			Elective project I (UCT Prague)												
			ELECTIVE Basics of Czech (UCT Prague)												
			Master Dissertation at UCP Prague												
			Advances & Trends in Environmental Technology (UGent)												
			Basics of Process Engineering (UGent)												
			Basics of Control Engineering (UGent)												
			Bioresource Recovery Processes and Engineering (UGent)												
			Urban and Indoor Air Pollution (UGent)												
			Advanced Waste Gas Treatment (UGent)												
			Pedology (UGent)												
			Soil Remediation (UGent)												
			Elective module(s) at UGent												
			Master Dissertation at UGent												

3. Water Science and Engineering programme

Coastal Engineering and Port Development

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3332	Hydrology and Hydraulics	sma	Dr. S. Maskey	5	146	80						20	
Compulsory	201819T01	M3378	Introduction to Water Science and Engineering	lha	Dr. L.G. Hayde, MSc	4	96						55	45	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T03	M3348	Introduction to Coastal Science and Engineering	als	Dr. A.A. Milho Semedo	5	132	100							
Compulsory	201819T04	M3165	Port Planning and Infrastructure Design	ada	A. Dastgheib, PhD, MSc	5	150							100	
Compulsory	201819T05	M3330	Coastal Systems	rra	Prof. dr. R.W.M.R.J.B. Ranasing	5	140						100		
Compulsory	201819T06	M3369	Design of Breakwaters and Dikes	ada	A. Dastgheib, PhD, MSc	5	142							100	
Compulsory	201819T07	M3162	Process-based Coastal Modeling	jre	J.A.H. Reyns, MSc	5	152							100	
Elective	201819T08	M3009	Dams and Hydropower	mma	Dr. techn. M. Marence, MSc	5	161	45					45	10	
Elective	201819T08	M1309	Integrated Hydrological and River Modelling	sma	Dr. S. Maskey	5	138		15					85	
Elective	201819T08	M2709	River Flood Analysis and Modelling	ipo	Dr. I.I. Popescu	5	134	50						50	
Elective	201819T08	M3275	Planning and Delivery of Flood Resilience	bge	B. Gersonius, PhD, MSc	5	132		50			20		30	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigati	zov	Dr. Z. Vojinovic	5	140	40						60	
Elective	201819T08	M3449	Management of Irrigation and Drainage Systems	adu	Ir. A.E.C. Duker	5	140						50	50	
Elective	201819T08	M3439	Climate change impacts and adaptation in deltas	als	Dr. A.A. Milho Semedo	5	140							100	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Elective	201819T10	M3036	Drought Management and Reservoir Operations	mwe	M.G.F. Werner, PhD, MSc	5	138	60						40	
Elective	201819T10	M2214	Geotechnical Engineering and Dredging	mw	M. van der Wegen, PhD, MSc	5	140				60			40	
Elective	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Elective	201819T10	M3448	Innovative Water Systems for Agriculture	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T10	M3405	Urban Water Systems	zov	Dr. Z. Vojinovic	5	142	40						60	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3367	Groupwork WSE	wve	W. Veerbeek, PhD	5	140		100						
Compulsory	201819T14	M3284	Thesis Research Proposal Development for WSE	gco	G.A. Corzo Perez, PhD, MSc	9	196							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

River Basin Development

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3378	Introduction to Water Science and Engineering	lha	Dr. L.G. Hayde, MSc	4	96						55	45	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3332	Hydrology and Hydraulics	sma	Dr. S. Maskey	5	146	80						20	
Compulsory	201819T03	M3389	River Basin Development and Environmental Impact	ima	Dr. I. Masih	5	142	50						50	
Compulsory	201819T04	M3090	Data Collection and Analysis and Design	mwe	M.G.F. Werner, PhD, MSc	5	138	70						30	
Compulsory	201819T05	M3412	Hydraulics and Remote Sensing for River Basin Deve	ppa	P. Paron, PhD, MSc	5	138	20						80	
Compulsory	201819T06	M2730	River Morphodynamics	acr	A. Crosato, PhD, MSc	5	140						80	20	
Compulsory	201819T07	M3440	Hydraulic Structures	alc	Ir. A. Cattapan	5	140				40			60	
Elective	201819T08	M3009	Dams and Hydropower	mma	Dr. techn. M. Marence, MSc	5	161	45					45	10	
Elective	201819T08	M1309	Integrated Hydrological and River Modelling	sma	Dr. S. Maskey	5	138		15					85	
Elective	201819T08	M2709	River Flood Analysis and Modelling	ipo	Dr. I.I. Popescu	5	134	50						50	
Elective	201819T08	M3275	Planning and Delivery of Flood Resilience	bge	B. Gersonius, PhD, MSc	5	132		50			20		30	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigati	zov	Dr. Z. Vojinovic	5	140	40						60	
Elective	201819T08	M3449	Management of Irrigation and Drainage Systems	adu	Ir. A.E.C. Duker	5	140						50	50	
Elective	201819T08	M3439	Climate change impacts and adaptation in deltas	als	Dr. A.A. Milho Semedo	5	140							100	
Elective	201819T08	M3166	International Port Seminar	ada	A. Dastgheib, PhD, MSc	5	140		100						
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Elective	201819T10	M3036	Drought Management and Reservoir Operations	mwe	M.G.F. Werner, PhD, MSc	5	138	60						40	
Elective	201819T10	M2214	Geotechnical Engineering and Dredging	mww	M. van der Wegen, PhD, MSc	5	140				60			40	
Elective	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Elective	201819T10	M3448	Innovative Water Systems for Agriculture	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140						0	100	
Compulsory	201819T13	M3367	Groupwork WSE	wve	W. Veerbeek, PhD	5	140		100						
Compulsory	201819T14	M3284	Thesis Research Proposal Development for WSE	gco	G.A. Corzo Perez, PhD, MSc	9	196							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Land and Water Development for Food Security

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3378	Introduction to Water Science and Engineering	lha	Dr. L.G. Hayde, MSc	4	96						55	45	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3332	Hydrology and Hydraulics	sma	Dr. S. Maskey	5	146	80						20	
Compulsory	201819T03	M3381	Principles and Practices of Land and Water Development	lha	Dr. L.G. Hayde, MSc	5	140						44	56	
Compulsory	201819T04	M3252	Design Aspects of Irrigation and Drainage	lha	Dr. L.G. Hayde, MSc	5	140	31						69	
Compulsory	201819T05	M3447	Irrigation and drainage design	sur	F.X. Suryadi, PhD, MSc	5	141				55			45	
Compulsory	201819T07	M3309	Conveyance and Irrigation Structures	sur	F.X. Suryadi, PhD, MSc	5	140						35	65	
Elective	201819T08	M3009	Dams and Hydropower	mma	Dr. techn. M. Marence, MSc	5	161	45					45	10	
Elective	201819T08	M1309	Integrated Hydrological and River Modelling	sma	Dr. S. Maskey	5	138		15					85	
Elective	201819T08	M2709	River Flood Analysis and Modelling	ipo	Dr. I.I. Popescu	5	134	50						50	
Elective	201819T08	M3275	Planning and Delivery of Flood Resilience	bge	B. Gersonius, PhD, MSc	5	132		50			20		30	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigation	zov	Dr. Z. Vojinovic	5	140	40						60	
Compulsory	201819T08	M3449	Management of Irrigation and Drainage Systems	adu	Ir. A.E.C. Duker	5	140						50	50	
Elective	201819T08	M3450	Food Security, Health and Environment	adu	Ir. A.E.C. Duker	5	142						100	0	
Elective	201819T08	M3439	Climate change impacts and adaptation in deltas	als	Dr. A.A. Milho Semedo	5	140							100	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	0							100	
Elective	201819T10	M3036	Drought Management and Reservoir Operations	mwe	M.G.F. Werner, PhD, MSc	5	138	60						40	
Elective	201819T10	M2214	Geotechnical Engineering and Dredging	mw	M. van der Wegen, PhD, MSc	5	140				60			40	
Elective	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Elective	201819T10	M3448	Innovative Water Systems for Agriculture	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3367	Groupwork WSE	wve	W. Veerbeek, PhD	5	140		100						
Compulsory	201819T14	M3284	Thesis Research Proposal Development for WSE	gco	G.A. Corzo Perez, PhD, MSc	9	196							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Hydrology and Water Resources

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3378	Introduction to Water Science and Engineering	lha	Dr. L.G. Hayde, MSc	4	96						55	45	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3332	Hydrology and Hydraulics	sma	Dr. S. Maskey	5	146	80						20	
Compulsory	201819T03	M2166	Hydrogeology	zyx	Y. Zhou, PhD, MSc	5	140	70						30	
Compulsory	201819T04	M2367	Surface Hydrology	ven	Dr. R.G.W. Venneker	5	94	70						30	
Compulsory	201819T05	M3425	Water Quality	mmc	Prof. M.E. McClain, PhD, MSc	5	104			30				70	
Compulsory	201819T06	M1903	Tracer Hydrology and Flow Systems Analysis	jwe	Dr. J.W. Wenninger	5	142	100							
Elective	201819T07	M1554	Hydrological Data Collection and Processing	ven	Dr. R.G.W. Venneker	5	136	60		40					
Elective	201819T07	M3160	Groundwater Data Collection and Interpretation	tst	T.Y. Stigter, PhD, MSc	5	140							100	
Elective	201819T08	M3009	Dams and Hydropower	mma	Dr. techn. M. Marence, MSc	5	161	45					45	10	
Elective	201819T08	M1309	Integrated Hydrological and River Modelling	sma	Dr. S. Maskey	5	138		15					85	
Elective	201819T08	M2709	River Flood Analysis and Modelling	ipo	Dr. I.I. Popescu	5	134	50						50	
Elective	201819T08	M3096	Groundwater in Adaptation to Global Change Impacts	tst	T.Y. Stigter, PhD, MSc	5	140							100	
Elective	201819T08	M3275	Planning and Delivery of Flood Resilience	bge	B. Gersonius, PhD, MSc	5	132		50			20		30	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigati	zov	Dr. Z. Vojinovic	5	140	40						60	
Elective	201819T08	M3449	Management of Irrigation and Drainage Systems	adu	Ir. A.E.C. Duker	5	140						50	50	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Elective	201819T10	M3036	Drought Management and Reservoir Operations	mwe	M.G.F. Werner, PhD, MSc	5	138	60						40	
Elective	201819T10	M2214	Geotechnical Engineering and Dredging	mvw	M. van der Wegen, PhD, MSc	5	140				60			40	
Elective	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Elective	201819T10	M3448	Innovative Water Systems for Agriculture	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3367	Groupwork WSE	wve	W. Veerbeek, PhD	5	140		100						
Compulsory	201819T14	M3284	Thesis Research Proposal Development for WSE	gco	G.A. Corzo Perez, PhD, MSc	9	196							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Hydroinformatics: Modelling and Information Systems for Water Management

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3378	Introduction to Water Science and Engineering	lha	Dr. L.G. Hayde, MSc	4	96						55	45	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3332	Hydrology and Hydraulics	sma	Dr. S. Maskey	5	146	80						20	
Compulsory	201819T03	M3337	Information Technology and Software Engineering	jal	Dr. J.L. Alfonso Segura	5	140							100	
Compulsory	201819T04	M3244	Modelling Theory and Computational Hydraulics	ipo	Dr. I.I. Popescu	5	138	55			25			20	
Compulsory	201819T05	M2128	Modelling and Information Systems Development	sva	Dr. S.J. van Andel	5	136							100	
Compulsory	201819T06	M3429	Computational Intelligence and Operational Water Ma	sol	Prof. dr. D. Solomatine	5	144	55						45	
Compulsory	201819T07	M3232	River Basin Modelling	jon	Dr. A. Jonoski	5	138	100							
Elective	201819T08	M3009	Dams and Hydropower	mma	Dr. techn. M. Marence, MSc	5	161	45					45	10	
Elective	201819T08	M1309	Integrated Hydrological and River Modelling	sma	Dr. S. Maskey	5	138		15					85	
Elective	201819T08	M2709	River Flood Analysis and Modelling	ipo	Dr. I.I. Popescu	5	134	50						50	
Elective	201819T08	M3275	Planning and Delivery of Flood Resilience	bge	B. Gersonius, PhD, MSc	5	132		50			20		30	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigatio	zov	Dr. Z. Vojinovic	5	140	40						60	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Elective	201819T10	M3036	Drought Management and Reservoir Operations	mwe	M.G.F. Werner, PhD, MSc	5	138	60						40	
Elective	201819T10	M2214	Geotechnical Engineering and Dredging	mw	M. van der Wegen, PhD, MSc	5	140				60			40	
Elective	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Elective	201819T10	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T10	M3448	Innovative Water Systems for Agriculture	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T10	M3449	Management of Irrigation and Drainage Systems	adu	Ir. A.E.C. Duker	5	140						50	50	
Elective	201819T10	M3439	Climate change impacts and adaptation in deltas	als	Dr. A.A. Milho Semedo	5	140							100	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T12	M3367	Groupwork WSE	wve	W. Veerbeek, PhD	5	140		100						
Compulsory	201819T14	M3284	Thesis Research Proposal Development for WSE	gco	G.A. Corzo Perez, PhD, MSc	9	196							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100						

Flood Risk Management

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T06	M3429	Computational Intelligence and Operational Water Management	sol	Prof. dr. D. Solomatine	5	144	55						45	
Compulsory	201819T07	M3232	River Basin Modelling	jon	Dr. A. Jonoski	5	138	100							
Elective	201819T08	M2709	River Flood Analysis and Modelling	ipo	Dr. I.I. Popescu	5	134	50						50	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigation	zov	Dr. Z. Vojinovic	5	140	40						60	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Compulsory	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Compulsory	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T14	M3231	MSc research, thesis and defence	edj	Drs. E.A. de Jong	30	840		100						
			Climatology and hydrology												
			Coastal flooding: impacts, conflicts and risks												
			Debris Flow and Flash Flood. Risk, Vulnerability, Hazard and Resilience concepts												
			Ecology												
			Flood Risk Management												
			Geodesy												
			Global warming effects, Flood and Drought Management												
			Hydraulic Engineering												
			Hydrochemistry												
			Hydromechanics												
			Socioeconomical assessment of flood protection												
			Spatial planning for flood protection												
			The Application of Radar-based Rainfall Observations and Forecast in Early Warning Systems and Flood Forecasting												

Groundwater and Global Change - Impacts and Adaptation

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819T06	M1903	Tracer Hydrology and Flow Systems Analysis	jwe	Dr. J.W. Wenninger	5	142	100							
Compulsory	201819T07	M3160	Groundwater Data Collection and Interpretation	tst	T.Y. Stigter, PhD, MSc	5	140	0						100	
Compulsory	201819T08	M3096	Groundwater in Adaptation to Global Change Impacts	tst	T.Y. Stigter, PhD, MSc	5	140							100	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Compulsory	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T14	M3231	MSc research, thesis and defence	edj	Drs. E.A. de Jong	30	840		100						
			Atmosphere Physics and Chemistry (FQA)												
			Climate Systems and Climate Modelling												
			Ecology												
			Environmental Policies and Law (DPA)												
			Groundwater Pollution and Protection (PPAS)												
			Hydrogeology (Hidr)												
			Hydrology, Environment and Water Resources (HARH)												
			Integrated land use management in the landscape												
			Integrated River Basin Management (GIBH)												
			Soil Water												
			Study Project IWRM (on Groundwater and Adaptation)												
			Treatment Plant Design												
			Water Quality and Water Treatment												
			Watershed Management II												

Sustainable Urban Water Management

type	defpln	code	name	resp	resp name	credits	studyload	written examination closed book	presentation	lab report	oral examination	homework	written examination open book	assignment	attendance
Compulsory	201819	M3327	Online course on Urban System Analysis, Planning and Mana	era	E.R. Raj, PhD, MSc	5	140		40					60	
Compulsory	201819T01	M3378	Introduction to Water Science and Engineering	lha	Dr. L.G. Hayde, MSc	4	96						55	45	
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T02	M3332	Hydrology and Hydraulics	sma	Dr. S. Maskey	5	146	80						20	
Compulsory	201819T03	M3326	Urban System Analysis, Planning and Management: An Introd	radha4	M. Radhakrishnan, PhD, MSc	5	140	50	25					25	
Compulsory	201819T04	M3343	Urban Drainage and Sewerage	asa	A. Sanchez Torres, PhD, MSc	5	142	60						40	
Compulsory	201819T05	M3350	Asset Management	apa	P.D.A. Pathirana, PhD, MSc	5	129				50			50	
Elective	201819T06	M2384	Resource Oriented Wastewater Treatment and Sanitation	rubio2	F.J. Rubio Rincón, PhD, MSc	5	142	80						20	
Elective	201819T06	M3429	Computational Intelligence and Operational Water Managemen	sol	Prof. dr. D. Solomatine	5	144	55						45	
Elective	201819T06	M3399	Environmental Systems Analysis	kir	Prof. K.A. Irvine, PhD, BSc	5	140	40	10					50	
Elective	201819T07	M3349	Water Quality Assessment and Monitoring	azu	Dr. A.L. Zuijdgeest	5	140			15				85	
Elective	201819T07	M3437	Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	20					40	40	
Elective	201819T07	M3401	Water Systems Modelling	mul5	M.L. Mul	5	140		40				60		
Elective	201819T08	M3275	Planning and Delivery of Flood Resilience	bge	B. Gersonius, PhD, MSc	5	132		50			20		30	
Elective	201819T08	M3241	Water Resources Planning	nca	Dr. N.J.M. van Cauwenbergh	5	143	60						40	
Elective	201819T08	M3413	Industrial Resource Management and Cleaner Production	era	E.R. Raj, PhD, MSc	5	140						60	40	
Elective	201819T08	M3404	Urban Flood Management and Disaster Risk Mitigation	zov	Dr. Z. Vojinovic	5	140	40						60	
Elective	201819T08	M3187	Environmental Monitoring and Modelling	azu	Dr. A.L. Zuijdgeest	5	140	55						45	
Compulsory	201819T09	M3167	Fieldtrip and Fieldwork WSE	adu	Ir. A.E.C. Duker	5	140							100	
Compulsory	201819T10	M3405	Urban Water Systems	zov	Dr. Z. Vojinovic	5	142	40						60	
Compulsory	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Compulsory	201819T15	M3231	MSc research, thesis and defence	edj	Drs. E.A. de Jong	30	840		100						

4. Water Management programme

Water management and Governance

type	defpln	code	name	resp	resp_name	credits	studyload	written examination closed book	presentation	lab_report	oral_examination	homework	written examination open book	assignment	attendance
Compulsory	201819T01	M3344	Introduction to Water for Development	jke	Dr. J.S. Kemerink - Seyoum	1	44							100	
Compulsory	201819T01	M3423	Introduction to Water Management and Governance	jev	J.G. Evers, PhD, MSc	4	110	50						50	
Compulsory	201819T02	M3335	The Water Resources System	jsu	J. Susnik, PhD	5	143	70						30	
Compulsory	201819T03	M3228	Water Governance	jke	Dr. J.S. Kemerink - Seyoum	5	142				40			60	
Compulsory	201819T04	M3451	Water Economics	yji	Dr. Y. Jiang, MSc	5	147	70						30	
Compulsory	201819T05	M3385	Water and Environmental Law	jas	F.G.W. Jaspers, MA, BSc	5	152	70						30	
Elective	201819T06	M3349	Water Quality Assessment and Monitoring	azu	Dr. A.L. Zuijdgeest	5	140			15				85	
Elective	201819T06	M3384	Water Resources Assessment	yam	Dr. Y.A. Mohamed	5	139	65						35	
Elective	201819T06	M3408	Water Conflict Management I	zsh	Z.S. Shubber, LLM	5	140	50						50	
Elective	201819T06	M3432	Managing Water Organisations	mtu	M. Tutusaus Luque, MSc	5	148						60	40	
Elective	201819T07	M3379	Environmental Management and Water Services	cabre7	A. Cabrera Flamini	5	140		10					90	
Elective	201819T07	M3212	Water and Environmental Policy Analysis	ams	Dr. A. Mendoza - Sammet	5	140	50						50	
Elective	201819T07	M3409	Water Conflict Management II	zsh	Z.S. Shubber, LLM	5	138	60						40	
Elective	201819T07	M3401	Water Systems Modelling	mul5	M.L. Mul	5	140		40				60		
Elective	201819T08	M3388	Finance in the Water Sector	pto002	P.C. Torio, PhD, MSc	5	140						50	50	
Elective	201819T08	M3241	Water Resources Planning	nca	Dr. N.J.M. van Cauwenbergh	5	143	60						40	
Elective	201819T08	M3421	Environmental Planning and Implementation	jev	J.G. Evers, PhD, MSc	5	138	40						60	
Compulsory	201819T09	M3380	International Fieldwork	anc	A. Cabrera Flamini, MSc	5	145		40					60	
Elective	201819T10	M3036	Drought Management and Reservoir Operations	mwe	M.G.F. Werner, PhD, MSc	5	138	60						40	
Elective	201819T10	M3353	Applied Groundwater Modelling	zyx	Y. Zhou, PhD, MSc	5	142							100	
Elective	201819T10	M3387	Partnerships for Water Supply and Sanitation	pto002	P.C. Torio, PhD, MSc	5	140				50			50	
Elective	201819T10	M3243	Flood Risk Management	bha	Dr. B. Bhattacharya	5	132	30						70	
Elective	201819T10	M3415	Environmental Assessment for Water-related Policies and Development	ams	Dr. A. Mendoza - Sammet	5	140	50						50	
Elective	201819T10	M3448	Innovative Water Systems for Agriculture	pka	P. Karimi, PhD, MSc	5	140							100	
Elective	201819T10	M3430	Aquatic Ecosystems Processes and Applications	gge	G.M. Gettel, PhD, MSc	5	140		10					90	
Elective	201819T10	M3427	Institutional Analysis	hsm	Ir. H. Smit	5	140		20					80	
Elective	201819T11	M3048	Water Sensitive Cities	apa	P.D.A. Pathirana, PhD, MSc	5	160		25		25			50	
Elective	201819T11	M2810	Decentralised Water Supply and Sanitation	roj	S.K. Sharma, PhD	5	140	60	10					30	
Elective	201819T11	M3217	Faecal Sludge Management	ssi002	Dr. S. Singh	5	140	100							
Elective	201819T11	M3214	Wetlands for Livelihoods and Conservation	ehe	E.M.A. Hes, MSc	5	140		10					80	10
Elective	201819T11	M3417	Solid Waste Management	cdu001	Dr. C.D.M. Dupont	5	140	50	15					35	
Elective	201819T11	M3420	Hydroinformatics for Decision Support	jon	Dr. A. Jonoski	5	134							100	
Elective	201819T11	M3433	Urban Water Governance	tag	T. Acevedo Guerrero, PhD	5	140		30					60	10
Elective	201819T11	M3438	Advanced Water Transport and Distribution	tri	N. Trifunovic, PhD, MSc	5	140	60						40	
Elective	201819T11	M3428	Modelling River Systems and Lakes	alc	Ir. A. Cattapan	5	142	40						60	
Elective	201819T11	M3422	Strategic Planning for River Basins and Deltas	jev	J.G. Evers, PhD, MSc	5	140							100	
Elective	201819T11	M3400	Remote Sensing for Agricultural Water Management	pka	P. Karimi, PhD, MSc	5	140							100	
Compulsory	201819T13	M3393	Research Skills and Dissemination	jsu	J. Susnik, PhD	5	144		50					50	
Compulsory	201819T14	M3410	Thesis Research Proposal Development for WMG	efa	E. Fantini, PhD, MA	9	264							100	
Compulsory	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36			100						

Water Cooperation and Diplomacy

type	defpln	code	name	resp	resp_name	credits	studyload	written_examination _closed_book	presentation	lab_report	oral examination	homework	written examination open book	assignment
Compulsory	201819T03	M3228	Water Governance	jke	Dr. J.S. Kemerink - Seyoum	5	142				40			60
Compulsory	201819T04	M3451	Water Economics	yji	Dr. Y. Jiang, MSc	5	147	50						50
Compulsory	201819T05	M3385	Water and Environmental Law	jas	F.G.W. Jaspers, MA, BSc	5	152	70						30
Compulsory	201819T06	M3408	Water Conflict Management I	zsh	Z.S. Shubber, LLM	5	140	50						50
Compulsory	201819T07	M3409	Water Conflict Management II	zsh	Z.S. Shubber, LLM	5	138	60						40
Elective	201819T08	M3241	Water Resources Planning	nca	Dr. N.J.M. van Cauwenbergh	5	143	60						40
Elective	201819T08	M3421	Environmental Planning and Implementation	jev	J.G. Evers, PhD, MSc	5	138	40						60
Compulsory	201819T09	M3254	Research Methodology and Proposal Drafting	jse002	Dr. M.J. Sehring	3	78							100
Elective	201819T15	M2927	MSc research, thesis and defence	edj	Drs. E.A. de Jong	36	1008		100					

Appendix E MSc thesis marking guidelines (latest update: August 2018)

Criterion 1	9.0 - 10.0 Excellent	8.0 - 8.9 Very Good	7.0 - 7.9 Good	6.0 - 6.9 Sufficient	5.9 and below Fail
Knowledge and understanding of the subject and answers to questions	An excellent and informative introduction, well-researched, with appropriate and key references. Evidence of critical thinking. Clear aims and objectives, within an overall context, which identifies knowledge gaps. Sets the scene for the research succinctly and elegantly. Gives answers that are internally consistent, with plausible explanations for observations. Clearly explains the logic steps in reasoning. Shows ability to distinguish major and minor points. Not only answers the question, but is able to discuss various aspects of possible answers.	Good project background, with reference to key literature. A logical framework that identifies the research objectives, but may lack some thoroughness, or comprise a limited series of research questions. It might be competent but a little mundane. Gives answers that are internally consistent, with plausible explanations for observations. Clearly explains the logic steps in reasoning. Shows ability to distinguish major and minor points.	Covers the main areas, but has minor flaws in logic or omissions of important detail, or minor flaws in structure. Aims and objectives comprehensible, but maybe slightly over or under ambitious, and/or lacking in clarity or precision. Objectives may be unrealistic. Gives answers that are internally consistent, with plausible explanations for observations. Clearly explains the logic steps in reasoning	Generally lacks some coherence; may be poorly referenced, but includes at least the major points relevant to the research. Aims and objectives no more than adequate. Gives answers that are internally consistent but do not give plausible explanations for observations. Reasoning shows logic.	Poorly structured, with significant omissions of key background literature. No logical progression. Fails to set the context of the project. Research question not developed into appropriate or testable hypotheses. Gives answers that are not internally consistent and gives wrong or doubtful explanations for observations made. Reasoning based on illogical assumptions, feelings, beliefs.

Criterion 2		9.0 - 10.0 Excellent	8.0 - 8.9 Very Good	7.0 - 7.9 Good	6.0 - 6.9 Sufficient	5.9 and below Fail
Originality, analysis and interpretation	Methods	Well-chosen and entirely appropriate and often novel methods identified clearly. Clear and easy to follow procedures and techniques. Where appropriate, good site description, with informative figures, maps, diagrams etc.	Appropriate actions and methods identified and detailed. Where appropriate, setting of research well described with relevant figures, maps, diagrams etc.	Methodology generally sound but with some lapses in detail of methods, and/or proposed analysis. Figures, maps or diagrams may be poorly produced, or not clear in the context of the research	Significant gaps in methods, or methods not always appropriate to the research questions, or very difficult to comprehend. Lapses in detail in parts of methodology. Figures, maps and diagrams may be absent or poorly produced.	Methodology vague and poorly detailed. No obvious understanding of methodology relevant to research theme. Figures, maps and diagrams may be poorly produced or absent.
	Results	These are well analysed and presented with clarity, with clear and comprehensive relationship to the the research questions.	Results reported well and with clarity. Some minor lapses in summary of findings. Shows ability to address methodological short-comings.	Results comprehensible, generally linking with the research questions. Figures and tables convey adequate meaning, providing a summary of at least some of the key findings.	Some flaws in analysis, but the general essence of the key findings conveyed.	Obvious flaws in analysis. Difficult to follow the results and, analysis. Presentation careless and poor summary of the key findings
	Discussion	Elegant and well structured, placing the results in the context of the international literature and demonstrating a clear understanding of their significance, and/or shortcomings. Show some new ideas and novel interpretation.	Identifies the key finding and relevance of these to some key literature. A well-ordered sequence to the chapter to produce a logical framework.	Recognises some interesting findings, but may be limited in placing these into a wider context. At least some use of key literature. There will likely to be some repetition with the results section.	Some repetition of the results section, with minimal context to wider understanding and relevant literature.	Largely a repetition of results. Fails to identify key findings and/or their wider significance. Little logical framework and lacking any individual ideas or interpretation.

Criterion 3	9.0 - 10.0 Excellent	8.0 - 8.9 Very Good	7.0 - 7.9 Good	6.0 - 6.9 Sufficient	5.9 and below Fail
Organisation, style, presentation	Writing elegant and succinct. Uses precise language and correct terminology throughout. Figs and Tables well laid out to	A clear and well-written report that is technically proficient.	A generally well-written report that is understandable. Uses appropriate terminology. Occasional spelling or	Language generally clear and uses correct terminology, but with some misunderstandings and lapses in grammar or	Sentences and/or paragraphs poorly constructed. Language inexact or ambiguous. Contains numerous

and communication	a publishable quality with accurate and succinct legends.		grammatical errors. Presentation generally neat	spelling. Presentation and use of tables and figures may be sloppy.	grammatical and spelling mistakes.

Criterion 4	**9.0 - 10.0 Excellent**	**8.0 - 8.9 Very Good**	**7.0 - 7.9 Good**	**6.0 - 6.9 Sufficient**	**5.9 and below Fail**
Creativity, independence, work planning and critical attitude	Student self-motivated and independent. Engages in intelligent discussion and responds well to suggestions.	Significant help may be given, but students show ability to learn from suggestions and develop ideas and research approaches accordingly.	Needs clear guidance and support, but gradually develops the required competencies.	A need to repeat instructions a number of times. Generally finds taking initiative difficult, and limited self-reliance.	Lacks motivation, or much ability to develop competencies. Shows little self-reliance or interest in the topic.

Appendix F Appeal procedure

(annex to the Examination Regulations)
28 April 2016

A student has the right to lodge an appeal against:

- decisions by examiners, the MSc Examination Committee, or the Examination Board;
- termination of registrations by the Academic Registrar.

NB: An appeal against the decision of an Examiner or an MSc Examination Committee is lodged with the Examination Board. The Examination Board's decision is final and binding, and can therefore not be appealed against with the Academic Appeals Board.

Before starting an appeal procedure, the student has the obligation to attempt to solve the case amicably with the body or person who took the disputed decision.

Appeal against the decision of an Examiner or an MSc Examination Committee:

1. The appeal shall be submitted in hard copy to the Examination Board (via its secretary) within 3 weeks following the date on which the decision was made known.
2. The appeal must be signed by the student (= appellant) and contain at least the following:
    a. name and address, degree programme and student number of the appellant;
    b. details of the Examiner or MSc Examination Committee concerned;
    c. a clear description of the decision against which the appeal has been lodged, on submission of a copy of the decision, if possible, or, if the appeal has been lodged against a refusal to decide, a clear description of the decision which should have been taken in the appellant's opinion;
    d. the grounds of the appeal;
    e. an account of the initiatives taken by the appellant to come to an amicable agreement with the decision maker.

3. The chair of the Board will inform the appellant of any omissions on the appellant's part and will invite him to rectify these within a period of time to be set by the chair. In the event that the appellant fails to rectify the omissions on his/her part, the appeal may be declared inadmissible.
4. The Examination Board may decide to hear the concerned parties.
5. The Examination Board will take a decision within three (3) weeks of receipt of the letter of appeal and inform the parties concerned accordingly in writing, stating whether the initial decision is to be upheld or a new decision taken.
6. The decision of the Examination Board is final and binding.

Appeal against the decision of the Examination Board or the Academic Registrar:

1. The appeal shall be submitted in hard copy to the Academic Appeals Board (via its secretary) within 3 weeks following the date on which the decision was made known.
2. The appeal must be signed by the student (= appellant) and contain at least the following:
    a. name and address, degree programme and student number of the appellant;
    b. details of the body or person who has taken the contested decision;
    c. a clear description of the decision against which the appeal has been lodged, on submission of a copy of the decision, if possible, or, if the appeal has been lodged against a refusal to decide, a clear description of the decision which should have been taken in the appellant's opinion;
    d. the grounds of the appeal;
    e. an account of the initiatives taken by the appellant to come to an amicable agreement with the decision maker.
3. The chair of the Board will inform the appellant of any omissions on the appellant's part and will invite him to rectify these within a period of time to be set by the chair. In the event that the appellant fails to rectify the omissions on his part, the appeal may be declared inadmissible.
4. The Academic Appeals Board may decide to hear the concerned parties.
5. The Academic Appeals Board will take a decision within four (4) weeks of receipt of the letter of appeal and inform the parties concerned accordingly in writing, stating whether the initial decision is to be upheld or a new decision taken.
6. The decision of the Academic Appeals Board is final and binding.

Appendix G Procedures when using eCampusXL for assessments

GENERAL RULES

Students taking part in an examination are expected to have taken notice of these procedures and are expected to understand the implied meaning of these procedures.

Electronic examinations take place in lecture rooms A4, A5 and B6

In the examination room

1. The student brings his/her own laptop to the examination room.
2. When the examination takes place in rooms A4 and A5, students for safety reasons have to connect their laptops with the available network cables in that room instead of using the less stable Wi-Fi.
3. The student brings his/her student card and displays it on the table.
4. A check of attendance is required to proof that the student has taken part in the examination. The invigilator (examination supervisors) verifies the student card and confirms attendance by the student by ticking the box of the student on the attendance list.
5. The invigilators ensure a proper conduct of the examination and maintain order in the examination room. They will announce the beginning and the duration of the examination, and will warn the students 10 minutes before the ending of the examination.
6. The invigilators will instruct the students to log in to the safe browser environment for the examination.
7. At the start of the examination the invigilator announces the password to the students to get access to the examination.
8. The programme will automatically save all answers during an examination every 5 minutes. However during the examination students are strongly advised to save his/her current answers as well various times before the final submission to prevent loss of work in case the server goes down. Students remain responsible for the final submission of their work.
9. For a situation where the time of an examination expires without the final submission, for example when the server is not available on that specific moment, a grace period has been set where attempts can be submitted even after the deadline, but questions cannot be answered/changed.
10. When the laptop of the student stops working correctly, the student can restart the computer and will arrive at the same place in the examination. (this will also work when restart/login is made on a different machine).
11. At the end of the examination the invigilators return the attendance list to the Planning Office.

Other issues:

Bags: Bags and carrying cases, including penholders, are to be placed along the side of the room before the start of the examination.

Dictionary: The use of a printed language dictionary without any additional written annotations is allowed (all languages are allowed). Invigilators are allowed to check the dictionaries for hand-written annotations during the exam (spot checks while they are walking around).
Electronic dictionaries are not allowed.

Calculators:. Use of calculators is not allowed and must be switched off. A scientific calculator inside the save browser environment is available.

Cell phones: Use of cell phones is not allowed and must be switched off

Communication: During the examination, students are not allowed to exchange materials or to communicate with other students. If something is unclear, students have to inform the invigilator, who will contact the programme coordinator, the examiner or planning officer if necessary.

Other materials: The use of materials other than listed above, including blank paper, texts, of any kind, is not allowed.
Examiners may nevertheless allow students to use specified text matter or other effects in a so-called ‘open book’ examination. These materials shall not include previous or example examinations and solutions.

Toilet visit: Only one student at a time will be allowed by the invigilator to leave the examination room for a short visit to the lavatory, except during the first 15 and the last 15 minutes of the examination. Examination materials and requirements may not be taken outside the examination room. Before leaving the examination room, students have to hand over their cell phone to the invigilator.

IHE DELFT - Academic Calendar 2018/2020

YEAR 1	2018											2019																				fieldtrip			2019								Groupw ork			2019	
	October		November				December					January				February				March					April				May				June					July				August				Sept	
Terms		Term 1			Term 2			..	Term 3					Term 4			..	Term 5			Term 6			..	Term 7			Term 8			..	Term 9			Term 10			Term 11			..	T12	Term 13			..	
Week	42	43	44	45	46	47	48	49	50	51	52	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Mon	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04	11	18	25	04	11	18	25	01	08	15	22	29	06	13	20	27	03	10	17	24	01	08	15	22	29	05	12	19	26	02
Tue	16	23	30	06	13	20	27	04	11	18	25	01	08	15	22	29	05	12	19	26	05	12	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	03
Wed	17	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24	01	08	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04
Thu	18	25	01	08	15	22	29	06	13	20	27	03	10	17	24	31	07	14	21	28	07	14	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	04	11	18	25	01	08	15	22	29	05
Fri	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	01	08	15	22	01	08	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06
Sat	20	27	03	10	17	24	01	08	15	22	29	05	12	19	26	02	09	16	23	02	09	16	23	30	06	13	20	27	04	11	18	25	01	08	15	22	29	06	13	20	27	03	10	17	24	31	07
Sun	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	03	10	17	24	03	10	17	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	01	08
Credits		1E	4ECTS		5 ECTS				2x5 ECTS									2x5 ECTS							2x5 ECTS							5 ECTS			2x5 ECTS							1E	5 ECTS				
Modules		M1	M2a		Module 2b				Module 3					Module 4				Module 5			Module 6				Module 7			Module 8				Module 9			Module 10			Module 11				M12	Module 13				

YEAR 2	2019																2020																
	September			October			November					December					January				February				March					April			
Terms	Term 14					T15	Term 1			Term 2			..	Term 3					Term 4			..	Term 5			Term 6			..	Term 7			T8
Week	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Mon	09	16	23	30	07	14	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	03	10	17	24	02	09	16	23	30	06	13	20
Tue	10	17	24	01	08	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04	11	18	25	03	10	17	24	31	07	14	21
Wed	11	18	25	02	09	16	23	30	06	13	20	27	04	11	18	25	01	08	15	22	29	05	12	19	26	04	11	18	25	01	08	15	22
Thu	12	19	26	03	10	17	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06	13	20	27	05	12	19	26	02	09	16	23
Fri	13	20	27	04	11	18	25	01	08	15	22	29	06	13	20	27	03	10	17	24	31	07	14	21	28	06	13	20	27	03	10	17	24
Sat	14	21	28	05	12	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	01	08	15	22	29	07	14	21	28	04	11	18	25
Sun	15	22	29	06	13	20	27	03	10	17	24	01	08	15	22	29	05	12	19	26	02	09	16	23	01	08	15	22	29	05	12	19	26
	9 ECTS						36 ECTS																										
	Module 14						Module 15																										

Legend

- = Opening academic year
- = Week one
- = Freetime
- = Holiday
- = MSc diploma aw arding
- = Lecture period
- = Msc thesis w riting
- = Examination w eek
- = Submit thesis
- = Summer course
- = MSc diploma aw arding *(prev year)*

Christmas:	Dec 25-26 2018
Good Friday:	April 19, 2019
Easter:	April 21-22, 2019
Kingsday:	April 27, 2019
Liberationday:	May 5, 2019
Ascencion:	May 30, 2019
Pentecost:	June 9-10, 2019
Christmas:	Dec 25-26, 2019
Good Friday:	April 10, 2020
Easter:	April 12-13, 2020
Kingsday:	April 27, 2020

Water Science and Engineering Programme Overview 2018-2020

		INFO WSE programme	SUWM Sustainable Urban Water Management C2227	HWR Hydrology and Water Resources C1501	HI HydroInformatics Modelling and Information Systems for Water Management C1490	HERBD Hydraulic engineering River Basin Development C1477	CEPD Hydraulic Engineering Coastal Engineering and Port Development C1427	LWDFS Land and Water Development for Food Security C1505	LWDFS Nebraska C1048	GroundwatCH C1441	FRM Flood Risk Management C1440	IMH International Master in Hydroinformatics C2249
	1	........-19/10 22/10-26/10	Introduction to water development M3344							IST Lisbon	TU Dresden	External
	2a	29/10-02/11 05/11-09/11	Introduction to water science and engineering (WSE/02a/c) M3378			Hydrology and hydraulics (WSE/02b/c) M3332						
	2b	12/11-16/11 19/11-23/11 26/11-30/12										
	..	03/12-07/12	Examination Week									
	3	10/12-14/12 17/12-21/12	Urban system analysis planning and management introduction M3326	Hydrogeology M2166	Information technology and software engineering M3337	River basin development and environmental impact assessment M3389	Introduction to coastal science and engineering M3348	Principles and practices of land and water development M3381				
	..	24/12-28/12 31/01-04/01	Free Period									
	3	07/01-11/01	3 continue..	3 continue..	3 continue	3 continue..	3 continue..	3 continue..				
	4	14/01-18/01 21/01-25/01 28/01-01/02	Urban drainage and sewerage M3343	Surface hydrology M2367	Modeling theory and computational hydraulics M3244	Data collection and analysis and design M3090	Port planning and infrastructure design M3165	Design aspects of irrigation and drainage M3252				
	..	04/02-08/02	Examination Week									
	5	11/02-15/02 18/02-22/02 25/02-01/03	Asset management M3350	Water quality M3425	Modeling and information systems development M3340	Hydraulics and Remote Sensing for River Basin Development (WSE/HERBD/06/s) M3412	Coastal systems M3330	Irrigation and drainage design M3447				Modeling and information systems development M3340
Students arrive: Erasmus Mundus Flood Risk Management and Groundwatch	6	04/03-08/03 11/03-15/03 18/03-22/03	M3429 Computational intelligence + operational water management M2384 - Resource oriented wastewater treatment and sanitation M3384 - Water resources assessment M3399 - Environmental systems analysis	Tracer hydrology and flow systems analysis (WSE/HWR/06/s) M1903	Computational intelligence and operational water management (WSE/HI/06/s) M3429	River Morphodynamics M2730	Design of breakwaters and dikes (WSE/CEPD/06/s) M3369	Management of Irrigation and Drainage Systems (WSE/LWDFS/06/s) M3449		Tracer hydrology and flow systems analysis (WSE/HWR/06/s) M1903	Computational intelligence and operational water management (WSE/HI/06/s) M3429	Computational intelligence and operational water management M3429
		25/03-29/03	Examination Week									
	7	01/04-05/04 08/04-12/04 15/04-19/04	M3401 - Water systems modelling M3437 - Water transport and distribution M3349 - Water quality assessment and monitoring	Hydrological data collection and processing M1554 Groundwater data collection and interpretation M3160 HWR: choose your module 7	River basin modelling M3232	Hydraulic structures (WSE/HERBD/07/s) M3440	Process-based coastal modeling (WSE/CEPD/07/s) M3162	Conveyance and irrigation structures (WSE/LWDFS/07/s) M3309		Groundwater data collection and interpretation (WSE/HWR/07B/s) M3160	River basin modelling (WSE/HI/07s) M3232	River basin modelling M3232
	8	22/04-26/04 29/04-03/05 06/05-10/05	M2187 - Environmental monitoring and modelling M3413 - Industrial resource management and cleaner production M3404 - Urban flood management and disaster risk mitigation M3241 - Water resources planning M3275 - Planning and delivery of flood resilience	Choice for HWR only: M3096 - Groundwater in adaptation to global change impacts (WSE/HWR/08B/e/GroundwatCH) All: M1309 - Integrated hydrological and river modelling (WSE/HWR/08/e) All: M2709 - River flood analysis and modelling (WSE/HI/08A/e) All: M3404 - Urban flood management and disaster risk mitigation (WSE/HI/08B/e) All: M3009 - Dams and hydropower (WSE/HERBD/08B/e/UniKL) All: M3275 - Planning and delivery of flood resilience (WSE/HERBD/08A/e) All: M3166 - International port seminar (WSE/CEPD/08A/e) All: M3439 - Climate change impacts and adaptation in deltas (WSE/CEPD/08B/e) All: M3450 - Food security, health and environment (WSE/LWDFS/08/e)					Food security, health and environment (WSE/LWDFS/08/e) M3450	Groundwater in adaptation to global change impacts (WSE/HWR/08B/e/Groundwatch) M3096	River flood analysis and modelling (WSE/HI/08A/e) M2709 Urban flood management and disaster risk mitigation (WSE/HI/08B/e) M3404	M1309 - Integrated hydrological and river modelling M2709 - River flood analysis and modelling M3404 - Urban flood management and disaster risk mitigation M3439 - Climate change impacts and adaptation in deltas M3450 - Food security, health and environment
			WSE: Click HERE TO CHOOSE YOUR MODULE 8						--	--	Choose 8	Choose 8
	..	13/05-17/05	Examination Week									
	9	20/05-24/05 27/05-31/05 03/06-07/06	Fieldtrip and fieldwork WSE (WSE/09/c) M3167						University of Nebraska, Lincoln, USA	Fieldtrip and fieldwork WSE (WSE/09/c) M3167	Fieldtrip and fieldwork WSE (WSE/09/c) M3167	Fieldtrip and fieldwork WSE (WSE/09/c) M3167
	10	10/06-14/06 17/06-21/06 24/06-28/06	Urban water systems (WSE/SUWM/10/e) M3405	All: M3353 - Applied groundwater modeling (WSE/HWR/10B/e) All: M3243 - Flood risk management (WSE/HI/10A/e) All: M3036 - Drought management and reservoir operations (WSE/HERBD/10/e) All: M2214 - Geotechnical engineering and dredging (WSE/CEPD/10/e) All: M3448 - Innovative water systems for agriculture (WSE/LWDFS/10/e)						Applied groundwater modelling (WSE/HWR/10B/e) M3353	Flood risk management (WSE/HI/10A/e) M3243	M3353 - Applied groundwater modeling M3243 - Flood risk management M3036 - Drought management and reservoir operations M2214 - Geotechnical engineering and dredging M3448 - Innovative water systems for agriculture
Click HERE TO CHOOSE YOUR MODULE 10 and 11 (2017-2019)										--	--	Choose 10 and 11
	11	01/07-05/07 08/07-12/07 15/07-19/07	Water sensitive cities (WSE/SUWM/11e) M3048	M3422 - Strategic planning for river basins and deltas M3433 - Urban water governance M3400 - Remote Sensing for Agricultural Water Management M3214 - Wetlands for Livelihoods and Conservation M3048 - Water Sensitive Cities M3217 - Faecal Sludge Management M2810 - Decentralised Water Supply and Sanitation M3428 - Modelling River Systems and Lakes M3417 - Solid Waste Management M3438 - Advanced Water Transport and Distribution M3420 - Hydroinformatics for Decision Support						M2810 - Decentralised water supply and sanitation M3433 - Urban water governance M3420 - Hydroinformatics for decision support (WSE/HI/11e) M3422 - Strategic planning for river basins and deltas M3048 - Water sensitive cities (WSE/11) M3400 - Remote sensing for agricultural water management (WSE/LWDFS/11/e)	Hydroinformatics for decision support M3420	M3433 - Urban water governance M3438 - Advanced Water Transport and Distribution M3420 - Hydroinformatics for Decision Support
	..	22/07-26/07	Examination Week							Examination Week		
Students leave: Erasmus Mundus FRM, GroundwatCH	12	29/07-02/08	Click here to choose your summer course							Free/Internship	Free	Choose your summer course
	13	05/08-09/08 12/08-16/08 19/08-23/08	…	Groupwork WSE (WSE/13/c) M3367								Groupwork WSE M3367
	..	26/08-30/08	Examination Week									Exam Week
	..	02/09-06/09	Free									Free
	14	09/09-13/09 16/09-20/09 23/09-27/09 30/09-04/10 07/10-11/10	…	Thesis Research Proposal Development for WSE (WSE/14/c) M3284						TU Dresden (Sept 17, 2019) MSc Research Strat: March 2020> Defence: September 20202 M3231	UPC (Sept 17, 2019)	Thesis Research Proposal Development for WSE M3284
	..	14/10-18/10	Examination Week								UL Dec'9-Feb'20 MSc research Start: March '20 Defence: Aug '20 M3231	Exam Week
	15	21/10/18 .... 27/03/20	(4 monthsin China) MSc research, thesis and defence (6 months) (WSE/15) M3231	MSc research, thesis and defence (6 months) (WSE/15) M2927								MSc research Start: March'20 Defence: Aug'20 M3231
		30/03-03/04 06/04-10/04	Final Examination Week - Diploma awarding 23/04/2020									Final Exam Week - Diploma awarding 23/04/2020

Water Science and Engineering

Certificate course

2018/2019

Design of Breakwaters

M3411

Short Course on Design of Breakwaters

Term	201718
Coordinator	A. Dastgheib
Credit points	3.500000000
Specialization	

Target Group

This course is useful for engineers involved in the design of breakwaters and/or the supervision of construction of them. Knowledge of the coastal processes such as wind, waves, tides and tidal currents is necessary.

Prerequisites

Learning Objectives

1 Understand the difference between alternative types of breakwaters and governing factors for their selection; Design breakwaters from conceptual to detailed and prepare the layouts and detailed cross-sections.

2 Learning objectives Understand the basic principles of physical scale model and know how to design such a mode to test the design of Breakwaters

Assessments

%	Type	Name
1	Attendance	

Topics

1 Design of Breakwaters

Types, functions, design procedure for breakwaters, data collection; soils, hydraulic conditions, construction materials, definition of requirements, governing parameters for breakwater design such as wave parameters, structural parameters, conceptual design, selection, preliminary design for rubble mound breakwaters, hydraulic response, structural response for rubble mound breakwaters , design of composite type, vertical wall and berm breakwaters,design of low crested and submerged structures, construction methods, case studies, physical modelling. Applications using BREAKWAT, exercise on design of rubble mound and vertical type breakwaters, exercise on scaling a design for physical modeling.

2 Design of Breakwaters Exercise

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Design of Breakwaters	26	0	0	0	0	0	26	78	J.W. van der Meer
2	Design of Breakwaters Exercise	0	0	0	0	0	14	14	42	A. Dastgheib, J.W. van der Meer
	Total	26	0	0	0	0	14	40	120	

Education Material

Scientific Software

M3332

Hydrology and Hydraulics

Term	201819
Coordinator	S. Maskey
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants.

Prerequisites

Entry requirements for WSE

Learning Objectives

1 Describe the main concepts of steady/unsteady and uniform/non-uniform flow.
2 Describe the principles and basic equations of water flow and to apply them to various practical situations.
3 Carry out basic measurements in the wave and current flumes at the hydraulic laboratory.
4 Describe and apply the concepts of hydrology needed for their specialisation.
5 Explain the concepts of Geographical Information Systems and apply them in practical examples relevant to their specialization.
6 Describe the main techniques of remote sensing and know when their use is appropriate or inappropriate.

Assessments

%	Type	Name
40	Written examination (closed book)	Engineering Hydrology
40	Written examination (closed book)	Free Surface Hydrodynamics
20	Assignment	GIS & Remote Sensing

Topics

1 Free-Surface Hydrodynamics

Topics include: Introduction to free-surface hydrodynamics; 1-D Channel Flow and Equations; Uniform and Non-uniform Flow Computations (exercises); 2-D and 3-D Shallow Water Equations; Hydraulic Laboratory

1.1 Introduction to Free Surface Hydrodynamics

Introduction. Governing Laws of free-surface hydrodynamics. Development of hydrodynamic equations.

Topics

1.2 1-D Channel Flow and Equations

Steady uniform flow, normal depth, Chezy and Manning's formulas. Specific energy, critical depth, Froude number. Sub-critical and supercritical flows. Non-uniform flow; rapid and gradually varied flow; computation of water surface profiles. Unsteady flow; Saint-Venant equations for 1-D flow.

1.3 Uniform and Non-uniform Flow Computations

Exercises: Computation of uniform flow in open channel (single and composite channels); Computation of non-uniform steady flow in open channel (flow surface profiles and backwater curve); Application of Bernoulli equation.

1.4 2-D and 3-D Shallow Water Equations

Introduction to 2-D and 3-D flows and application examples.

1.5 Hydraulics Laboratory

Various types of measuring equipment. Choice of various flow types: over a broad crested weir, through a contraction, underneath a gate; wave propagation and dissipation in a flume.

2 Engineering Hydrology

Topics include: Engineering Hydrology (lectures and exercises); Engineering Hydrology Workshop

2.1 Engineering Hydrology (lectures and exercises)

Hydrological cycle, water balance, catchment, water divide, influence of man, rainfall measurement, areal rainfall, depth-duration-frequency curves, types of evaporation, evaporation equations, infiltration (formula of Horton), soil moisture, groundwater, measurement of water level and discharge, flow duration curves, rainfall-runoff relationship, rainfall-runoff analysis, Rational Method for estimating peak discharge.

2.2 Engineering Hydrology Workshop

Workshop exercises on duration curve, extreme value analysis, flood routing, reservoir simulation.

3 Geographical Information Systems and Remote Sensing

Introduction to geographic information systems and remote sensing technologies; active and passive remote sensing; data structures, map projections and coordinate systems; processing of digital geographic information; creation of digital elevation models; visualisation, mapping of water and environmental features; watersheds, streams and aquifers delineation; digitisation, soil and land use mapping; map algebra; terrain analysis for hydrological and hydraulic modeling; production of thematic maps; GIS as a decision support tool.Exercise and assignment using a case study data.

Software: ArcGIS.

3.1 Introduction to GIS

3.2 Introduction to Remote Sensing

3.3 GIS exercises

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Free-Surface Hydrodynamics	0	0	0	0	0	0	0	0	
1.1	Introduction to Free Surface Hydrodynamics	2	0	0	0	0	0	2	6	J.A. Roelvink
1.2	1-D Channel Flow and Equations	6	0	0	0	0	0	6	18	S. Maskey
1.3	Uniform and Non-uniform Flow Computations	0	0	2	4	0	0	6	10	L.G. Hayde, S. Maskey
1.4	2-D and 3-D Shallow Water Equations	4	0	0	0	0	0	4	12	J.A. Roelvink
1.5	Hydraulics Laboratory	2	0	0	4	0	0	6	14	L.G. Hayde
2	Engineering Hydrology	0	0	0	0	0	0	0	0	
2.1	Engineering Hydrology (lectures and exercises)	10	0	0	4	0	0	14	38	J.W. Wenninger
2.2	Engineering Hydrology Workshop	0	0	4	4	0	0	8	12	R.G.W. Venneker, S. Maske
3	Geographical Information Systems and Remote Sensing	0	0	0	0	0	0	0	0	
3.1	Introduction to GIS	2	0	0	0	0	0	2	6	J.L. Alfonso Segura
3.2	Introduction to Remote Sensing	2	0	0	2	0	0	4	10	P. Paron
3.3	GIS exercises	0	0	0	10	0	0	10	20	F.X. Suryadi, J. van der Kwast, J.L. Alfonso Segura, M. Mazzoleni
	Total	28	0	6	28	0	0	62	146	

Education Material

Lecture notes	Paron P., 2009. Introduction to GIS and Remote Sensing, Lecture Notes
Handout	Van der Kwast, H. (2017). Exercises Open Source Software for Preprocessing GIS Data for Hydrological Models, Lecture Notes.

Scientific Software

ArcGIS

QGis

M3337

Information Technology and Software Engineering

Term	201819
Coordinator	J.L. Alfonso Segura
Credit points	5.000000000
Specialization	Hydroinformatics: Modelling and Information Systems for Water Management

Target Group

Participants in WSE Programme - Hydroinformatics, including the IMHI participants (following the courses at partner institutions).

Prerequisites

Acquaintance with computing

Learning Objectives

1 Develop computer code for general and water-related problems, applying the main principles of software engineering and computer programming

2 Describe the Python environment, explain its working philosophy and use it to perform basic operations and plots

3 Explain and apply the main operation principles of computers, networks and Internet

4 Select and apply software tools to increase productivity

Assessments

%	Type	Name
0,13	Written examination (open book)	Information Technology
0,07	Written examination (open book)	Introduction to Database Systems
0,3	Written examination (closed book)	Software Engineering in Python
0,2	Assignment	Software engineering in Python, assignment 1
0,3	Assignment	Software engineering in Python, assignment 2

Topics

1 Information and communication technology

2 Software Engineering in Python

Introduction to Software Engineering, Flow Charts & Pseudocode, Logic, conditionals and loops, Practice conditionals, Loops For, While, Loop (Exercises), File manipulation, Introduction to SE project, Functions, Objects

3 Field visit

Topics

4 Introduction to database systems

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Information and communication technology	4	0	4	8	0	0	16	32	G.A. Corzo Perez
2	Software Engineering in Python	6	0	26	16	0	0	48	76	Chacon Hurtado, J.L. Alfons Segura
3	Field visit	0	0	0	0	8	0	8	8	
4	Introduction to database systems	6	0	6	0	0	0	12	24	D. Solomatine, S.J. van And
	Total	16	0	36	24	8	0	84	140	

Education Material

Lecture notes	Introduction to Databases. D.P. Solomatine, IHE Delft
E-book	J. Chacón-Hurtado and L. Alfonso, Introduction to Python (Jupyter Notebook)

Scientific Software

M3378

Introduction to Water Science and Engineering

Term	201819
Coordinator	L.G. Hayde
Credit points	4.000000000
Specialization	Core Program

Target Group

Entry level with a background in engineering, geoscience, and related disciplines

Prerequisites

Entry requirements of the WSE-programme

Learning Objectives

1 Understand the field of water science and engineering, identify its different specialisations and understand the structure of the programme at IHE

2 Apply mathematical, statistical and frequency analysis concepts and techniques relevant to water science and engineering

3 Describe geologic, geomorpholgical and anthropogenic processes at the surface of the Earth that form and sculpt landscapes

4 Explain how to use different types of literature in scientific work in an ethical manner

Assessments

%	Type	Name
45	Assignment	Review of Mathematics and Statistics
55	Written examination (open book)	The Earth System

Topics

1 Review of Mathematics

Coordinate systems: Cartesian, cylindrical, spherical; Calculus: functions, differentiation and integration, complex numbers; Linear algebra: vector spaces, matrix algebra; Differential equations: ODEs, PDEs, differential operators; Fourier series and harmonic analysis. Statistics and frequency analysis: Data, variables, classification, stat. moments, frequency distributions; samples populations and probablility models; parameter estimation and confidence intervals.

2 Review of Statistics and Frequency Analysis

Data, variables, classification, stat. moments, frequency distributions; samples, populations and probability models; parameter estimation and confidence intervals.

Topics

3 The Earth System (geology, geomorphology, the anthropocene)

Overview of the geological materials, processes and shapes of the earth at different time and space scales that are interconnected with the water system and engineering. Overview of the geomorphological processes shaping the Earth's surface and interacting with the water system. Overview of the human influences shaping the Earth's surface. The overall integration in shown with the aid of exercises and practicals.

4 Referencing Guidelines, Literature Research & Plagiarism Awareness

Different types of literature, the relevance of literature, how to use it in assignments and research, how to make proper referencing, what plagiarism is and how to avoid it.

5 Fieldtrip - Excursion Deltaworks

Excursion to hydraulic engineering flood protection works in the south-western delta of The Netherlands.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Review of Mathematics	4	0	6	0	0	0	10	18	I.I. Popescu
2	Review of Statistics and Frequency Analysis	2	0	4	0	0	0	6	10	P.H.A.J.M. van Gelder
3	The Earth System (geology, geomorphology, the anthropocene)	10	14	12	0	0	0	22	56	A.C. Seijmonsbergen, C.M.S de Fraiture, P. Paron
4	Referencing Guidelines, Literature Research & Plagiarism Awareness	0	0	4	0	0	0	4	4	L. Westerveen, L.P. Darvis
5	Fieldtrip - Excursion Deltaworks	0	0	0	0	8	0	8	8	A. Roos, L.G. Hayde
	Total	16	14	26	0	8	0	50	96	

Education Material

Handout	1 Price, R. & Popescu, I.: Review of Mathematics Handouts: Lecturing material available as on-line resource
Lecture notes	2 LN00072, Van Gelder, P.: Review of Statistics and Frequency Analysis Handouts: Lecturing material available as on-line resource
Lecture notes	4 LN0194/10/1, Rondeel, H.E.: Geology. (b) LN0410/09/1. Seijmonsbergen, A.C.: Introduction to Air-Photo interpretation Handouts: Lecturing material available as on-line resource
Handout	5 De Heer, Geurtsen, Bijnsdorp, 2005. Handout Visit to the Deltaworks.

Scientific Software

M3449

Management of Irrigation and Drainage Systems

Term	201819
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	

Target Group

All Land and Water Development participants, and those interested in the management aspects of irrigation and drainage systems.

Prerequisites

Agronomy, irrigation methods, socio-economic and environmental aspects of irrigation, irrigation flow control and conveyance

Learning Objectives

1 Evaluate objectives, tasks and types of irrigation management arrangements and its implications for irrigation peformance

2 Demonstrate the role of property creation for the management and development of irrigation and drainage system

3 Discuss the importance of the social aspects that define the feasibility, implementation and continuation of land and water development projects

4 Assess the relevance and concepts of stakeholder participation in irrigation management

5 Explain the theory, key concepts, conceptual framework and merits of water accounting in irrigation schemes

6 Apply key concepts of irrigation performance assessment, including its role, types of assessment, criteria, indicators, benchmarking and targets, in addressing problems related to irrigation performance

7 Use the IWMI water accounting framework to perform water accounting in irrigation schemes, interpret the results provide situation analysis and formulate relevant recommendations for improvements.

Assessments

%	Type	Name
50	Written examination (open book)	Hydraulic property and ownership relations in irrigation systems, Irrigation performance assessment and irrigation water accounting
30	Assignment	Irrigation management
20	Assignment	Sociological Aspects of LWD

Topics

1 Management tasks in different types of irrigation and drainage systems

Terminology and definitions, management approaches, objectives in irrigation, interest groups, conflicting objectives and interests, large and small scale systems. Water delivery policies: entitlement to water, operational objectives (adequacy, equity, reliability), cropping policies. Water delivery systems: arranged, on-request, on-demand, irrigation scheduling. Formal and informal irrigation management. Concept of service oriented management: typology of goods and services, clients and stakeholders, service determining factors, levels of service, infrastructure, flow control and service potential, organisational structures, cost recovery, farmers participation, role of line agencies and accountability mechanisms in water management institutions.

2 Hydraulic property and ownership relations in irrigation systems

Dynamics of hydraulic property and ownership relations in irrigation systems, investments and interventions in irrigation and drainage, the relevance and impact of different water rights arrangements.

3 Sociological aspects of land and water development

Introduction to the social sciences of irrigation and drainage. Challenges of water distributions among competing users. Understanding the influence of irrigation technology, projects, management and organization on social constellations. The influence of various distributions on social aspects of irrigation: distributions of water, distributions of authority and voice (incl. gender), distributions of knowledge and expertise (incl. the role of the social sciences in irrigation knowledge). Case studies based on participants' experiences.

4 Irrigation Management Game

The students will engage in the roles of farmers or water judge in an irrigation management game in which water delivery and cropping choices will be implemented in the occurence of several events.

5 Irrigation performance assessment and water accounting

Performance assessment in irrigation and drainage is the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement. It is an important management tool to improve overall function of a scheme in terms of service and productivity. The course will discuss the key concepts and theoretical framework of performance assessment by drawing examples from the past field projects. This theoretical knowledge will then be used to solve problems and discuss the results and implications. The course will introduce and discuss the water accounting framework created by the International Water Management Institute (IWMI WA). The theory, terminologies, the conceptual framework of IWMI WA will be explained. The discussion on the conceptual framework will be followed by a practical problem solving in class, visualizing the results and discussing the implications.

6 Field trip

Visits to Dutch water management institutions such as the water board and agricultural association.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Management tasks in different types of irrigation and drainage systems	14	0	0	0	0	0	14	42	A.E.C. Duker, M.A. Burton
2	Hydraulic property and ownership relations in irrigation systems	6	0	0	0	0	0	6	18	J.A. Bolding
3	Sociological aspects of land and water development	8	0	2	0	0	0	10	26	J.G. Evers
4	Irrigation Management Game	0	0	8	0	0	0	8	8	M.A. Burton
5	Irrigation performance assessment and water accounting	10	0	4	2	0	0	16	38	P. Karimi
6	Field trip	0	0	0	0	8	0	8	8	A.E.C. Duker
	Total	38	0	14	2	8	0	62	140	

Education Material

Scientific journal	Malano, H., Burton, M. and Makin, I. (2004), Benchmarking performance in the irrigation and drainage sector: a tool for change. Irrig. and Drain., 53: 119–133. doi:10.1002/ird.126
Scientific journal	Molden, D., Burton, M. and Bos, M. G. (2007), Performance assessment, irrigation service delivery and poverty reduction: benefits of improved system management. Irrig. and Drain., 56: 307–320. doi:10.1002/ird.313
Scientific journal	Molden, D.; Sakthivadivel, R. 1999. Water accounting to assess use and productivity of water. International Journal of Water Resources Development 15(1&2): 55-71.
Scientific journal	Robbins, P., 2007. The reflexive engineer: perceptions of integrated development. Journal of International Development, 19(1).

Scientific Software

M3244

Modelling Theory and Computational Hydraulics

Term	201819
Coordinator	I.I. Popescu
Credit points	5.000000000
Specialization	Hydroinformatics: Modelling and Information Systems for Water Management

Target Group

Hydroinformatics participants

Prerequisites

Basic Mathematics ; Hydraulics & Computational Fluid Dynamics ;

Learning Objectives

1 Explain the structure of the 1D, 2D and 3D flow equations as representations of conservation laws and know whei to use the full dynamic equations and their approximations

2 Understand and explain the foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, selecting modelling software

3 Understand and use main principles and methods of analysing and predicting models uncertainty; be able to develop computer code for analysing uncertainty of a hydrological model

4 Identify differential equations, as well as indicating the nature of the initial and boundary conditions for well posed problems.

5 Implement finite difference schemes to solve differential equations.

6 Analyse a numerical scheme and indicate its behaviour, as well as implement different numerical schemes for solution of equations used in water related problems.

Assessments

%	Type	Name
25	Written examination (closed book)	Equations of Water Flows
25	Oral examination	Modelling Theory and Uncertainty
20	Assignment	Numerical Methods I
30	Written examination (closed book)	Numerical Methods I

Topics

1 Equations of water flows

Basic concepts; basic physical laws; mass, momentum and energy fluxes; Eulerian equations; differential forms in common use; De Saint Venant equations; unsteady flow in pipes; Navier-Stokes equations; 3D Navier-Stokes equations to De Saint Venant equations; advection and diffusion; dimensional and order of magnitude analyses

2 Modelling theory and uncertainty

Foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, sequence of steps in building a model, selecting modelling software, use of models by decision makers and other stakeholders. Essence of data collection and analysis, model
calibration and testing, models integration. Analysis of a number of examples of using models in solving water-related issues (floods, urban water). Main principles and methods of analysing and predicting models uncertainty, with exercises (using MATLAB)

3 Numerical methods I

Introduction to numerical solutions of difefrential equations used in fluid dynamics. Initial and boundary value problems, method of characteristics, finite differences for ODEs and PDEs. Consistency,stability, convergence of a numerical method. Exercises that will show the application of the numerical methods.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Equations of water flows	12	0	0	4	0	0	16	44	Mazzoleni, I.I. Popescu
2	Modelling theory and uncertainty	8	0	6	0	0	0	14	30	D. Solomatine
3	Numerical methods I	12	0	4	12	0	0	28	64	I.I. Popescu
	Total	32	0	10	16	0	0	58	138	

Education Material

Book	Popescu: Computational Hydraulics, IWA Publishing, 2014
Lecture notes	Popescu: Lecture notes on Numerical methods for Differential Equations
Lecture notes	Price: Lecture notes on Mathematical Basis of Computational Hydraulics

Scientific Software

Matlab

M3327

Online course on Urban System Analysis, Planning and Management: Developing Skills and Attitudes

Term	201819
Coordinator	E.R. Raj
Credit points	5.000000000
Specialization	Sustainable Urban Water Management

Target Group

SUWM students

Prerequisites

Module 3 (Urban System Analysis, Planning and Management: An Introduction) of the SUWM programme and the ability to participate in online forum discussions.

Learning Objectives

1 Analyze the different characteristics of integrated urban water management (IUWM) frameworks and demonstrate critical thinking skills

2 Develop leadership qualities and reflecting the role in the context of integrated urban water management (IUWM) in sponge cities

3 Apply a range of tools and methodologies to effectively co-discover, co-learn and co-design opportunities and challenges with different stakeholders

4 Demonstrate the links between urban water cycle and urban planning, design and engineering aspects in sponge cities

5 Develop fit-for-purpose policy briefs for the identified urban challenges based on the principles of integrated urban water management (IUWM)

Assessments

%	Type	Name
60	Assignment	Individual assignments on policy briefs
40	Presentation	Individual presentation during design days. Part of the 40% from presentation includes contribution in online forum discussions

Topics

1 Design, engineering and planning framework

The following design framework in the context of integrated urban water management (IUWM) will be covered in this topic:

1) System analysis (why ?)

2) Design, engineering and planning (what ?)

3) Governance (how ?)

- Active participation in forum discussions facilitated by Eldon Raj

2 Applying the principles of asset management

The following aspects will be covered in this topic:

- Developing skills and attitudes required to manage different urban systems

- Leadership skills to manage different Asset management in sponge cities

3 Skills required for urban water resources management

The following aspects will be covered in this topic:

- Responsibilities of stakeholders in water management (in sponge cities)

- Critical thinking and promote various initiatives for resource recovery in different urban systems

- Compare the different water quality indices in different urban systems

- Active participation in forum discussions facilitated by Eldon Raj

Topics

4 Computational tools for water transport and distribution

The following aspects will be covered in this topic:

- Create a shared goal and identify the interactions between different water systems and their transport

- Getting acquainted with software used for water transport and distribution in urban systems

- Active participation in forum discussions facilitated by Eldon Raj

5 Responsibilities of different stakeholders in industrial resource management

The following aspects will be covered in this topic:

- Role of managers in implementing cleaner production and clean technologies

- Engineering and technological skills required for resource recovery from waste

- Learn from case studies from specific industries (metal plating, leather manufacturing, food and beverage)

- Active participation in forum discussions facilitated by Eldon Raj

6 Environmental quality monitoring in urban systems

The following aspects will be covered in this topic:

- Water quality monitoring

- Air quality monitoring

- Noise pollution monitoring

- Policies related to environmental quality in urban systems

- Active participation in forum discussions facilitated by Eldon Raj

Topics

7 Creativity in promoting sustainable urban water systems

The following aspects will be covered in this topic:

- The managerial attitude and role in mapping the relationship between urban water systems

- Examples from sponge cities

- Active participation in forum discussions facilitated by Eldon Raj

8 Managing water sensitive cities

The following aspects will be covered in this topic:

- Manage conflicts and cultural differences in urban systems

- Social and institutional aspects

- City to city learning

- Case studies from different water sensitive cities

- Active participation in forum discussions facilitated by Eldon Raj

9 Nature based solutions for sponge cities - skills and attitudes

The following aspects will be covered in this topic:

- The interaction between different stakeholders in managing natural treatment systems (example - wetland) for water treatment, air pollution control and solid waste treatment

- Preparedness of water supply networks and systems and sanitation in sponge cities

- Design and implementing nature based solutions in sponge cities

- Active participation in forum discussions facilitated by Eldon Raj

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Design, engineering and planning framework	0	12	4	0	0	0	4	16	E.R. Raj, M. Radhakrishnan
2	Applying the principles of asset management	0	12	4	0	0	0	4	16	E.R. Raj, P.D.A. Pathirana
3	Skills required for urban water resources management	0	12	4	0	0	0	4	16	E.R. Raj
4	Computational tools for water transport and distribution	0	12	4	0	0	0	4	16	E.R. Raj, M. Radhakrishnan
5	Responsibilities of different stakeholders in industrial resource management	0	12	4	0	0	0	4	16	E.R. Raj, M. Radhakrishnan
6	Environmental quality monitoring in urban systems	0	12	4	0	0	0	4	16	E.R. Raj
7	Creativity in promoting sustainable urban water systems	0	16	0	0	0	0	0	16	M. Radhakrishnan
8	Managing water sensitive cities	0	0	20	0	0	0	20	20	M. Radhakrishnan, P.D.A. Pathirana
9	Nature based solutions for sponge cities - skills and attitudes	0	8	0	0	0	0	0	8	E.R. Raj
	Total	0	96	44	0	0	0	44	140	

Education Material

Scientific journal	Background reading materials
Handout	Design, engineering and planning framework literatures
Lecture notes	Lecture notes and powerpoints from other SUWM modules
Digital files	Movies
E-book	PDF of the book on sponge cities

Scientific Software

M3378

Introduction to Water Science and Engineering

Term	201819T01
Coordinator	L.G. Hayde
Credit points	4.000000000
Specialization	Core Program

Target Group

Entry level with a background in engineering, geoscience, and related disciplines

Prerequisites

Entry requirements of the WSE-programme

Learning Objectives

1. Understand the field of water science and engineering, identify its different specialisations and understand the structure of the programme at IHE
2. Apply mathematical, statistical and frequency analysis concepts and techniques relevant to water science and engineering
3. Describe geologic, geomorpholgical and anthropogenic processes at the surface of the Earth that form and sculpt landscapes
4. Explain how to use different types of literature in scientific work in an ethical manner

Assessments

%	Type	Name
45	Assignment	Review of Mathematics and Statistics
55	Written examination (open book)	The Earth System

Topics

1 Review of Mathematics

Coordinate systems: Cartesian, cylindrical, spherical; Calculus: functions, differentiation and integration, complex numbers; Linear algebra: vector spaces, matrix algebra; Differential equations: ODEs, PDEs, differential operators; Fourier series and harmonic analysis. Statistics and frequency analysis: Data, variables, classification, stat. moments, frequency distributions; samples populations and probablility models; parameter estimation and confidence intervals.

2 Review of Statistics and Frequency Analysis

Data, variables, classification, stat. moments, frequency distributions; samples, populations and probability models; parameter estimation and confidence intervals.

Topics

3 The Earth System (geology, geomorphology, the anthropocene)

Overview of the geological materials, processes and shapes of the earth at different time and space scales that are interconnected with the water system and engineering. Overview of the geomorphological processes shaping the Earth's surface and interacting with the water system. Overview of the human influences shaping the Earth's surface. The overall integration in shown with the aid of exercises and practicals.

4 Referencing Guidelines, Literature Research & Plagiarism Awareness

Different types of literature, the relevance of literature, how to use it in assignments and research, how to make proper referencing, what plagiarism is and how to avoid it.

5 Fieldtrip - Excursion Deltaworks

Excursion to hydraulic engineering flood protection works in the south-western delta of The Netherlands.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Review of Mathematics	4	0	6	0	0	0	10	18	I.I. Popescu
2	Review of Statistics and Frequency Analysis	2	0	4	0	0	0	6	10	P.H.A.J.M. van Gelder
3	The Earth System (geology, geomorphology, the anthropocene)	10	14	12	0	0	0	22	56	A.C. Seijmonsbergen, C.M.S de Fraiture, P. Paron
4	Referencing Guidelines, Literature Research & Plagiarism Awareness	0	0	4	0	0	0	4	4	L. Westerveen, L.P. Darvis
5	Fieldtrip - Excursion Deltaworks	0	0	0	0	8	0	8	8	A. Roos, L.G. Hayde
	Total	16	14	26	0	8	0	50	96	

Education Material

Handout	1 Price, R. & Popescu, I.: Review of Mathematics Handouts: Lecturing material available as on-line resource
Lecture notes	2 LN00072, Van Gelder, P.: Review of Statistics and Frequency Analysis Handouts: Lecturing material available as on-line resource
Lecture notes	4 LN0194/10/1, Rondeel, H.E.: Geology. (b) LN0410/09/1. Seijmonsbergen, A.C.: Introduction to Air-Photo interpretation Handouts: Lecturing material available as on-line resource
Handout	5 De Heer, Geurtsen, Bijnsdorp, 2005. Handout Visit to the Deltaworks.

Scientific Software

M3344

Introduction to Water for Development

Term	201819T01
Coordinator	J.S. Kemerink - Seyoum
Credit points	1.000000000
Specialization	Core Program

Target Group

All new incoming IHE MSc students

Prerequisites

Enrolled in one of the four IHE 18 months MSc programmes.

Learning Objectives

1. Place the specialized knowledge on own discipline into a broader understanding of water related issues, challenges, debates and developments
2. Recognize and distinguish different ways of knowing and framing water questions and problems in order to appraise water challenges from an interdisciplinary perspective
3. Reflect critically on water related interventions, formulate own standpoint and engage constructively in debates
4. Familiarize with the educational environment and procedures of IHE Delft and collaborate in multidisciplinary and intercultural teams

Assessments

%	Type	Name
1	Assignment	My trajectory: a short essay reflecting on how social identities shaped the course of your life (individual written assignment)

Topics

1 Introduction to Pluralizing Water Sciences

Introduction lecture in which the theme will be introduced, the learning objectives of this course will be explained and the logistics for the week will be discussed.

This is followed by three keynotes delivered by guest speakers that aim to address different ways of pluralizing conventional approaches by scrutinizing common and persisting boundaries in water sciences, namely 1) gender and racial boundaries and dichotomies in water sciences; 2) disciplinary boundaries between social sciences and engineering and natural sciences; and 3) geographical boundaries of knowledge production and the mobility of knowledge.

2 Art workshop: heroines and heroes

Creative workshop in which students will use different forms of arts to visualize their heroines and heroes as a way to articulate what drives them, explain what motivates their choices and share with others why they choose to do an MSc at IHE Delft. Making this explicit not only helps to get to know each other, but also in understanding how IHE Delft can best help students in achieving their ambitions in life. Students can choose any person, spirit or even animal as their as their heroine or hero and can choose which materials (e.g. clay, paint, drawing, dressing-up) they would like to use to portrait their favourite being. On a voluntary basis students will be asked to share their story on camera, which will be in a short documentary screened in the next day in class and on IHE social media.

3 Ethics in Science

An interactive session on Ethics in Science in which the students made interactive word clouds to define ethics and to articulate the need for ethics in science. In addition, students will be informed on how IHE Delft strives for ethical behaviour in research and education and what the implications are thereof for students and staff.

4 Seeing water from many places

This session on ‘seeing water from many places’ includes four pitches of researchers using different perspectives and methodologies for studying water. Dr. Roos van Oosten looks at water from the past by delving into the medieval sanitation practices in Dutch towns. Dr. Micha Werner will look with students into future by explaining the possibilities of flood forecasting models. Dr. Gonzalo Espinoza Davalos will show the students water from above by taking them on a satellite ride and illuminating them on the fast developing field of remote sensing techniques mobilized for water research. And Hermen Smit will bring the students with their feet back on the ground by exposing them to the multiple lived experiences of different farmers in a Sudanese irrigation scheme.

These pitches are followed by a panel discussion in which the speakers and students together examine the assumptions and added value of each research approach and discuss opportunities for, and tensions in, integrating different research methodologies.

Topics

5 Embodiements of knowledge: How do we think our water leaders should look like?

The lecture will focus on how expertise becomes embodied and why being recognized as an expert is easier for some than for others. Margreet will discuss with the students the symbolic, cultural and performative dimensions of scientific expertise. Understanding these dimensions will help to reveal how ‘otherness’ itself has become constructed and performed within and through scientific expertise and how such constructions work to legitimize and endorse some forms of scientific authority and expertise, and not others. The lecture aims to help students to understand that scientific expertise is ‘made’ white and masculine as it is coloured and shaped by colonial histories as well as by contemporary geo-political and economic relations of power. The main message of the lecture is for students to nurture and cherish their own ‘otherness’ as a source of creativity and strength.

6 What about me? Workshop on life trajectories and social identitie

Students will be shown a short documentary on how gender, race and socio-economic class shapes perceptions and opportunities, and therefore affects personal and professional trajectories. Based on this documentary we will engage in an exercise and conversation on the different paths that can lead to becoming recognized water scholars, even if this is against the odds and requires tremendous perseverance and sacrifices.

Students will be tasked to write their own trajectory in the water sector and critically reflect on how their gender, race, culture and socio-economic class has enabled or constraint their education and career ambitions. The 2 page document (see format in Annex 1) needs to be submitted on the e-campus and will be graded as part of the formal assessment of the General Introduction Week.

7 Ravilla Game

Students will be engaged in the interactive LIBRA role game. This game simulates the process of water resources planning and management within a river basin in which three stakeholder groups with different interests and perspectives compete for water, namely the River Basin Authority, City Water Utility and Irrigation District Association. The game will be played in two rounds of eleven parallel sessions, each representing a specific river basin in the world, in which groups of about ten students negotiate how water should be distributed in their basin. During each round individual and joint actions will be proposed by the different stakeholder groups as input for a fifteen year water allocation plan for each river basin after which the outcomes and effects of these actions will be calculated by the LIBRA model and share with each group. The objective of the game is for students to experience the challenges in achieving multiple, and sometimes competing, goals often included river basin management plans, such as decreasing existing water deficits, improving wetland status, improving the situation of different economic sectors (e.g. industry, farming, fisheries) and avoiding financial disruption of the three stakeholder organizations. The group succeeds best in optimizing the allocation of water resources and negotiating the trade-offs will be awarded the winning prize!

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to Pluralizing Water Sciences	4	0	0	0	0	0	4	12	J.S. Kemerink - Seyoum, M.Z. Zwarteveen, T. Acevedo Guerrero
2	Art workshop: heroines and heroes	1	0	2	0	0	0	3	5	J.S. Kemerink - Seyoum, T. Acevedo Guerrero
3	Ethics in Science	0	0	1	0	0	0	1	1	C.M.S. de Fraiture
4	Seeing water from many places	0	0	2	0	0	0	2	2	G.E. Espinoza Davalos, H. Smit, J.S. Kemerink - Seyoum, M.G.F. Werner
5	Embodiements of knowledge: How do we think our water leaders should look like?	2	0	0	0	0	0	2	6	M.Z. Zwarteveen
6	What about me? Workshop on life trajectories and social identitie	0	6	2	0	0	0	2	8	J.S. Kemerink - Seyoum, T. Acevedo Guerrero
7	Ravilla Game	0	0	10	0	0	0	10	10	J.G. Evers
	Total	7	6	17	0	0	0	24	44	

Education Material

Lecture notes	Rivalla Role Game
Handout	Syllabus

Scientific Software

M3332

Hydrology and Hydraulics

Term	201819T02
Coordinator	S. Maskey
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants.

Prerequisites

Entry requirements for WSE

Learning Objectives

1 Describe the main concepts of steady/unsteady and uniform/non-uniform flow.
2 Describe the principles and basic equations of water flow and to apply them to various practical situations.
3 Carry out basic measurements in the wave and current flumes at the hydraulic laboratory.
4 Describe and apply the concepts of hydrology needed for their specialisation.
5 Explain the concepts of Geographical Information Systems and apply them in practical examples relevant to their specialization.
6 Describe the main techniques of remote sensing and know when their use is appropriate or inappropriate.

Assessments

%	Type	Name
40	Written examination (closed book)	Engineering Hydrology
40	Written examination (closed book)	Free Surface Hydrodynamics
20	Assignment	GIS & Remote Sensing

Topics

1 Free-Surface Hydrodynamics

Topics include: Introduction to free-surface hydrodynamics; 1-D Channel Flow and Equations; Uniform and Non-uniform Flow Computations (exercises); 2-D and 3-D Shallow Water Equations; Hydraulic Laboratory

1.1 Introduction to Free Surface Hydrodynamics

Introduction. Governing Laws of free-surface hydrodynamics. Development of hydrodynamic equations.

Topics

1.2 1-D Channel Flow and Equations

Steady uniform flow, normal depth, Chezy and Manning's formulas. Specific energy, critical depth, Froude number. Sub-critical and supercritical flows. Non-uniform flow; rapid and gradually varied flow; computation of water surface profiles. Unsteady flow; Saint-Venant equations for 1-D flow.

1.3 Uniform and Non-uniform Flow Computations

Exercises: Computation of uniform flow in open channel (single and composite channels); Computation of non-uniform steady flow in open channel (flow surface profiles and backwater curve); Application of Bernoulli equation.

1.4 2-D and 3-D Shallow Water Equations

Introduction to 2-D and 3-D flows and application examples.

1.5 Hydraulics Laboratory

Various types of measuring equipment. Choice of various flow types: over a broad crested weir, through a contraction, underneath a gate; wave propagation and dissipation in a flume.

2 Engineering Hydrology

Topics include: Engineering Hydrology (lectures and exercises); Engineering Hydrology Workshop

2.1 Engineering Hydrology (lectures and exercises)

Hydrological cycle, water balance, catchment, water divide, influence of man, rainfall measurement, areal rainfall, depth-duration-frequency curves, types of evaporation, evaporation equations, infiltration (formula of Horton), soil moisture, groundwater, measurement of water level and discharge, flow duration curves, rainfall-runoff relationship, rainfall-runoff analysis, Rational Method for estimating peak discharge.

2.2 Engineering Hydrology Workshop

Workshop exercises on duration curve, extreme value analysis, flood routing, reservoir simulation.

3 Geographical Information Systems and Remote Sensing

Introduction to geographic information systems and remote sensing technologies; active and passive remote sensing; data structures, map projections and coordinate systems; processing of digital geographic information; creation of digital elevation models; visualisation, mapping of water and environmental features; watersheds, streams and aquifers delineation; digitisation, soil and land use mapping; map algebra; terrain analysis for hydrological and hydraulic modeling; production of thematic maps; GIS as a decision support tool.Exercise and assignment using a case study data.

Software: ArcGIS.

3.1 Introduction to GIS

3.2 Introduction to Remote Sensing

3.3 GIS exercises

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Free-Surface Hydrodynamics	0	0	0	0	0	0	0	0	
1.1	Introduction to Free Surface Hydrodynamics	2	0	0	0	0	0	2	6	J.A. Roelvink
1.2	1-D Channel Flow and Equations	6	0	0	0	0	0	6	18	S. Maskey
1.3	Uniform and Non-uniform Flow Computations	0	0	2	4	0	0	6	10	L.G. Hayde, S. Maskey
1.4	2-D and 3-D Shallow Water Equations	4	0	0	0	0	0	4	12	J.A. Roelvink
1.5	Hydraulics Laboratory	2	0	0	4	0	0	6	14	L.G. Hayde
2	Engineering Hydrology	0	0	0	0	0	0	0	0	
2.1	Engineering Hydrology (lectures and exercises)	10	0	0	4	0	0	14	38	J.W. Wenninger
2.2	Engineering Hydrology Workshop	0	0	4	4	0	0	8	12	R.G.W. Venneker, S. Maske
3	Geographical Information Systems and Remote Sensing	0	0	0	0	0	0	0	0	
3.1	Introduction to GIS	2	0	0	0	0	0	2	6	J.L. Alfonso Segura
3.2	Introduction to Remote Sensing	2	0	0	2	0	0	4	10	P. Paron
3.3	GIS exercises	0	0	0	10	0	0	10	20	F.X. Suryadi, J. van der Kwast, J.L. Alfonso Segura, M. Mazzoleni
	Total	28	0	6	28	0	0	62	146	

Education Material

Lecture notes — Paron P., 2009. Introduction to GIS and Remote Sensing, Lecture Notes

Handout — Van der Kwast, H. (2017). Exercises Open Source Software for Preprocessing GIS Data for Hydrological Models, Lecture Notes.

Scientific Software

ArcGIS

QGis

M2166
Hydrogeology

Term	201819T03
Coordinator	Y. Zhou
Credit points	5.000000000
Specialization	Hydrology and Water Resources

Target Group

Participants in Hydrology and Water Resources specialisation

Prerequisites

Approved BSc degree and basic hydrology/hydraulics and earth sciences subjects.

Learning Objectives

1 understand groundwater occurrences, aquifer classification and aquifer properties in various geological settings;
2 understand the concepts related to groundwater storage, recharge and discharge;
3 understand steady state and transient groundwater flow processes and their physical description;
4 the ability to apply analytical solutions to solve steady state and transient groundwater problems;
5 determine groundwater balances and to carry out pumping test analyses.

Assessments

%	Type	Name
30	Assignment	Hydrogeology and Groundwater Hydraulics
70	Written examination (closed book)	Hydrogeology and Groundwater Hydraulics

Topics

1 Hydrogeology

Hydrogeological principles and concepts, and the underlying physics of groundwater flow processes. The place of groundwater systems in the hydrological cycle. The interaction between rock and water and the concepts of porosity and permeability. Definition of aquifer, aquitard, aquifuge and aquiclude. Rock types and the related groundwater system. Concepts of regional flow based on Darcy and Continuity equations. Flow computation methods. The concept and formulation of groundwater balances. Estimation of recharge terms. Groundwater management and the concept of groundwater availability.

2 Steady Groundwater Hydraulics

Principles of groundwater flow: hydraulic head, Darcy’s law, continuity equation; steady state groundwater flow equations; Analytical solutions of steady state groundwater flow in aquifers and towards wells; Methods of superposition and image; Flow net.

Topics

3 Transient Groundwater Hydraulics

Dynamics of groundwater systems; Concepts of storage of water in groundwater systems; Analytic solutions and their implementation and use (groundwater hydraulics); Superposition in time and convolution; Pumping tests; Exercises.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydrogeology	16	0	4	0	0	0	20	52	T.Y. Stigter
2	Steady Groundwater Hydraulics	14	0	4	0	0	0	18	46	Y. Zhou
3	Transient Groundwater Hydraulics	12	0	6	0	0	0	18	42	
	Total	42	0	14	0	0	0	56	140	

Education Material

Scientific Software

M3337

Information Technology and Software Engineering

Term	201819T03
Coordinator	J.L. Alfonso Segura
Credit points	5.000000000
Specialization	Hydroinformatics: Modelling and Information Systems for Water Management

Target Group

Participants in WSE Programme - Hydroinformatics, including the IMHI participants (following the courses at partner institutions).

Prerequisites

Acquaintance with computing

Learning Objectives

1 Develop computer code for general and water-related problems, applying the main principles of software engineering and computer programming
2 Describe the Python environment, explain its working philosophy and use it to perform basic operations and plots
3 Explain and apply the main operation principles of computers, networks and Internet
4 Select and apply software tools to increase productivity

Assessments

%	Type	Name
0,13	Written examination (open book)	Information Technology
0,07	Written examination (open book)	Introduction to Database Systems
0,3	Written examination (closed book)	Software Engineering in Python
0,2	Assignment	Software engineering in Python, assignment 1
0,3	Assignment	Software engineering in Python, assignment 2

Topics

1 Information and communication technology

2 Software Engineering in Python

Introduction to Software Engineering, Flow Charts & Pseudocode, Logic, conditionals and loops, Practice conditionals, Loops For, While, Loop (Exercises), File manipulation, Introduction to SE project, Functions, Objects

3 Field visit

Topics

4 Introduction to database systems

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Information and communication technology	4	0	4	8	0	0	16	32	G.A. Corzo Perez
2	Software Engineering in Python	6	0	26	16	0	0	48	76	Chacon Hurtado, J.L. Alfons Segura
3	Field visit	0	0	0	0	8	0	8	8	
4	Introduction to database systems	6	0	6	0	0	0	12	24	D. Solomatine, S.J. van And
	Total	16	0	36	24	8	0	84	140	

Education Material

Lecture notes	Introduction to Databases. D.P. Solomatine, IHE Delft
E-book	J. Chacón-Hurtado and L. Alfonso, Introduction to Python (Jupyter Notebook)

Scientific Software

M3348

Introduction to Coastal Science and Engineering

Term	201819T03
Coordinator	A.A. Milho Semedo
Credit points	5.000000000
Specialization	Coastal Engineering and Port Development

Target Group

Graduates from civil and coastal engineering, environmental engineering graduates and managers with interest in the coastal area, oceanographers, ocean engineers, and marine science graduates.

Prerequisites

Basic knowledge of calculus and hydraulics.

Learning Objectives

1 Understand the basics of coastal engineering and apply the sediment balance concept to concrete coastal situations, and explain when and where to (or not to) apply different coastline protection measures.

2 Explain wave key concepts, wave propagation and breaking (deep and shallow waters) from linear theory, observations and models, describe the concept of radiation stress and its importance in forcing currents and shallow water level gradients at the coast.

3 Generate wave statistics, including extremes, understand concept of wave spectra and bulk parameters, identify the basics of wave climate, from global to regional/local scales, apply wave growth curves and understand wave energy balance concept.

4 Explain the origin and generation of tides, understand the tide generating forces, describe the analysis and prediction of tides process, and understand tidal currents in one and two dimensions.

5 Recognize the different areas of the Matlab environment, and explain their purpose, as well as being able to perform operations such as data manipulation, statistics and plotting, related to costal engineering problems.

Assessments

%	Type	Name
0,2	Written examination (closed book)	Introduction to Coastal Engineering
0,1	Lab. Report	Matlab for Coastal Engineering
0,15	Lab. Report	Ocean Waves Dynamics
0,3	Written examination (closed book)	Ocean Waves Dynamics
0,25	Written examination (closed book)	Tides and Tidal Currents

Topics

1 Introduction to Coastal Engineering

- •Introduction of the Module

- •Coastal Environments

- •Sediment balances in coastal environments

- •Coastline management methods (hard and soft)

Topics

2 Ocean Waves Dynamics

Basic wave characteristic

- Types of waves in the ocean
- Wave parameters (wave height and amplitude, wave period and length, etc.)

Linear wave theory

Non-linear waves

Wave propagation

- Deep to shallow waters
- Dispersive characteristics of waves
- Wave group concept

Wave transformation in shallow waters

- Wave shoaling
- Wave refraction and diffraction
- Wave reflection
- Standing waves

Waves in the nearshore zone

- Wave breaking processes

Topics

- Influence of bathymetry
- Types of breaking
- Radiation stress
- Wave set-up and set-down

Wave generation

- Wave generation theories (sheltering, Miles and Phillips theories)
- Fetch concept
- Wave generation curves (nomograms)
- Empirical wave generation expressions

Wave modelling

- Spectral wave energy balance
- Different wave models
- Global and regional domains
- < >

  1D and 2D wave spectra
- Bulk parameters: significant wave height, peak period, mean wave period, etc.
- Wind sea and swell

Topics

- Extremes (POT, return values, yearly maxima)

Wave data sources

- Wave observations (buoys, remote sensing, ADCP, HF radars, etc.)
- Reanalysis and hindcasts

Wave climate

- Global and regional winds and wave climates
- Wind sea and swell and wave age concept

Wave climate projections

Topics

3 Tides and Tidal Currents

- Origin and generation of tides
- Tide generating forces
- Analysis and prediction of tides
- Main constituents of the tide
- Types of tides
- Equations for tidal waves in one dimension
- Harmonic waves, resonance
- Short basin
- Tidal waves on a river
- Tidal windows for navigation

4 Introduction to Matlab

- Introduction to MATLAB environment
- Expression and commands
- Vectors and strings, array indexing
- Time series statistics, interpolation
- Simple input and output
- Useful and handy commands
- Basic plotting, saving figures
- Programming with M Files
- Introduction to functions
- Importing external data

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to Coastal Engineering	4	0	6	0	0	0	10	18	J.A. Roelvink, R.W.M.R.J.B. Ranasinghe
2	Ocean Waves Dynamics	14	0	20	0	0	0	34	62	A.A. Milho Semedo, S. Caire
3	Tides and Tidal Currents	10	0	12	0	0	0	22	42	A.A. Milho Semedo, J.A. Roelvink, J.A.H. Reyns
4	Introduction to Matlab	0	0	10	0	0	0	10	10	J.L. Alfonso Segura
	Total	28	0	48	0	0	0	76	132	

Education Material

Scientific Software

Matlab

M3381

Principles and Practices of Land and Water Development

Term	201819T03
Coordinator	L.G. Hayde
Credit points	5.000000000
Specialization	Land and Water Development for Food Security

Target Group

Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development.

Prerequisites

Basic knowledge in alterative land and water development approaches, irrigation and drainage systems, soil physical and chemical properties

Learning Objectives

1 Analyse the relevance, concept, elements and needs of irrigation and drainage.

2 Analyse soil-water-crop yield relationships, management options under land or water scarcity and water saving techniques, and be able to determine crop water requirements

3 Explian commonalities and differences between traditional and improved agronomic practices and plan improved irrigation agronomy and field water management

4 Understand the unique characteristics and technical and practical conditions for optimum application of different irrigation methods.

5 Analyse and evaluate the design and operational aspects of various surface irrigation systems.

6 Assess and evaluate various types of flow and apply the hydraulic principles for uniform and non-uniform open channel flow, and flow in specific hydraulic structures in irrigation and drainage engineering.

Assessments

%	Type	Name
44	Written examination (open book)	Agronomy and Soil Water Plant Relations
29	Assignment	Applied Hydraulics of Irrigation Systems I
27	Assignment	Irrigation Methods

Topics

1 Introduction - Irrigation and Drainage Systems

Needs for irrigation and drainage systems. Basic functions, elements of the irrigation and drainage systems, topography, irrigation and drainage system lay-out, development and water management aspects, main d'eau, sizing tertiary units, required water levels, design cropping pattern, irrigation requirements, canal design discharges, longitudinal and cross sections, relative sediment transport capacity, shear stress. Structures and emergency measures.

2 Agronomy and Soil Water Plant Relations

This course will cover theoretical and practical knowledge and experiences focusing on the following four topics: 1) Commonalities and differences between traditional and improved agronomic practices with emphasis on crop selection, irrigation scheduling, farming practices; 2) Importance of irrigation agronomy for productivity and resistance to water and climate stress; 3) AquaCrop modelling: concepts, principles and simulation approaches, data creation, data input, simulation results and their interpretation; 4) Case study: Practical planning of improved irrigation agronomy and field water management (including groundwater and conjunctive use) for different types of irrigation systems (precision irrigation systems, surface irrigation systems, flood-based farming systems) with the help of AquaCrop Model.

Physical and chemical properties of soils: texture; structure; density; colour; temperature; specific surface of particles; structure of clays; cation exchange capacity; exchange equations. Soil moisture: potential energy of soil water, measurement of soil moisture content and water pressure, soil moisture characteristics (readily) available moisture. Unsaturated flow: equations of subsurface flow, hydraulic conductivity relation, steady flow situations, computation of pressure profiles, moisture distributions, infiltration of water in dry soil. Methods to determine the saturated hydraulic conductivity saturated media and the hydraulic conductivity relation in unsaturated media. Parameters that determine evapotranspiration, methods to estimate potential evapotranspiration; relation between actual evapotranspiration and soil moisture situation. Procedure to estimate crop water-, leaching- and irrigation requirements.
Estimating the potential crop yield in relation to atmospheric conditions; the actual evapotranspiration in relation to soil moisture conditions and the actual crop yield and crop production under limited water supply.

3 Irrigation Methods

Surface and sub-surface irrigation, sprinkler and drip irrigation, surface irrigation methods (furrow, border and basin): classification, advance and recession curves, operational aspects, efficiency and uniformity definitions, recent developments, application of WinSRFR programme to evaluate the performance of various irrigation systems.

4 Applied Hydraulics of Irrigation Systems I

Classification of flow types in irrigation systems; energy and momentum principle, uniform flow; water surface profiles. Application of the energy principle and continuity concept in irrigation systems, e.g. flow over control sections, sills and contractions, outflow problems. Specific phenomena like the hydraulic jump, spillways, energy dissipation in general and small stilling basins. Gradually varied flow; basic equations and simplified equation for prismatic channels; determination of flow profiles. Computation of gradually varied flow in channels by direct integration and numerical methods. Exercise gradually varied flow. CANDES to design the dimensions of irrigation canals in view of erosion and sedimentation. FLOP to calculate gradually varied flow profiles in open (semi) prismatic channels based on either Manning or Chezy. Checking the design of irrigation and drainage canals under (semi) steady flow conditions.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction - Irrigation and Drainage Systems	4	0	2	0	0	0	6	14	L.G. Hayde
2	Agronomy and Soil Water Plant Relations	14	0	12	0	0	0	26	54	D.E. Eisenhauer
3	Irrigation Methods	8	4	6	0	0	0	14	34	R.H. Cuenca
4	Applied Hydraulics of Irrigation Systems I	8	6	8	0	0	0	16	38	L.G. Hayde
	Total	34	10	28	0	0	0	62	140	

Education Material

Lecture notes	Depeweg, H.W.Th., 1998. Field Irrigation and Drainage - Surface Irrigation Methods, LN0213/98/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Gradually Varried Flow, LN0443/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Manual Flop - Gradually Varried Flow Profiles, LN0333/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Supplementary notes,LN0442/11/1
Lecture notes	Hayde,L.G., 2011. Applied Hydraulics - Synopsis, LN 0378/11/1
Lecture notes	L.G. Hayde, 2016. Basic Principles of Irrigation and Drainage - ln0439/16/1
Lecture notes	de Laat, P.J.M., 2011. Soil-Water-Plant Relations, LN006/11/1

Scientific Software

Basdev

Furdev

flop

M3389

River Basin Development and Environmental Impact Assessment

Term	201819T03
Coordinator	I. Masih
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

This is a compulsory module for MSc Participants of Hydraulic Engineering and River Basin Development.

Prerequisites

Working knowledge and keen interests in topics such as hydrology, water availability and demand, environmental issues, river basin development, planning and management is an advantage.

Learning Objectives

1 Explain and evaluate the concepts and approaches for sustainable river basin development in a given context

2 Explain integrated river basin planning and management framewroks and appraise basin development and management plans

3 Describe the principles, approaches and practices of environmental impact assessment (EIA)

4 Apply range of tools and models (e.g. problem tree, water allocation modelling, EIA, cost-benefit analysis, multi-criteria analysis) to develop scientifically sound river basin development strategies

5 Effectively work in teams to evaluate and develop river basin plans and clearly communicate the outcomes in written and oral forms

Assessments

%	Type	Name
20	Assignment	Assignment presentation: modelling outcomes for supporting planning process
15	Assignment	EIA Report
15	Assignment	River basin development and planning
50	Written examination (closed book)	Written Examination

Topics

1 River basin development and sustainability

In this topic, the participants will study variouse concepts and approaches related to river basin development and management including river basin development trajectory, integrated water management, water allocation, transboundary water management, sustainability for a given context, sustainable development goals and relevance for river basin development. The participants will also apply these concepts and approaches while studying the given case study basins.

2 River basin planning and management

The participants will be familiarized with different frameworks for conducting a river basin planning process. They will learn major steps in a planning process such as Inception, situation analysis, strategy building, action planning and plan implementation. The lectures will also focus presenting data, tools and models applicable for developing a basin plan. The participatory planning process inclduing stakeholder analysis and participation will be crtically discussed. The participants will how to appraise a basin development plan for a given case study, based on some key features of a sound river basin plan.

3 Environmental Impact Assessment

In this part, the participants will learn the essentials of an environmental assessment. They will be familiarized with key components of an environmental impact assessment including screening, scoping & alternatives, impact analysis, mitigation management, reporting, reviewing decision, implementation & follow-up. The application of these steps to a case study will also be carried out by the participants. Moreover, the participants will be made familiar with the practices of EIA across different country through case study presentations.

4 Hands on training on tools and models

In a guiding workshop settings, the participants will learn how to apply river basin allocation models (with Ribasim software). This activity will be based on a design exercise for a given case study basin. Few other tools will also be introduced such as cost-benefit analysis, scorecard and multi-criteria analysis. The participants will develop a river basin development strategy, which will be underpinned by the application of range of different tools and models they have learned in this course such as Ribsim model, cost-benefit analysis, EIA and MCA.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	River basin development and sustainability	10	4	4	0	0	0	14	38	I. Masih, P. van der Zaag
2	River basin planning and management	6	4	4	0	0	0	10	26	I. Masih
3	Environmental Impact Assessment	10	8	8	0	0	0	18	46	A. Mendoza - Sammet, V.T. Langenberg
4	Hands on training on tools and models	4	6	14	0	0	0	18	32	I. Masih, W.N.M. van der Krogt
	Total	30	22	30	0	0	0	60	142	

Education Material

Scientific journal	Ahmad and Wood, 2002. A comparative evaluation of the EIA systems in Egypt, Turkey and Tunisia. Environmental Impact Assessment Review 22: 213-234
Lecture notes	Clouting, H., Beevers, L. and Vis, R. Environmental impact assessment of water related projects. IHE Delft Lecture notes
E-book	GWP and INBO. 2009. A handbook for integrated water resources management in basins
Scientific journal	Molle 2009_River basin planning and management: The social life of a concept. Geoforum 40: 484-494
Scientific journal	Vorosmarty et al 2018_Ecosystem-based water security and the sustainable development goals. Ecohydrology & Hydrobiology (in press).

Scientific Software

Ribasim

M3326

Urban System Analysis, Planning and Management: An Introduction

Term	201819T03
Coordinator	M. Radhakrishnan
Credit points	5.000000000
Specialization	Sustainable Urban Water Management

Target Group

SUWM programme students

Prerequisites

Basic knowledge on hydrology

Good knowledge of hydraulics

Good understaning of the field of water science and engineering as well as identify its different specialisations

Learning Objectives

1 Describe Integrated urban water management frameworks, urban water cycle components and their interrelations
2 Recognise systems thinking and analysis in relation to cities
3 Identify a range of tools and methodologies that are useful to effectively discover, learn and design urban water systems
4 Relate the links between urban water cycle, urban planning, design and implementation processes
5 Compare the various planning and management aspects that are prevalent in their cities
6 Explain the lack of integration and constraints in the environment which hinders systems approach in cities

Assessments

%	Type	Name
25	Assignment	Policy brief on Urban systems analysis, planning and Management
25	Presentation	Understanding Urban Systems, analysis, planning and management
50	Written examination (closed book)	Urban Systems Analysis Planning and Management

Topics

1 Introduction to Urban Systems

This topic will cover the following aspects

- Scope of course, changing landscape, challenges
- Historical context, current state, Future visions
- What is a city? Subsystems of a city and their interactions
  - Technical systems (Drinking water, sewerage, urban drainage, transportation, energy, etc.)
  - Social and institutional systems
- Mapping relationships between urban systems

2 Concepts of Sustainability, Resilience and Livability

- Theory of sustailability, resilience and liveability
- Application in urban context
- Sustainable Development Goals (SDGs), City Indexes,

3 Managing cities

- Interactive City profiling
- Urban planning: Current practices & paradigm shifts in planning
- Urban governance: top-down vs bottom up; City to City Learning
- Environmental management
- General Economic principles in urban water management context
- Asset management
- Elements of modelling: Water transport and distribution, Sewerage, Urban drainage and Flooding

4 Towards Green Citites

- Sponge cities in global context
- Role of 'green' in making cities liveable
- Urban systems analysis based on sytems approach

5 Reflection and design workshop

- Reflection
- Cocreating the terms of reference for analysing, planning and management of urbansystems in Sponge cities
- Introduction to online module

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to Urban Systems	10	0	4	0	0	0	14	34	C. Zevenbergen, M. Radhakrishnan, M.E. Kooy
2	Concepts of Sustainability, Resilience and Livability	7	0	5	0	0	0	12	26	M. Radhakrishnan
3	Managing cities	10	0	10	0	0	0	20	40	C. Zevenbergen, E.R. Raj, M. Radhakrishnan, P.D.A. Pathirana, Y. Jiang
4	Towards Green Citites	8	0	0	0	0	0	8	24	C. Zevenbergen, K.A. Irvine
5	Reflection and design workshop	2	0	10	0	0	0	12	16	
	Total	37	0	29	0	0	0	66	140	

Education Material

Digital files	Asset Management
Digital files	Concepts of Sustainability, Resilience and Livability
Handout	Introduction to Urban systems
Digital files	Managing cities- Urban planning, Governence, Environmental management, General economic principles
Book	Sponge Cities
Scientific journal	Sponge cities in Global context
Digital files	Systems theory and Systems approach

Scientific Software

Epanet

SWMM

M3090

Data Collection and Analysis and Design

Term	201819T04
Coordinator	M.G.F. Werner
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

Engineers, geoscientists, and other professionals that need to have a sound foundation in data collection and analysis, including field monitoring techniques, remote sensing & GIS methods.

Prerequisites

Experience with basic statistics, basic GIS & Remote Sensing, and hydrology and hydraulics are welcome

Learning Objectives

1 1 Gain an in-depth knowledge of the monitoring schemes and field techniques for water and sediment sampling.

2 2 Be able to apply methods for validation and processing of data, including developing flood frequency statistics.

3 3 Gain an introduction to the concepts of deterministic and probabilistic design for river and coastal structures.

Assessments

%	Type	Name
10	Assignment	Data Collection in the River Basin
40	Written examination (closed book)	Data Collection in the River Basin
20	Assignment	Deterministic and Probabilistic Design
30	Written examination (closed book)	Examination Deterministic and Probabilistic Design

Topics

1 Data collection in the River Basin

Collection, management, and analysis of data in the river basin; Data measurement and analysis of data for water resources, including sediments, and deriving statistical properties of time series such as for flood frequency analysis etc.

2 Deterministic & Probabilistic Design

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Data collection in the River Basin	24	0	16	0	0	0	40	88	F. Diermanse, M.G.F. Werne
2	Deterministic & Probabilistic Design	12	0	14	0	0	0	26	50	M.G.F. Werner
	Total	36	0	30	0	0	0	66	138	

Education Material

Lecture notes 2 Hand-outs and Lecture Notes provided by the instructor, reading list

Lecture notes Hydrometry, W. Booiten, 3rd Edition, UNESCO-IHE Lecture Notes Series, 2008

Scientific Software

HEC-SSP

M3252

Design Aspects of Irrigation and Drainage

Term	201819T04
Coordinator	L.G. Hayde
Credit points	5.000000000
Specialization	Land and Water Development for Food Security

Target Group

Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development.

Prerequisites

Good knowledge of global, regional and local land and water development perspectives, irrigation and drainage systems, soil characteristics and irrigation agronomy.

Learning Objectives

1 Make a preliminary layout and design of gravity irrigation and drainage networks.
2 Analyse, evaluate and apply the hydraulic principles for pipe flow in irrigation and drainage engineering.
3 Assess the need and implications of drainage
4 Determine the requirements for water table in irrigated area and design a subsurface drainage system

Assessments

%	Type	Name
31	Written examination (closed book)	Applied Hydraulics of Irrigation Systems II
45	Assignment	Irrigation and Drainage Main System Design
24	Assignment	Main and Subsurface Drainage

Topics

1 Irrigation and Drainage Main System Design

Layout and design of primary and secondary irrigation and drainage networks, including canals, drains, roads, farms, and tertiary blocks. Types, specifications and locations of various irrigation and drainage structures. Longitudinal terrain and water level profiles of one irrigation canal and one drain through the whole project area, also indicating design parameters and structures. Typical cross-sections of the (above) irrigation and drainage canals.

Topics

2 Applied Hydraulics of Irrigation Systems II

Pipe flow: main dimensionless numbers, theory and application of the momentum principle in pipes, the Moody diagram. Pipe flow equations; Colebrook-White, Chezy, Hazen and Williams. Minor losses in pipes, pipe bends and other components.

3 Main and Subsurface Drainage

The need for drainage: water ponding, water logging and salinisation. Components of a surface drainage system. Factors related to drainage: agricultural objectives, environmental aspects, and soil and hydrological conditions. Drainage design criteria and layout.
Drainage design equations: principles and applications.

Components of subsurface drainage systems. Subsurface drainage design considerations: design criteria and layout. Subsurface drainage design equations: principles and applications. Preparation of the layout and design of a subsurface drainage system.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Irrigation and Drainage Main System Design	8	0	13	0	0	9	30	64	P. Karimi
2	Applied Hydraulics of Irrigation Systems II	12	0	8	0	0	0	20	44	L.G. Hayde
3	Main and Subsurface Drainage	7	4	7	0	0	0	14	32	H.P. Ritzema
	Total	27	4	28	0	0	9	64	140	

Education Material

Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Supplementary notes,LN0442/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics; Pipe flow, LN0444/11/1
Lecture notes	Hayde,L.G., 2011. Applied Hydraulics - Synopsis, LN 0378/11/1
Lecture notes	L.G. Hayde, 2007. Canal design – ln0326/13/1
Lecture notes	L.G.Hayde, 2011. Irrigation and Drainage System Design - ln0321/13/1
Lecture notes	Ritzema, H., 2009. Main Drainage Systems, LN0340/09/1
Lecture notes	Ritzema, H., 2014. Subsurface Drainage LN0125/14/1

Scientific Software

candes

M3244

Modelling Theory and Computational Hydraulics

Term	201819T04
Coordinator	I.I. Popescu
Credit points	5.000000000
Specialization	Hydroinformatics: Modelling and Information Systems for Water Management

Target Group

Hydroinformatics participants

Prerequisites

Basic Mathematics ; Hydraulics & Computational Fluid Dynamics ;

Learning Objectives

1	Explain the structure of the 1D, 2D and 3D flow equations as representations of conservation laws and know whe to use the full dynamic equations and their approximations
2	Understand and explain the foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, selecting modelling software
3	Understand and use main principles and methods of analysing and predicting models uncertainty; be able to develop computer code for analysing uncertainty of a hydrological model
4	Identify differential equations, as well as indicating the nature of the initial and boundary conditions for well posed problems.
5	Implement finite difference schemes to solve differential equations.
6	Analyse a numerical scheme and indicate its behaviour, as well as implement different numerical schemes for solution of equations used in water related problems.

Assessments

%	Type	Name
25	Written examination (closed book)	Equations of Water Flows
25	Oral examination	Modelling Theory and Uncertainty
20	Assignment	Numerical Methods I
30	Written examination (closed book)	Numerical Methods I

Topics

1 Equations of water flows

Basic concepts; basic physical laws; mass, momentum and energy fluxes; Eulerian equations; differential forms in common use; De Saint Venant equations; unsteady flow in pipes; Navier-Stokes equations; 3D Navier-Stokes equations to De Saint Venant equations; advection and diffusion; dimensional and order of magnitude analyses

2 Modelling theory and uncertainty

Foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, sequence of steps in building a model, selecting modelling software, use of models by decision makers and other stakeholders. Essence of data collection and analysis, model
calibration and testing, models integration. Analysis of a number of examples of using models in solving water-related issues (floods, urban water). Main principles and methods of analysing and predicting models uncertainty, with exercises (using MATLAB)

3 Numerical methods I

Introduction to numerical solutions of difefrential equations used in fluid dynamics. Initial and boundary value problems, method of characteristics, finite differences for ODEs and PDEs. Consistency,stability, convergence of a numerical method. Exercises that will show the application of the numerical methods.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Equations of water flows	12	0	0	4	0	0	16	44	Mazzoleni, I.I. Popescu
2	Modelling theory and uncertainty	8	0	6	0	0	0	14	30	D. Solomatine
3	Numerical methods I	12	0	4	12	0	0	28	64	I.I. Popescu
	Total	32	0	10	16	0	0	58	138	

Education Material

Book	Popescu: Computational Hydraulics, IWA Publishing, 2014
Lecture notes	Popescu: Lecture notes on Numerical methods for Differential Equations
Lecture notes	Price: Lecture notes on Mathematical Basis of Computational Hydraulics

Scientific Software

Matlab

M3165

Port Planning and Infrastructure Design

Term	201819T04
Coordinator	A. Dastgheib
Credit points	5.000000000
Specialization	

Target Group

This course is useful for engineers involved in the design and/or supervision of ports and coastal structures. Having knowledge about the coastal processes such as wind, waves, tides and tidal currents is necessary

Prerequisites

Short Waves, Tides and Tidal Currents,

Learning Objectives

1 List different types of Sea going vessels and identify the main characteristics of the ship and Explain the International functions of a port, governance and economic and financial aspects of port management

2 Explain the administration models of ports and the various steps in port masterplanning

3 Determine the main dimensions of the Terminals in the port. Determine the alignment and dimensions of the approach channel base on the PIANC guideline and the main dimensions of the wet infrastructure in the port

4 Choose the equipments needed in a Container Terminal and Design the Terminal

5 Design the layout of the port and the details of berthing facility for different type of berths and Evaluate a port layout based on multi-criteria analysis

6 Include uncertainty in port planning and management

Assessments

%	Type	Name
1	Assignment	Port Planning and Marine Structures

Topics

1 Maritime transport

Overview of main maritime trade routes, different sea going vessels and different commodities

2 Port Planning

2.1 Port Functions

2.2 Introduction to Master Planning

2.3 Adaptive Port Planning

2.4 Design of Wet Areas

Topics

2.5 Design of General cargo/ Multipurpose/ RoRo Terminals

2.6 Container Terminals

2.7 Queuing theory and traffic simulation

2.8 Design of Liquid Bulk Terminals

2.9 Design of Dry Bulk Terminals

2.10 Design of LNG Terminals

3 Marine Structures

4 Excursion Port of Rotterdam

5 Serious game on container terminals

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Maritime transport	0	0	4	0	0	0	4	4	A. Dastgheib
2	Port Planning	0	0	0	0	0	0	0	0	A. Dastgheib
2.1	Port Functions	2	0	0	0	0	0	2	6	M. van Schuylenburg
2.2	Introduction to Master Planning	2	0	0	0	0	0	2	6	M. van Schuylenburg
2.3	Adaptive Port Planning	2	0	0	0	0	0	2	6	P. Taneja
2.4	Design of Wet Areas	4	0	0	0	0	0	4	12	A. Dastgheib
2.5	Design of General cargo/ Multipurpose/ RoRo Terminals	2	0	0	0	0	0	2	6	P Quist
2.6	Container Terminals	4	0	0	0	0	0	4	12	C.J. Klaver
2.7	Queuing theory and traffic simulation	6	0	0	0	0	0	6	18	A. Dastgheib
2.8	Design of Liquid Bulk Terminals	0	0	2	0	0	0	2	2	P Quist
2.9	Design of Dry Bulk Terminals	0	0	2	0	0	0	2	2	J.G.C. Smits
2.10	Design of LNG Terminals	0	0	2	0	0	0	2	2	J.S.F.M. Huisman
3	Marine Structures	14	12	8	0	0	0	22	62	L.A.M. Groenewegen
4	Excursion Port of Rotterdam	0	0	0	0	8	0	8	8	A. Dastgheib
5	Serious game on container terminals	0	0	4	0	0	0	4	4	A. Dastgheib
	Total	36	12	22	0	8	0	66	150	

Education Material

Scientific Software

M2367

Surface Hydrology

Term	201819T04
Coordinator	R.G.W. Venneker
Credit points	5.000000000
Specialization	Hydrology and Water Resources

Target Group

Students WSE/HWR Programme

Prerequisites

Previous modules in the WSE/HWR Programme

Learning Objectives

1 Explain the global hydrological cycle and water budget, the global energy budget, and the relation between, hydrology, climate, soils and vegetation.

2 Explain the surface hydrological processes related to evapotranspiration, soil water movement and rainfall-runoff dynamics, and the concepts and theories that describe the physics of these processes.

3 Independently apply the understanding with analytical methods and conceptual models to quantitatively assess th surface hydrology for situations at catchment scales.

Assessments

%	Type	Name
30	Assignment	
70	Written examination (closed book)	Written exam

Topics

1 Radiation, energy and hydrological balances

The role and physical description of radiation and energy balances and the relation with the hydrological cycle. Climate, climate change and the relation with hydrology. Land surface hydrological processes and interactions with the atmosphere, and the relationships between hydrology, hydrology, climate vegetation and soils. Precipitation processes and the physics of evaporation and energy exchange between the land surface and the atmosphere.

2 Soil water and evaporation

Application of practical methods for open water evaporation, potential evaporation and transpiration and actual evapotranspiration. Concepts to describe soil water transport and derivation of relations between hydraulic properties and soil water characteristics. Practical methods to compute infiltration, water movement in the unsaturated zone and the availability of soil water for crops.

Topics

3 Conceptual catchment modelling

Types of models and the use of conceptual models for rainfall-runoff modelling. Catchment hydrograph analysis and application to simulating runoff components. Model performance criteria, calibration and validation methods.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Radiation, energy and hydrological balances	12	6	0	0	0	0	12	42	R.G.W. Venneker
2	Soil water and evaporation	8	0	4	0	0	0	12	28	J.W. Wenninger, R.G.W. Venneker
3	Conceptual catchment modelling	6	0	6	0	0	0	12	24	J.W. Wenninger
	Total	26	6	10	0	0	0	36	94	

Education Material

Lecture notes	Soil-Water-Plant Relations, lecture notes
Lecture notes	Surface Hydrology, lecture notes
Lecture notes	Workshop Hydrology, lecture notes

Scientific Software

M3343
Urban Drainage and Sewerage

Term	201819T04
Coordinator	A. Sanchez Torres
Credit points	5.000000000
Specialization	Core Program

Target Group

Professionals interested in achieving and maintaining proper functioning of urban drainage and sewerage systems, the environment and public health. Typical students include civil, process and sanitary engineers, university faculty and researchers, and technical managers.

Prerequisites

The same as the specializations' (SE, UWEM) pre-requisites and having followed all the preceding modules.

Learning Objectives

1	Describe the chemical and biological processes that take place within sewer systems, and evaluate their implications for the design and operate of urban drainage systems
2	Explain the standard practice in designing urban drainage systems. Prepare drainage system designs by integrating information on hydrological, hydraulic, economic and practical engineering concerns.
3	Critically assess and analyse quantity and quality characteristics of stormwater and wastewaters originating from urban environments as a basis for the design, operation and maintenances of urban drainage system facilities.
4	Be able to judge different design options and alternative scenarios

Assessments

%	Type	Name
15	Assignment	Computer workshops and Individual assignment
25	Assignment	Design Exercises
60	Written examination (closed book)	Intro. to urban drainage and sewerage, Rainfall characteristics, Dry and wet weather flows, Review of hydraulics, Sewer processes, Sewerage layout and design.

Topics

1 Introduction to urban drainage and sewerage and types of drainage and sewer system

Purpose, types and historical development, system components and layout.

2 Urban hydrological processes

Urban hydrology, processing IDF curves and rainfall - runoff

3 Hydraulics of urban drainage and sewerage

Review of hydraulic principles, free surface flow equations and pipe flow.

4 Dry and wet weather flows quantitative characterization and exercise

Estimation of wastewater quantitites and review of main charateristics of wastewater quality.

5 Sewerage layout and design

Layout generation and design principles applied to urban drainage and sewerage networks.

6 Conventional sewer design exercise

Hands-on exercise to analise a practical case, with real data to applied the design principles and procedures learnt during the lectures. The exercises expose the students to define boundaries, layouts, assumptions, loads and to do hydraulic calculations by hand or with excel.

7 LAB BOD/COD

Basic principles of pumps operation and selection.

8 Sewer processes

Review of processes and transformations occurring in sewer netwroks, gas formation,sewer odors, corrosion and modelling exercises to mitigate them.

9 Data acquisition for urban drainage and sewerage studies

Review of data requirements to analyse the preformance of sewer networks, monitoring, spatial data, geometry data, flows and water levels, etc.

10 Model-based design and simulation

Introduction to modeling sewer networks, proformance assessment and evaluation of mitigation measures. Design approach using modeling tools.

Topics

11 Field trip

Site visit to the city of Rotterdam, Participants get expose and visit some mitigation multi-functional measures to alleviate flooding problems around the city center of Rotterdam.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to urban drainage and sewerage and types of drainage and sewer system	2	0	0	0	0	0	2	6	A. Sanchez Torres
2	Urban hydrological processes	6	0	2	0	0	0	8	20	P.D.A. Pathirana
3	Hydraulics of urban drainage and sewerage	4	0	2	0	0	0	6	14	A. Sanchez Torres, S. Maskey
4	Dry and wet weather flows quantitative characterization and exercise	4	0	0	0	0	0	4	12	D. Brdanovic
5	Sewerage layout and design	2	0	0	0	0	0	2	6	A. Sanchez Torres
6	Conventional sewer design exercise	1	0	0	0	0	8	9	27	A. Sanchez Torres, J.A.E. ten Veldhuis
7	LAB BOD/COD	0	0	2	0	0	0	2	2	J.L.C.M. van de Vossenberg
8	Sewer processes	8	0	12	0	0	0	20	36	A.H. Nielsen, J. Vollertsen
9	Data acquisition for urban drainage and sewerage studies	2	0	0	0	0	0	2	6	Z. Vojinovic
10	Model-based design and simulation	2	0	4	0	0	0	6	10	A. Sanchez Torres, Z. Vojinovic
11	Field trip	0	0	0	0	3	0	3	3	A. Sanchez Torres
	Total	31	0	22	0	3	8	64	142	

Education Material

Book	Sewer Processes. (2013). Thorkild Hvitved-Jacobsen, Jes Vollertsen, Asbjørn Haaning Nielsen. CRC Press
Book	Urban Hydroinformatics (2011). Roland Price and Zoran Vojinovic. IWA Publishing

Scientific Software

ArcGIS

Mike Urban

M3350

Asset Management

Term	201819T05
Coordinator	P.D.A. Pathirana
Credit points	5.000000000
Specialization	Core Program

Target Group

Engineers and Managers of organizations involved in Water, Wastewater, Drainage and Flood management in cities. However, this course assumes very little as pre-requisites, so, if you are from another discipline, but interested in the content (see description and learning objectives below), you are welcome to apply.

Prerequisites

A first degree in Engineering, Science or a related field. However,enthusiastic participants who possess degrees of different backgroundswould be admitted on case-by-case basis.

Learning Objectives

1 Explain the historical processes that made asset management approach important for urban infrastructure engineers and managers and describe the drivers that make asset management crucial for sustainable provision of water related infrastructure services

2 o Define asset management in your own words. List and describe the essential steps of an asset management plan and provide example problems from one’s own experience which asset management approach would be/ would have been able to solve;

3 Describe the techniques used in asset inventories (e.g. condition rating) and describe the importance of data for asset management process.

5 Explain Risk-based asset management decision making. Apply hydraulic modelling to establish significance of asset components of water distribution/drainage systems;

6 Describe asset condition modelling approaches. Recommend suitable modelling approaches for practical problems and appraise the recent developments in the field of Asset Management of water infrastructure.

7 Describe the concept of asset life-cycle costing. Perform LCC calculations using spreadsheet; o Describe the role of optimization in asset management. Apply optimization techniques for solving simple urban water problems.

Assessments

%	Type	Name
0,5	Assignment	All assignments including workshops and homework
0,5	Oral examination	

Topics

1 Introduction + Overview of the course

Topics

2 **Asset Inventory**

6 **Risk-based decision making in AM**

7 **Risk-based decision making - workshop**

8 **Condition Modelling**

9 **Condition Modelling exercise**

10 **Field trip**

11 **Advancements in Asset Management**

12 **Economics of AM**

13 **Failure registration in AM**

14 **Special considerations in applying AM in developing countries**

15 **Historical context of modern Asset Management**

16 **Sustainable Water Services and AM**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction + Overview of the course	1	0	0	0	0	0	1	3	P.D.A. Pathirana
2	Asset Inventory	2	0	0	0	0	0	2	6	B. Gersonius
6	Risk-based decision making in AM	2	0	0	0	0	0	2	6	P.D.A. Pathirana
7	Risk-based decision making - workshop	1	0	8	0	0	0	9	11	P.D.A. Pathirana
8	Condition Modelling	8	0	0	0	0	0	8	24	
9	Condition Modelling exercise	0	0	10	0	0	0	10	10	
10	Field trip	0	0	0	0	8	0	8	8	P.D.A. Pathirana
11	Advancements in Asset Management	6	0	2	0	0	0	8	20	P.D.A. Pathirana
12	Economics of AM	2	0	0	0	0	0	2	6	J.A. van Dijk
13	Failure registration in AM	2	0	0	0	0	0	2	6	W. Veerbeek
14	Special considerations in applying AM in developing countries	2	0	2	0	0	0	4	8	P.D.A. Pathirana
15	Historical context of modern Asset Management	1	0	0	0	0	0	1	3	P.D.A. Pathirana
16	Sustainable Water Services and AM	6	0	0	0	0	0	6	18	P.B. Sayers
	Total	33	0	22	0	8	0	63	129	

Education Material

Scientific Software

M3330

Coastal Systems

Term	201819T05
Coordinator	R.W.M.R.J.B. Ranasinghe
Credit points	5.000000000
Specialization	

Target Group

Students in coastal engineering and port development

Prerequisites

Basic knowledge of waves and hydraulics

Learning Objectives

1 understand the governing processes in coastal hydrodynamics and morphology

2 assess processes related to salt intrusion and density currents;

3 apply understanding of hydrodynamic and morphological processes in diverse coastal environments, such as reefs, mangroves and rocky coasts

4 Understand estuarine morphological processes

Assessments

%	Type	Name
0,2	Assignment	Coastal hydrodynamics and sediment transport
0,2	Assignment	Estuarine morphodynamics and salt water intrusion
0,6	Written examination (open book)	Written exam Coastal Systems

Topics

1 Coastal Hydrodynamics and Morphology

Estuarine morphodynamics; salt intrusion; inlet morphodynamics

2 Coastal Hydrodynamics and Morphology

Wave energy balance; Longshore currents; wind driven circulation; tides in shallow seas; coastline models; sediment transport;

Topics

3 Coastal Hydrodynamics and Morphology

Coastline and beach types; surf zone cross-shore hydrodynamics; introduction to rip currents; Cross-shore morphodynamics; beach states; introduction to coastal models

4 Coastal hydrodynamics and morphology

Hydrodynamics and morphodynamics of coral reefs and mangroves

5 Barrier island coasts

Geomorphology of barrier island systems; processes governing long-term change of tidal basins

6 Rip currents

Infragravity waves and associated hydrodynamics; rip current generation and evolution

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Coastal Hydrodynamics and Morphology	10	0	4	0	0	0	14	34	M. van der Wegen
2	Coastal Hydrodynamics and Morphology	8	0	16	0	0	0	24	40	J.A. Roelvink
3	Coastal Hydrodynamics and Morphology	10	0	0	0	0	0	10	30	R.W.M.R.J.B. Ranasinghe
4	Coastal hydrodynamics and morphology	4	0	0	0	0	0	4	12	J.A.H. Reyns
5	Barrier island coasts	4	0	0	0	0	0	4	12	A.J.F. van der Spek
6	Rip currents	4	0	0	0	0	0	4	12	M.A. de Schipper
	Total	40	0	20	0	0	0	60	140	

Education Material

Lecture notes — Os, A.G. van, Salt intrusion and density currents - Lecture notes In 0286/98/

Scientific Software

Matlab

M3412

Hydraulics and Remote Sensing for River Basin Development

Term	201819T05
Coordinator	P. Paron
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

Students and professionals with a basic knowledge of hydraulics, hydrology and earth science

Prerequisites

Basic knowledge of hydraulics

Learning Objectives

1 classify different types of fluid motion conditions in open channel flow

2 apply mass, energy and momentum conservation laws to solve problems in hydraulic engineering

3 compute fundamental flow variables in pressure-flow systems

4 apply the appropriate models to the analysis of Gradually and Rapidly Varying Flow (GVF-RVF) conditions in open channel flow

5 search and select freely available remote sensing data

6 carry out image interpretation and classification

7 select and use the appropriate remote sensing data and tools for water resources monitoring

Assessments

%	Type	Name
20	Written examination (closed book)	Hydraulics
15	Assignment	Open-channel flow
15	Assignment	Pipe flow
50	Assignment	Remote Sensing

Topics

1 Hydraulics

1. Fundamentals of fluid mechanics
2. Conservation laws: mass, momentum, energy
3. Pressure-flow:
   - steady flow in simple systems
   - steady flow in networks
   - unsteady flow in simple systems
4. Open channel flow:
   - Uniform flow in compact and compound channels
   - Steady flow:
     - Gradually Varied flow
     - Rapidly Varied Flow
   - Unsteady flow:
     - Kinematic wave
     - Diffusive wave
     - Dynamic wave
5. Introduction to Turbulence in open channel flows

2 Remote Sensing for Water Resources

(1) Review of basic concepts and foundations of optical RS. (2) Freely available data sources and software. (3) Digital image processing: enhancement, filtering, and band combination. (4) Compound indexes for water resource analysis. (5) Digital image analysis: spectral profiles, supervised and unsupervised classification. (6) River Remote Sensing: methods and data to analyse river characteristics and changes. (7) Multitemporal analysis (land use/land cover, soil moisture, lake and river channel changes, river bathymetry, flood extent, etc). (8) (Kite) Aerial Photography and UAV principles.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Hydraulics	18	2	12	0	0	0	30	68	A. Cattapan, M.J. Franca
2	Remote Sensing for Water Resources	20	0	6	2	0	0	28	70	C.I.B. Michailovsky, M.J. Smith, P. Paron
	Total	38	2	18	2	0	0	58	138	

Education Material

Handout — Handouts, reading list will be provided by lecturers

Scientific Software

Epanet
HEC-RAS
Multispec
Photoscan
ROCLAB

M3447

Irrigation and Drainage Design

Term	201819T05
Coordinator	F.X. Suryadi
Credit points	5.000000000
Specialization	Land and Water Development for Food Security

Target Group

Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development (LWDFS)

Prerequisites

Irrigation agronomy, applied hydraulics, plant water relationships

Learning Objectives

1 Analyse, evaluate and apply the hydraulic principles in irrigation and drainage engineering.

2 Present, process and interpret results of hydraulic laboratory measurements in a technical report

3 Assess the need and implication of proper irrigation and drainage management for salinity control

4 Prepare detailed irrigation and drainage system layout and design that leads to optimum field water distribution uniformity, optimum productivity, minimizes costs, mitigates conflicts and facilitates cooperation among beneficiaries.

Assessments

%	Type	Name
0	Lab. Report	Hydraulic Laboratory 2
55	Oral examination	Irrigation and Drainage - Tertiary Unit Design Assignment
35	Assignment	Precision irrigation design
10	Assignment	Salinity control

Topics

1 Irrigation and Drainage - Tertiary Unit Design

Detailed layout of basin and furrow tertiary units: Alternative canal, drainage and road networks that result in short canals and drains, compact field blocks with easily accessible roads, convenient irrigation delivery schedules; requires less water distribution, drainage and road structures, allow furrow length and basin size that deliver good water distribution uniformity (>80%) and good tertiary system efficiency (65 to 75%). The distribution uniformity and efficiency for furrow and basin irrigation systems are evaluated using Furdev and Basdev programmes respectively. Longitudinal profile of tertiary canals and drains as well as typical cross-sections of these canals.

Topics

2 Hydraulics Laboratory 2

Various types of measuring equipment. Various flow types: over a broad crested weir, through a contraction, underneath a gate. Gradually varied flow profiles. Forces due to flowing water. Discharge-depth relationship.

3 Precision irrigation design

Historical background, modern irrigation, definition, decision variables. Sprinkle irrigation: The sprinkler: classification of types; hydraulics, theoretical and empirical equations, water patterns; The lateral: distribution, length, diameter, spacing between the sprinklers, uniformity; The set: decision variables, uniformity and coefficients, winds, efficiency, automation, fertigation, control; Design procedures and considerations, analysis of factors affecting uniformity, optimal design of networks using Linear Programming. Planning: data, objectives, constraints, and optimisation. Economic evaluation. Drip irrigation: The emitter: types, hydraulics, theoretical and empirical equations; the lateral: hydraulics, length; The set: decision variables, uniformity, automation, control, fertigation.

4 Salinity control

Application of irrigation water means input of salts. What are the primary and secondary effects of salts for agricultural production. How to sustain a feasible production area considering a proper management of irrigation and drainage. Factors related to irrigation development: agricultural objectives, environmental aspects, and soil and hydrological conditions.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Irrigation and Drainage - Tertiary Unit Design	10	0	16	0	0	8	34	70	F.X. Suryadi
2	Hydraulics Laboratory 2	2	0	0	4	0	0	6	14	L.G. Hayde
3	Precision irrigation design	8	0	0	0	0	6	14	42	F.B. Reinders
4	Salinity control	5	0	0	0	0	0	5	15	P.H.J. Hollanders
	Total	25	0	16	4	0	14	59	141	

Education Material

Lecture notes	Depeweg, H.W.Th., 2001. Off-Farm Irrigation and Drainage - Design and Operation of Tertiary Units, LN0185/01/1
Handout	Van Hoorn and Van Alphen. Salinity control

Scientific Software

Basdev

Furdev

candes

M3340

Modelling and Information Systems Development

Term	201819T05
Coordinator	S.J. van Andel
Credit points	5.000000000
Specialization	Hydroinformatics: Modelling and Information Systems for Water Management

Target Group

Participants of WSE Programme - Hydroinformatics

Prerequisites

Modules 1-4

Learning Objectives

1 Develop a computer code for calculating free-surface flow in canals and provide interpretation of a series of tests involving various initial and boundary conditions

2 Use advanced GIS procedures and tools related to aquatic systems

3 Understand the process of river model building: data analysis, model calibration and verification.

4 Specify, design and build a prototype modelling system with a graphical user interface

Assessments

%	Type	Name
20	Assignment	Advanced GIS
20	Assignment	Modelling Systems Development
30	Assignment	Numerical Methods II
30	Assignment	River Modelling

Topics

1 Numerical methods II

Introduction to finite volume method. Introduction to finite element method. Exercises.

2 Advanced GIS

Exercises in GIS, advanced topics, and examples from practice.

3 River modelling

Application of 1D river modelling using Mike11 and Sobek modelling systems. Model development, calibration and validation.

Topics

4 Modelling systems development

Developing modelling and graphical user interface components of a water-based system using the Python or MATLAB environment.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Numerical methods II	8	0	0	10	0	0	18	44	I.I. Popescu
2	Advanced GIS	0	0	0	8	0	0	8	16	S. Velickov
3	River modelling	4	0	4	10	0	0	18	36	I.I. Popescu, K. Yan, S.J. va Andel
4	Modelling systems development	2	0	6	14	0	0	22	40	Chacon Hurtado, G.A. Corz Perez
	Total	14	0	10	42	0	0	66	136	

Education Material

Lecture notes	Popescu: Lecture notes on numerical methods
Lecture notes	Price: Lecture notes on modelling theory and practice

Scientific Software

Mike 11

sobek-RUR

M3425

Water Quality

Term	201819T05
Coordinator	M.E. McClain
Credit points	5.000000000
Specialization	Hydrology and Water Resources

Target Group

All WSE students

Prerequisites

No special prerequisites

Learning Objectives

1 Apply basic chemical principles and determine reactions that play a role in the determination and evolution of water quality.

2 Apply appropriate methods to monitor, analyze and assess the water quality characteristics of hydrological systems.

Assessments

%	Type	Name
40	Assignment	Hydrochemical Reactions and Processes
30	Lab. Report	Water Quality Laboratory Analyses and Data Interpretation
30	Assignment	Water Quality Monitoring and Assessment

Topics

1 Biogeochemistry

1.1 Forms and causes of water pollution

1.2 Carbon Cycling

1.3 Nutrient Cycling

2 Water Quality Monitoring

2.1 Water quality standards

2.2 Designing a monitoring program

2.3 Physico-chemical and bio-Monitoring

2.5 Case study - monitoring program design

Topics

3 Hydrochemistry

3.1 Introduction to hydrochemistry: parameters, units, sampling and graphical representations

3.2 Importance of rainwater for surface and groundwater quality

3.3 Minerals and water quality: reactions, solubility, carbonate and silicate chemistry

3.4 Redox processes

3.5 Cation exchange and seawater intrusion

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Biogeochemistry	0	0	0	0	0	0	0	0	M.E. McClain
1.1	Forms and causes of water pollution	2	0	0	0	0	0	2	6	
1.2	Carbon Cycling	1	0	3	0	0	0	4	6	
1.3	Nutrient Cycling	1	0	3	0	0	0	4	6	
2	Water Quality Monitoring	0	0	0	0	0	0	0	0	M.E. McClain
2.1	Water quality standards	1	0	0	0	0	0	1	3	
2.2	Designing a monitoring program	3	0	0	0	0	0	3	9	
2.3	Physico-chemical and bio-Monitoring	1	0	3	0	0	0	4	6	
2.5	Case study - monitoring program design	0	0	8	0	0	0	8	8	
3	Hydrochemistry	0	0	0	0	0	0	0	0	T.Y. Stigter
3.1	Introduction to hydrochemistry: parameters, units, sampling and graphical representations	2	0	2	0	0	0	4	8	T.Y. Stigter
3.2	Importance of rainwater for surface and groundwater quality	2	0	2	0	0	0	4	8	T.Y. Stigter
3.3	Minerals and water quality: reactions, solubility, carbonate and silicate chemistry	4	0	3	0	0	0	7	15	T.Y. Stigter
3.4	Redox processes	4	0	3	0	0	0	7	15	
3.5	Cation exchange and seawater intrusion	4	0	2	0	0	0	6	14	
	Total	25	0	29	0	0	0	54	104	

Education Material

Lecture notes Lecture Notes

Scientific Software

M3429

Computational Intelligence and Operational Water Management

Term	201819T06
Coordinator	D. Solomatine
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants of the WSE programmme (typically from specialisation "Hydroinformatics", and specialisation "Flood Risk Management"), participants of the short course "Computational Intelligence and Operational Water Management".

Prerequisites

Basic knowledge of statistics, hydrology and hydraulics.

Learning Objectives

1 Understand the principles and techniques of optimisation, and formulate and solve optimisation problems related to modelling and water management

2 Understand and apply the principles and techniques of real-time control, and anticipatory water management

3 Understand the main principles of data assimilation using Kalman filter and related techniques

4 Understand and apply data-driven modelling using computational intelligence techniques (neural networks, model trees, instance-based learning), and select proper methods and tools

Assessments

%	Type	Name
20	Assignment	Data driven modelling and computational intelligence
30	Written examination (closed book)	Data-driven modelling, computational intelligence, optimisation and data assimilation
25	Written examination (closed book)	Operational water management and real-time control
25	Assignment	Operational water management

Topics

1 Introduction to optimisation

Introduction to classical optimisation. Linear and non-linear optimisation. Derivative-based and direct methods. Notion of dynamic programming. Global (multi-extremum) optimisation. Randomized search, genetic and evolutionary approaches. Multi-objective optimization. Applications in water-related problems (model calibration, reservoir optimization, urban networks rehabilitation).

2 Operational water management

Introduction to operational water management and real-time control; modelling for control; optimal control problems; characterisation of control systems; operational forecasting; data assimilation

3 Introduction to data assimilation

Introduction to the main principles of model updating, data assimilation, Kalman filter, and its extensions. Exercise in developing a data assimilation scheme for a hydrological model.

4 Computational intelligence and data-driven modelling

Modelling in the framework of Hydroinformatics. Data-driven and physically based models. Overview of machine learning and computational intelligence. Main types of machine learning: classification, association, clustering, numeric prediction. Decision, regression and model trees. Artificial neural networks. Instance-based learning. Committees of models. Fuzzy logic and fuzzy rule-based systems. Exercise in applying computational intelligence techniques in building a data-driven rainfall-runoff model.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to optimisation	4	0	8	0	0	0	12	20	D. Solomatine
2	Operational water management	10	0	18	0	0	0	28	48	J.L. Alfonso Segura, S.J. van Andel
3	Introduction to data assimilation	4	0	0	0	0	0	4	12	
4	Computational intelligence and data-driven modelling	14	0	22	0	0	0	36	64	B. Bhattacharya, D. Solomatine
	Total	32	0	48	0	0	0	80	144	

Education Material

Lecture notes	Lobbrecht: Lecture notes on Real time control of water systems
Lecture notes	Solomatine. Lecture notes on Data-driven modelling.

Scientific Software

Epanet

Weka

M3369

Design of Breakwaters and Dikes

Term	201819T06
Coordinator	A. Dastgheib
Credit points	5.000000000
Specialization	Coastal Engineering and Port Development

Target Group

This course is useful for engineers involved in the design of breakwaters, Dikes and Revetments and/or the supervision of construction of them. Knowledge of the coastal processes such as wind, waves, tides and tidal currents is necessary.

Prerequisites

Short Waves, Tides and Tidal Currents, Coastal Processes

Learning Objectives

1 Understand the difference between alternative types of breakwaters and governing factors for their selection; Design breakwaters from conceptual to detailed and prepare the layouts and detailed cross-sections.

2 Understand the basic principles of physical scale model and know how to design such a model to test the design of coastal and port structures.

3 Carry out a basic design of dikes and revetments

Assessments

%	Type	Name
0,7	Assignment	Design of Breakwaters
0,3	Oral examination	Design of Dikes and Revetments

Topics

1 Design of Breakwaters

Types, functions, design procedure for breakwaters, data collection; soils, hydraulic conditions, construction materials, definition of requirements, governing parameters for breakwater design such as wave parameters, structural parameters, conceptual design, selection, preliminary design for rubble mound breakwaters, hydraulic response, structural response for rubble mound breakwaters , design of composite type, vertical wall and berm breakwaters,design of low crested and submerged structures, construction methods, case studies, physical modelling. Applications using BREAKWAT, exercise on design of rubble mound and vertical type breakwaters, exercise on scaling a design for physical modeling.

2 Design of Breakwaters Exercise

Topics

3 Design of Dikes and Revetments

Seadikes in The Netherlands, philosophy of dike design, definition of frequency of failure, risk analysis, design methodology for dikes, hydraulic boundary conditions, wave run-up and overtopping, geometrical design of dikes and revetments, stability for rock, artificial units, design criteria for placed block revetment, other types (bituminous, asphalt.. etc), other design considerations, geotechnical aspects related to dikes, overall stability, design of granular filter, geotextiles, geosystems, improvement and maintenance of dikes and revetments.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Design of Breakwaters	26	0	0	0	0	0	26	78	J.W. van der Meer
2	Design of Breakwaters Exercise	0	0	0	0	0	14	14	42	A. Dastgheib, J.W. van der Meer
3	Design of Dikes and Revetments	4	0	10	0	0	0	14	22	C. Dorst, J.W. van der Meer
	Total	30	0	10	0	0	14	54	142	

Education Material

Lecture notes	Breakwater Design; J.W. van der Meer, H. Ligteringen; ln0026/18
Lecture notes	Exercise Breakwater Design J.W. van der Meer, A. Dastgheib; ln0027/18

Scientific Software

Breakwat

M3399

Environmental Systems Analysis

Term	201819T06
Coordinator	K.A. Irvine
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in the Environmental Science MSc-programme at IHE

Prerequisites

Modules 1-4 of Environmental Science programme.

Learning Objectives

1 List and describe environmental systems analysis (ESA) concepts and methods
2 Identify how ESA can be applied to Ecosystem Services and applications of Environmental Technology
3 Perform a problem analysis and stakeholder analysis for a given socio-environmental system
4 Perform an analysis of drivers of change and their effect on ecosystem functions and services
5 Construct a simple dynamic simulation model of an environmental system
6 Discuss critically the strengths, weaknesses, missing information, advantages and disadvantages of the modelling and stakeholder analyses
7 Communicate effectively the methods, results and conclusions of a case study (presentation and written report)

Assessments

%	Type	Name
40	Written examination (closed book)	Ecosystem Services and Systems Analysis
50	Assignment	Individual report on the case study
10	Presentation	Stella model developed during the group work

Topics

1 Connecting ecosystem character with ecosystem services. Concept, application, and general use

An introduction to ecosystem character and type, including global biomes, prevailing pressures affecting structure and function, and how this relates to the concept of ecosystem services.

Topics

2 Drivers of change in ecosystems, and using the DPSIR framework to guide management

Exploration of the proximate and underlying drivers of ecosystem change and how this relates to emergent properties. Introduction to the Drivers, Pressures, State, Impact, Response framework for describing ecosystems and how these relate to each other. Evaluating options for management using DPSIR using examples from policy and the scientific literature

3 Modelling Biodiversity for identifying state and impact from pressures

Introduction and interactive sessions for global biodiversity assessment and modelling lake ecosystems

4 Stakeholder analysis

Identifying key stakeholders, and their roles within the DPSIR framework will lead to an exercise in assigning what impact they have on the ecosystem and influences in management.

5 Case study: modelling ecosystem functions and services

Working in groups participants will create a system model of each of a number of ecosystem case studies with defined pressures. This will apply knowledge acquired in the first part of the module.

6 Awareness of modelling frameworks in professional practice

An excusion to DELTARES in Delft will provide an introduction to a variety of modelling platforms and approaches that are used to help solve real world problems

7 Final presentation ESA

Each Group will present and describe the results of their modelling, identifying main challenges and overall summary of outputs

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Connecting ecosystem character with ecosystem services. Concept, application, and general use	8	0	0	0	0	0	8	24	A.A. van Dam, K.A. Irvine
2	Drivers of change in ecosystems, and using the DPSIR framework to guide management	8	0	2	0	0	0	10	26	A. Mendoza - Sammet, E.R. Raj, K.A. Irvine
3	Modelling Biodiversity for identifying state and impact from pressures	6	0	2	0	0	0	8	20	A.A. van Dam, J.H. Janse
4	Stakeholder analysis	2	16	0	0	0	0	2	22	A. Mendoza - Sammet
5	Case study: modelling ecosystem functions and services	4	0	28	0	0	0	32	40	A. Mendoza - Sammet, E.M.A. Hes, K.A. Irvine
6	Awareness of modelling frameworks in professional practice	0	0	0	0	4	0	4	4	A.L. Zuijdgeest, K.A. Irvine
7	Final presentation ESA	0	0	4	0	0	0	4	4	A. Mendoza - Sammet, E.M.A. Hes, K.A. Irvine
	Total	28	16	36	0	4	0	68	140	

Education Material

Scientific Software

stella

M3449

Management of Irrigation and Drainage Systems

Term	201819T06
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	

Target Group

All Land and Water Development participants, and those interested in the management aspects of irrigation and drainage systems.

Prerequisites

Agronomy, irrigation methods, socio-economic and environmental aspects of irrigation, irrigation flow control and conveyance

Learning Objectives

1 Evaluate objectives, tasks and types of irrigation management arrangements and its implications for irrigation peformance

2 Demonstrate the role of property creation for the management and development of irrigation and drainage system

3 Discuss the importance of the social aspects that define the feasibility, implementation and continuation of land and water development projects

4 Assess the relevance and concepts of stakeholder participation in irrigation management

5 Explain the theory, key concepts, conceptual framework and merits of water accounting in irrigation schemes

6 Apply key concepts of irrigation performance assessment, including its role, types of assessment, criteria, indicators, benchmarking and targets, in addressing problems related to irrigation performance

7 Use the IWMI water accounting framework to perform water accounting in irrigation schemes, interpret the results provide situation analysis and formulate relevant recommendations for improvements.

Assessments

%	Type	Name
50	Written examination (open book)	Hydraulic property and ownership relations in irrigation systems, Irrigation performance assessment and irrigation water accounting
30	Assignment	Irrigation management
20	Assignment	Sociological Aspects of LWD

Topics

1 Management tasks in different types of irrigation and drainage systems

Terminology and definitions, management approaches, objectives in irrigation, interest groups, conflicting objectives and interests, large and small scale systems. Water delivery policies: entitlement to water, operational objectives (adequacy, equity, reliability), cropping policies. Water delivery systems: arranged, on-request, on-demand, irrigation scheduling. Formal and informal irrigation management. Concept of service oriented management: typology of goods and services, clients and stakeholders, service determining factors, levels of service, infrastructure, flow control and service potential, organisational structures, cost recovery, farmers participation, role of line agencies and accountability mechanisms in water management institutions.

2 Hydraulic property and ownership relations in irrigation systems

Dynamics of hydraulic property and ownership relations in irrigation systems, investments and interventions in irrigation and drainage, the relevance and impact of different water rights arrangements.

3 Sociological aspects of land and water development

Introduction to the social sciences of irrigation and drainage. Challenges of water distributions among competing users. Understanding the influence of irrigation technology, projects, management and organization on social constellations. The influence of various distributions on social aspects of irrigation: distributions of water, distributions of authority and voice (incl. gender), distributions of knowledge and expertise (incl. the role of the social sciences in irrigation knowledge). Case studies based on participants' experiences.

4 Irrigation Management Game

The students will engage in the roles of farmers or water judge in an irrigation management game in which water delivery and cropping choices will be implemented in the occurence of several events.

5 Irrigation performance assessment and water accounting

Performance assessment in irrigation and drainage is the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement. It is an important management tool to improve overall function of a scheme in terms of service and productivity. The course will discuss the key concepts and theoretical framework of performance assessment by drawing examples from the past field projects. This theoretical knowledge will then be used to solve problems and discuss the results and implications. The course will introduce and discuss the water accounting framework created by the International Water Management Institute (IWMI WA). The theory, terminologies, the conceptual framework of IWMI WA will be explained. The discussion on the conceptual framework will be followed by a practical problem solving in class, visualizing the results and discussing the implications.

6 Field trip

Visits to Dutch water management institutions such as the water board and agricultural association.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Management tasks in different types of irrigation and drainage systems	14	0	0	0	0	0	14	42	A.E.C. Duker, M.A. Burton
2	Hydraulic property and ownership relations in irrigation systems	6	0	0	0	0	0	6	18	J.A. Bolding
3	Sociological aspects of land and water development	8	0	2	0	0	0	10	26	J.G. Evers
4	Irrigation Management Game	0	0	8	0	0	0	8	8	M.A. Burton
5	Irrigation performance assessment and water accounting	10	0	4	2	0	0	16	38	P. Karimi
6	Field trip	0	0	0	0	8	0	8	8	A.E.C. Duker
	Total	38	0	14	2	8	0	62	140	

Education Material

Scientific journal	Malano, H., Burton, M. and Makin, I. (2004), Benchmarking performance in the irrigation and drainage sector: a tool for change. Irrig. and Drain., 53: 119–133. doi:10.1002/ird.126
Scientific journal	Molden, D., Burton, M. and Bos, M. G. (2007), Performance assessment, irrigation service delivery and poverty reduction: benefits of improved system management. Irrig. and Drain., 56: 307–320. doi:10.1002/ird.313
Scientific journal	Molden, D.; Sakthivadivel, R. 1999. Water accounting to assess use and productivity of water. International Journal of Water Resources Development 15(1&2): 55-71.
Scientific journal	Robbins, P., 2007. The reflexive engineer: perceptions of integrated development. Journal of International Development, 19(1).

Scientific Software

M2384

Resource Oriented Wastewater Treatment and Sanitation

Term	201819T06
Coordinator	F.J. Rubio Rincón
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants of the MWI/SE programme, short course participants. SENSE participants

Prerequisites

Preceding Sanitary Engineering Modules.

Learning Objectives

1 describe the physical, chemical and microbiological processes occurring in anaerobic reactors and a number of natural systems

2 critically reflect on the current sanitation systems encountered in many urban areas and to indicate ways to improve this situation in a sustainable manner;

3 evaluate the possibilities for closing cycles of energy, water and nutrients

4 evaluate the feasibility of the application of the technologies studied in this module in urban settings in the developing world

5 carry out preliminary process design of treatment and reuse systems to assess the needs for capital, land, equipment and operation and maintenance

Assessments

%	Type	Name
20	Assignment	
80	Written examination (closed book)	

Topics

1 Anaerobic Wastewater Treatment

Fundamentals about anaerobic degradation and its application in wastewater treatment.

2 Waste Stabilisation Ponds

3 Urine Treatment

4 Field trip

Topics

5 Effluent reuse in agriculture

6 Algae photobioreactors

9 Introduction into resource orientation in wastewater treatment and sanitation

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Anaerobic Wastewater Treatment	10	4	18	0	0	0	28	52	C.A. de Lemos Chernicharo, F.J. Rubio Rincón, J.B. van Lier, J.L.C.M. van de Vossenberg, N.P. van der Steen
2	Waste Stabilisation Ponds	6	0	0	0	0	0	6	18	N.P. van der Steen
3	Urine Treatment	6	0	4	0	0	0	10	22	F.J. Rubio Rincón, K.M. Udert, M. Ronteltap
4	Field trip	0	0	0	0	6	0	6	6	F.J. Rubio Rincón, M. de Kreuk
5	Effluent reuse in agriculture	2	0	0	0	0	0	2	6	A.E.C. Duker, J.B. van Lier, M. de Kreuk
6	Algae photobioreactors	6	0	0	0	0	0	6	18	N.P. van der Steen, R. Kleerebezem
9	Introduction into resource orientation in wastewater treatment and sanitation	6	0	2	0	0	0	8	20	F.J. Rubio Rincón, L. Welles M.C.M. van Loosdrecht
	Total	36	4	24	0	6	0	66	142	

Education Material

Book	Chapter 16 _Biological wastewater treatment
E-book	Innovative Wastewater Treatment & Resource Recovery Technologies
Lecture notes	Lecture notes waste stabilization ponds
Lecture notes	WHO_Guidelines for Water Reuse_2004

Scientific Software

M2730

River Morphodynamics

Term	201819T06
Coordinator	A. Crosato
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

Environmental and Civil Engineers. Professionals dealing with river training and rehabilitation works. Scientists interested in the morphodynamics of alluvial systems.

Prerequisites

Basic knowledge of river hydraulics (uniform and non-uniform flows, backwater curves) and of river hydrology (discharge variations, floods)

Learning Objectives

1 understand some basic principles of river morphology and river morphological changes.
2 assess long-term and short-term impacts of human interventions.
3 understand the basics of river biogeomorphology.
4 perform 1-D morphodynamic modelling of rivers with mobile bed.

Assessments

%	Type	Name
20	Assignment	
80	Written examination (open book)	Written Exam

Topics

1 Principles of River Morphodynamics

River morphology at different spatial scales. River patterns (multi-thread and single-thread channels). Morphodynamic processes (erosion, deposition and transport of sediment, bank erosion, bank accretion), resulting phenomena (river bed aggradation and degradation, bank advance and retreat, river planimetric changes, scour forming) and their temporal scales. Concept of geomorphological equilibrium. Hydraulic roughness with and without vegetation, backwater effects, spiral flow and morphology in river bends. Exnerâ€™s principle, developement of a trench and a shoal, celerity of bed-level perturbations. Morphological changes at the reach scale: short and long term river response to human interventions. Morphological changes at the cross-sectional scale: bar development. Concepts of mathematical modelling of rivers with mobile bed. River habitats and river geomorphology. Interactions between the river abiotic and biotic systems.

2 River Morphodynamics in Engineering Projects

Flooding caused by sedimentation. River bifurcations. River bank erosion. River navigation.

Topics

3 1-D modeling of Rivers with Mobile Bed

SOBEK-RE: model description and exercises dealing with the simulation of temporal bed level changes (delopment of a trench or shoal, effects of interventions)

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Principles of River Morphodynamics	25	0	8	0	0	5	38	98	A. Crosato
2	River Morphodynamics in Engineering Projects	7	0	3	0	0	2	12	30	E. Mosselman
3	1-D modeling of Rivers with Mobile Bed	0	0	12	0	0	0	12	12	C.J. Sloff
	Total	32	0	23	0	0	7	62	140	

Education Material

Handout	Mosselman, E. 2001. Morphological development side channels. Handout.
Handout	Sloff, K., 2007. SOBEK-RE exercises. Handout.

Scientific Software

sobek-RE

M1903

Tracer Hydrology and Flow Systems Analysis

Term	201819T06
Coordinator	J.W. Wenninger
Credit points	5.000000000
Specialization	Core Program

Target Group

Interested students.

Prerequisites

Approved BSc degree and basic hydraulics/hydrology, earth sciences, hydrogeology, and water quality.

Learning Objectives

1 apply knowledge of the concepts of tracer hydrology, with emphasis on environmental isotopes.

2 derive and describe hydrosomes from (combinations of) hydrochemical facies to assess characteritics of groundwater flow systems.

3 integrate geology, flow field, isotope data and hydrochemistry into a comprehensive analysis of groundwater flow systems for different hydro-climatic regions and geological conditions.

Assessments

%	Type	Name
50	Written examination (closed book)	Flow Systems Analysis
50	Written examination (closed book)	Tracer Hydrology

Topics

1 Tracer Hydrology

This course treats different methods to analyse and assess hydrological flow systems. Special attention will be given to hydro-chemical and tracer hydrological approaches to delineate flow systems and understanding flow patterns in the environment. The us

2 Flow Systems Analysis

3 Case study

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Tracer Hydrology	16	6	0	4	0	4	24	74	J.W. Wenninger
2	Flow Systems Analysis	8	8	0	0	8	7	23	61	J.W.A. Foppen
3	Case study	1	4	0	0	0	0	1	7	J.W. Wenninger, J.W.A. Foppen
	Total	25	18	0	4	8	11	48	142	

Education Material

Lecture notes		Lecture Notes

Scientific Software

Phreeqc

M3349

Water Quality Assessment and Monitoring

Term	201819T06
Coordinator	A.L. Zuijdgeest
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals (scientists, consultants, decision makers) with a background in Water management or Environmental science.

Prerequisites

Required: Basic knowledge in chemistry and statistics || Basic knowledge in computer operations (MS-Windows, Office) || Basic knowledge in QGIS (ES programme module 2 or IHE Open CourseWare on *Open Source Software for Preprocessing GIS Data for Hydrological Models*, exercises 1, 2 and 7).

Recommended: basic knowledge of R statistical software (ES programme modules 2-3).

Learning Objectives

1 Select and apply appropriate methods to assess water quality in natural waters in relation to their anticipated use.

2 Design and evaluate water quality monitoring networks for different types of surface water in relation to set objectives.

3 Report the results of water quality assessment and monitoring programmes using appropriate statistical tools for interpretation and presentation of large data sets.

Assessments

%	Type	Name
25	Assignment	Assignment data analysis
60	Assignment	Assignment monitoring networks
15	Lab. Report	Laboratory report

Topics

1 Why would you monitor: pollution and land use; water uses; ecotoxicology

Topics

2 What to monitor: water chemistry; biological assessment; microbiology

3 How to monitor: laboratory activities; quality control and quality assurance; monitoring locations for catchments and point sources; making maps in GIS; frequency

4 Data analysis and reporting

Data management; descriptive statistics; tests for difference; regression analysis

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Why would you monitor: pollution and land use; water uses; ecotoxicology	6	0	6	0	0	0	12	24	A.L. Zuijdgeest, C.A.M. van Gestel
2	What to monitor: water chemistry; biological assessment; microbiology	6	0	2	0	0	0	8	20	A.L. Zuijdgeest, J.L.C.M. van de Vossenberg, J.P.E.H.B. Simaika
3	How to monitor: laboratory activities; quality control and quality assurance; monitoring locations for catchments and point sources; making maps in GIS; frequency	4	6	18	8	8	0	38	60	A.L. Zuijdgeest, J. van der Kwast
4	Data analysis and reporting	6	4	14	0	0	0	20	36	A.A. van Dam
	Total	22	10	40	8	8	0	78	140	

Education Material

Handout — Presentations, background reading, exercise materials, and other relevant information will be supplied

Scientific Software

QGis

R_statistics

M3309

Conveyance and Irrigation Structures

Term	201819T07
Coordinator	F.X. Suryadi
Credit points	5.000000000
Specialization	Land and Water Development for Food Security

Target Group

All Land and Water Development for Food Security participants.

Prerequisites

Agronomy, irrigation methods, applied hydraulics

Learning Objectives

1 Make simple unsteady flow computations for open channel systems;

2 Apply DUFLOW for non-steady flow phenomena in open irrigation and drainage networks; to evaluate the results and to assess the advantages and disadvantages of the model for solving surface flow problems;

3 Assess the advantages and disadvantages of various numerical schemes for solving sets of equations in surface flow modelling and to select the appropriate models for stationary and non-stationary flow in open channels and ir pipes and to evaluate the

4 Select the appropriate type of structure for irrigation and drainage networks, to establish the boundary conditions and to prepare a preliminary hydraulic design;

5 Select a suitable flow control system, the appurtenant flow control systems and to specify the operation rules of th hydraulic structures and social implications of applied irrigation techniques for different users.

6 Understand the sediment transport mechanism and how to control sediment transport in canal systems

Assessments

%	Type	Name
15	Assignment	Flow Control Systems
35	Assignment	Irrigation Structures
15	Assignment	Sediment Transport in Canals
35	Written examination (open book)	Unsteady Flow / DUFLOW

Topics

1 Unsteady Flow / DUFLOW

Basic equations of unsteady flow and their numerical treatment; development of the St.Venant equations; solutions to these equations;- Applications to rectangular channels; - Simple wave theory; - Surge formation; - Rapidly varied unsteady flow; - Flood waves in rivers; - Introduction to hydrodynamic models and the general structure of the DUFLOW model; - Application of DUFLOW for water quantity analysis in irrigation and drainage networks; - Propagation of waves through canals; - Effect of response time on operation; - Effect of maintenance on water levels and operation of off takes; - Exercises on the operation of an irrigation network with flow control systems.

2 Irrigation Structures

Overview of the boundary conditions for design. Hydraulic background: sub-critical and critical flow over a weir; - Basic equations and their application to side channel spillways, side weirs and bottom withdrawal; - Design of spillways, stilling basins, and weirs in irrigation and drainage canals; Flume is a computer programme to design long-throated (measuring) flumes and to evaluate the water flow through them; - Calculation methods; - Construction related aspects; - Hydraulic characteristics of conveyance structures under various flow conditions: culverts, drop structures, aqueducts, siphons and inverted siphons, cross regulators an drainage structures, transition, canal lining; - Spatially varied non-uniform flow, Basic equations and their application to side channel spillways, side weirs and bottom withdrawal; - Design od spillways, stilling basins, and weirs in irrigation and drainage canals; - Case studies on structure/controller design; - Modern irrigation systems; - Automated control systems: aspects of design, operation and maintenance.

3 Flow Control Systems

Introduction on flow control systems: purpose, classification, selection criteria, performance parameters; - Proportional control: sensitivity of structures, application; - Upstream control: principle, hydraulics, design of system, application; - Downstream control: principle, hydraulics, design of system, application; - Combined control: upstream and proportional control, mixed control, down- to upstream control, up- to downstream control, night reservoirs; - Electronic control systems: Bival control, El-flow control, Card control, Dynamic control, step controllers, PID controller; - Application of different flow systems: case studies.

4 Sediment Transport in Canals

- Properties of transported material and of water; - Initiation of particle motion; - Transportation mechanics, bed forms, alluvial roughness; - Examples of computation of sediment transport in canal systems.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Unsteady Flow / DUFLOW	10	0	8	0	0	0	18	38	F.X. Suryadi
2	Irrigation Structures	12	0	12	0	0	0	24	48	A. Clemmens, L.G. Hayde
3	Flow Control Systems	8	2	6	0	0	0	14	32	F.X. Suryadi
4	Sediment Transport in Canals	6	2	2	0	0	0	8	22	F.X. Suryadi, L.G. Hayde
	Total	36	4	28	0	0	0	64	140	

Education Material

Scientific Software

Duflow

M3160

Groundwater Data Collection and Interpretation

Term	201819T07
Coordinator	T.Y. Stigter
Credit points	5.000000000
Specialization	Core Program

Target Group

MSc students in Hydrology and Water Resources, Groundwater and Global Change and short course participants involved in groundwater and environmental impacts investigation and monitoring activities.

Prerequisites

Approved BSc degree and has followed basic hydraulics/hydrology subjects

Learning Objectives

1 outline the methodology for designing groundwater surveying programmes (GSP), including the main desk and field activities to be performed;

2 interpret the results from geophysical surveys, exploration borehole logging, pumping tests and groundwater observations within the context of GSP;

3 plan a GSP for a certain area based on the analysis of available data and field conditions;

4 interpret hydro(geo)logical time series and spatial data;

5 learn methods and procedures used in groundwater monitoring;

6 design a groundwater monitoring network and to assess the required measurement frequencies

Assessments

%	Type	Name
0,3	Assignment	Groundwater Monitoring
0,2	Assignment	Groundwater Surveys
0,2	Written examination (closed book)	Groundwater Surveys
0,15	Assignment	Hydrogeostatistics
0,15	Written examination (closed book)	Hydrogeostatistics

Topics

1 Groundwater Surveys

This subject deals with groundwater exploration and resources assessment. The first part deals with methods including desk studies, hydrogeological mapping and well inventories, and surface geophysical measurements. Insight into the interpretation of borehole data and geophysical measurements is obtained with an exercise regarding a case study in the northeastern part of The Netherlands. Then follow outlines on exploration drilling and logging techniques and the interpretation of results. Finally, the practical set up and execution of pumping tests and the interpretation of test results is dealt with.

2 Electromagnetic Surveys

This topic deals specifically with electro-magnetic surveying techniques for groundwater exploration.

3 Groundwater Monitoring

Principles and concepts of groundwater monitoring. The lectures and exercises discuss and practice the design and operational aspects of groundwater observation networks. Introduction: basic concepts and procedures; Network density for estimating the global mean; Monitoring of diffusive pollution; Monitoring of waste disposal sites; Network density graphs; Determination of network density with Kriging; Determination of sampling frequency with time series analysis.

4 Hydrogeostatistics

Statistical descriptors and their use in hydrological data analysis: Correlation and regression analysis; Time series analysis: autocorrelation, trend, periodicity and stochastic components; statistical test of trend; harmonic analysis; AR models; Spatial description: spatial hydrological and hydrogeological variables; spatial variability; trend surfaces; simple and ordinary kriging; intrinsic hypothesis; variograms; estimation of variograms using measurements; spatial interpretation with kriging.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater Surveys	11	4	9	0	4	0	24	50	T.Y. Stigter
2	Electromagnetic Surveys	2	0	2	0	0	0	4	8	
3	Groundwater Monitoring	12	0	8	0	0	0	20	44	Y. Zhou
4	Hydrogeostatistics	10	0	8	0	0	0	18	38	T.Y. Stigter, Y. Zhou
	Total	35	4	27	0	4	0	66	140	

Education Material

Book	Handouts from presentations, whiteboard, exercise book, participant laptop with dedicated softwar
Lecture notes	Nonner, J., Stigter, T., Introduction to groundwater exploration (Lecture notes LNOO72/15/1)
Lecture notes	Zhou, Y., Groundwater monitoring, Lecture notes, LN0053/09/1
Lecture notes	Zhou, Y., Hydrogeostatistics, Lecture notes

Scientific Software

Aqtesolv
Freq
Gewin Excel
netgraph
surfer

M3440
Hydraulic Structures

Term	201819T07
Coordinator	A. Cattapan
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

Students coming from:

- MSc programme in Water Science and Engineering with specialisation Hydraulic Engineering and River Basin Development

Prerequisites

Working knowledge in Applied Hydraulics, Sediment Transport and River Morphoynamics

Learning Objectives

1 Analyze the interaction between flow and hydraulic structures in natural open channels
2 Create preliminary hydraulic design of selected hydraulic structures
3 Determine the consequences of different design solutions on the river morphology

Assessments

%	Type	Name
60	Assignment	Assignment on hydraulic structures design
40	Oral examination	Oral exam

Topics

1 Hydraulic structures in mountain river training

Check dams and debris dams: principles of design and operation; interaction between flow and structures.

2 Hydraulic structures in low land river training and flood protection

Detention basins: principles of design and operation; interaction between flow and structures/Minor hydraulic structures: principles of design and operation/ Levee systems: failure, design and maintenance

Topics

3 Specific structures for hydraulic infrastructures

Spillways; Bottom outlets; Energy dissipaters: principles of design and operation

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydraulic structures in mountain river training	10	0	6	0	0	2	18	42	A. Cattapan, M.J. Franca
2	Hydraulic structures in low land river training and flood protection	9	0	9	0	0	2	20	42	A. Cattapan, M.J. Franca
3	Specific structures for hydraulic infrastructures	4	0	2	0	0	14	20	56	A. Cattapan, M.J. Franca
	Total	23	0	17	0	0	18	58	140	

Education Material

Book	Chen, Sheng-Hong. Hydraulic Structures. , 2015. Internet resource.
Handout	Handouts and references provided by Lecturers
Book	Wunderlich, W.O. 2005. Hydraulic structures: probabilistic approaches to maintenance. Reston, Va: ASCE.

Scientific Software

HEC-RAS

M1554

Hydrological Data Collection and Processing

Term	201819T07
Coordinator	R.G.W. Venneker
Credit points	5.000000000
Specialization	

Target Group

Students of the WSE/HWR Programme, and selected short course participants

Prerequisites

Good foundation and understanding in hydrology, hydrometeorology, and the water resources-related interactions taking place in hydrological basins

Learning Objectives

1 Comprehend the need for hydrological data and information, and the roles and functions of National Hydrological Services.

2 Comprehend the activities involved in water resources-related data collection, processing, storage and retrieval.

3 Explain the principles and concepts used in hydrological observing networks and routine data collection.

4 Apply standard methods for processing and analyzing hydrological data to prepare water resources information.

5 Apply hands-on experience with collecting, processing and comparative analysis of hydrometeorological station data.

Assessments

%	Type	Name
40	Lab. Report	
60	Written examination (closed book)	

Topics

1 Hydrological data processing and analysis

Overview of data collection, storage and information provision. Institutional and organizational aspects of national capabilities in hydrological data and information services. Data collection networks, observation, transmission, primary and secondary processing, and archiving. Principles of measurement and methods of observing hydrometeorological elements. Streamflow measurements and rating curve construction. Integration of data sources. Analysis of time series for provision of water resources information. Spatial integration of hydrological data for water resources assessment.

Topics

2 Practical: hydrometeorological data collection and analysis

In this practical the students carry out daily routine observations at the Institute's "roof hydromet station", and process and evaluate the measurements in order to produce a small report that includes a comparison with published data.

3 Excursion

A one-day excursion is part of this module to provide examples of practical hydrological data monitoring activities in the Netherlands.

4 Examination

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydrological data processing and analysis	28	0	20	0	0	0	48	104	R.G.W. Venneker, T.A. Bogaard, Y. Zhou
2	Practical: hydrometeorological data collection and analysis	4	0	20	0	0	0	24	32	R.G.W. Venneker
3	Excursion	0	0	0	0	0	0	0	0	
4	Examination	0	0	0	0	0	0	0	0	
	Total	32	0	40	0	0	0	72	136	

Education Material

Book	Book: Boiten, W. Hydrometry 2nd edition, CRC Press, 2008.
Lecture notes	Presentations, Lecture notes, and exercise materials.

Scientific Software

M3162

Process-based Coastal Modelling

Term	201819T07
Coordinator	J.A.H. Reyns
Credit points	5.000000000
Specialization	Coastal Engineering and Port Development

Target Group

Master students in Coastal Engineering

Prerequisites

- Knowledge of nearshore hydrodynamics and sediment transport
- Some experience with Matlab, Python or similar

Learning Objectives

1 Apply commonly used numerical methods in coastal modelling
2 Choose the appropriate model for a given problem
3 Apply commonly used hydrodynamic and morphodynamic model systems in a practical situation
4 Apply input reduction and schematisation techniques for simulation speedup
5 Explain the results of complex models and translate them into practical outcomes
6 Work in a design team

Assessments

%	Type	Name
0,75	Assignment	Marina design
0,25	Assignment	Numerical Methods

Topics

1 Numerical methods

2 Introduction to coastal modeling

Topics

3 Coastline modeling

Coastline model (ShorelineS)

–Time scale: decades

–Input reduction: actual wave climate vs schematized

–Calibration for IJmuiden 1970-1990

–Postprocessing

•Coastline trends

•Presentation of results on Google Earth

4 Detailed morphological modelling

Medium-term morphodynamic model (Delft3D/SWAN and XBeach):

–Time scale: years

–Spatial scale: 5 km longshore

–Hydrodynamic calibration for Coast3D

–Input reduction: derive wave climate from buoy data (energy flux method); morphological tide

–Postprocessing

•Integrated transports, sedimentation/erosion maps, volume changes

•Intercomparison of models and approaches

Topics

5 Wave penetration modelling

Model: XBeach in nonhydrostatic mode

–Apply statistical analysis of incoming waves

–Design criteria: derive exceedance curves to calculate downtime, extreme waves to evacuate,...

–translate to set of boundary conditions for structure design

6 Data sources

Students will learn where to find open access datasets to derive boundary conditions for morphidynamic model setup (ERA Interim /ERA 5; high-resolution NORA10 wave data; Buoy data from NOAA, CDIP,...; Tides from TPXO 8.1)

7 Regional coastal modeling

The aim of this topic is to learn how to set up a regional hydrodynamic/wave model in which a more detailed morphodynamic model can be subsequently nested.

8 Final presentation

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Numerical methods	2	20	8	0	0	0	10	34	I.I. Popescu
2	Introduction to coastal modeling	4	0	0	0	0	0	4	12	J.A. Roelvink
3	Coastline modeling	1	5	3	0	0	0	4	11	J.A. Roelvink
4	Detailed morphological modelling	2	12	10	0	0	0	12	28	J.A. Roelvink, J.A.H. Reyns
5	Wave penetration modelling	2	10	10	0	0	0	12	26	A. Dastgheib
6	Data sources	0	0	2	0	0	0	2	2	A.A. Milho Semedo
7	Regional coastal modeling	2	15	10	0	0	0	12	31	
8	Final presentation	0	8	0	0	0	0	0	8	A. Dastgheib, J.A. Roelvink
	Total	13	70	43	0	0	0	56	152	

Education Material

Scientific Software

Delft3D

Matlab

Xbeach

M3232
River Basin Modelling

Term	201819T07
Coordinator	A. Jonoski
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in WSE programmme - hydroinformatics specialisation; Participants in Erasmus Mundus Flood Risk Management Programme; Participants in short course "River Basin Modelling"

Prerequisites

Hydrology and Hydraulics

Learning Objectives

1 Explain the multi-purpose nature of river basins and approaches for their integrated planning and management, with special focus on role of modelling
2 Interpret solutions of groundwater flow problems based on governing physical laws and their mathematical representation
3 Apply MODFLOW modelling system to solve groundwater flow problems and examine the solutions
4 Model hydrological processes in catchments using MIKE SHE modelling system
5 Examine results of MIKE-SHE models that include both surface and groundwater flow in a natural catchment, including the unsaturated zone

Assessments

%	Type	Name
1	Written examination (closed book)	The exam will include questions from all topics of this module.

Topics

1 River basin management

Introduction to the management of river basins; water resources; Integrated Water Resources Management (IWRM); framework for analysis in water resources planning and management projects; role of modelling; case stusies. Exercises and workshops with RIBASIM.

Topics

2 Groundwater modelling

The continuum approach; definitions; Darcy's law; groundwater flow in the saturated zone: equations for 1D, 2D and 3D flow; modelling approaches; modelling protocol; contaminant transport through advection and diffusion; exercises and workshops with the MODFLOW modelling system (PMWin) for solving basic problems of groundwater flow through aquifers and moderately complex water resources and engineering problems: problem definition, model building, results analysis and interpretation.

3 Catchment modelling

Types of hydrological models: empirical/data-driven/black box; conceptual and physically based models; NAM lumped-conceptual model: model-set-up of a catchment & calibration from rainfall & discharge records; focus on distributed physically based catchment modelling with MIKE-SHE: 1) introduction to the modelling exercises and workshops; presentation of MIKE-SHE software package and the catchments used for the exercises; 1) Initial model building - saturated zone; 2) Overland and river flow modelling - comparison of models with and without the river network; 3) Unsaturated zone modelling 4) Fully integrated catchment model: river + drainage + saturated + unsaturated zone;

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	River basin management	6	0	4	4	0	0	14	30	E. van Beek, W.N.M. van de Krogt
2	Groundwater modelling	8	0	6	6	0	0	20	42	A. Jonoski
3	Catchment modelling	12	0	10	10	0	0	32	66	A. Jonoski, I.I. Popescu, M.E Butts
	Total	26	0	20	20	0	0	66	138	

Education Material

Handout — Handouts: Jonoski: Groundwater modelling using MODFLOW; Jonoski and Popescu: Catchment modelling with MIKE SHE; van der Krogt: RIBASIM user manual;

Scientific Software

Mike 11

Mike SHE

PmWin

Ribasim

M3349

Water Quality Assessment and Monitoring

Term	201819T07
Coordinator	A.L. Zuijdgeest
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals (scientists, consultants, decision makers) with a background in Water management or Environmental science.

Prerequisites

Required: Basic knowledge in chemistry and statistics || Basic knowledge in computer operations (MS-Windows, Office) || Basic knowledge in QGIS (ES programme module 2 or IHE Open CourseWare on *Open Source Software for Preprocessing GIS Data for Hydrological Models*, exercises 1, 2 and 7).

Recommended: basic knowledge of R statistical software (ES programme modules 2-3).

Learning Objectives

1 Select and apply appropriate methods to assess water quality in natural waters in relation to their anticipated use.

2 Design and evaluate water quality monitoring networks for different types of surface water in relation to set objectives.

3 Report the results of water quality assessment and monitoring programmes using appropriate statistical tools for interpretation and presentation of large data sets.

Assessments

%	Type	Name
25	Assignment	Assignment data analysis
60	Assignment	Assignment monitoring networks
15	Lab. Report	Laboratory report

Topics

1 Why would you monitor: pollution and land use; water uses; ecotoxicology

Topics

2 What to monitor: water chemistry; biological assessment; microbiology

3 How to monitor: laboratory activities; quality control and quality assurance; monitoring locations for catchments and point sources; making maps in GIS; frequency

4 Data analysis and reporting

Data management; descriptive statistics; tests for difference; regression analysis

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Why would you monitor: pollution and land use; water uses; ecotoxicology	6	0	6	0	0	0	12	24	A.L. Zuijdgeest, C.A.M. van Gestel
2	What to monitor: water chemistry; biological assessment; microbiology	6	0	2	0	0	0	8	20	A.L. Zuijdgeest, J.L.C.M. van de Vossenberg, J.P.E.H.B. Simaika
3	How to monitor: laboratory activities; quality control and quality assurance; monitoring locations for catchments and point sources; making maps in GIS; frequency	4	6	18	8	8	0	38	60	A.L. Zuijdgeest, J. van der Kwast
4	Data analysis and reporting	6	4	14	0	0	0	20	36	A.A. van Dam
	Total	22	10	40	8	8	0	78	140	

Education Material

Handout — Presentations, background reading, exercise materials, and other relevant information will be supplied

Scientific Software

QGis

R_statistics

M3401

Water Systems Modelling

Term	201819T07
Coordinator	M.L. Mul
Credit points	5.000000000
Specialization	Sustainable Urban Water Management

Target Group

Young and mid-career professionals, managers, engineers and technicians dealing with or interested in various aspects of water resources modelling.

Prerequisites

Affinity with quantitative approaches is required. Good command of English.

Learning Objectives

1 Describe the procedure of the modelling protocol.
2 Name and explain type of models used in different case studies.
3 Build water resources models that simulate river basin processes.
4 Clearly present the results of the water system models.
5 Critically analyse model outcomes.

Assessments

%	Type	Name
40	Presentation	Modelling Assignment Presentaion
60	Written examination (open book)	Written Exam (Open book) based on two selected journal papers

Topics

1 Water system modelling - Concepts

Introduction to water system modelling concepts, including procedure in the modelling protocol, different types of models (e.g. hydrological, water allocation, simulation and optimization models), calibration and validation procedures, uncertainty analysis, performance indicators and available software packages.

1.1 Module introduction and why use models in water resources management

1.2 Modelling process

1.3 Calibration and Uncertainty analysis

1.4 Types of models

1.5 Software Packages for Water Systems Modelling

Topics

2 River Basin Simulations - Practice

Application of 3 different models. A hydrological model (HBV); a water allocation model (Waflex) and a hydraulic model (Mike-11) will be build and tested after which the output will be analysed and interpreted. The developed models will increase the understanding of the participants in the possible applications of water system modelling within the concept of integrated river basin management. One of the models has to be chosen to be presented and critically discussed during an oral exam.

2.1 HBV (rainfall-runoff)

2.2 Waflex (water allocation)

2.3 Mike 11 (flood)

3 Analysis of model results

4 Paper discussion

Read two journal articles on the topic (selected by the lecturers) which are discussed during a session. The discussion will focus on the relevance of the modelling theory applied to the article in question, to appreciate the advantages of modelling for water resources management and to be able to understand, analyse and interpret model results.

5 Case studies

The invited (guest) lecturers will share their experience with respect to modelling water systems.

5.1 Hydro-economic modelling

5.2 Systems dynamic modelling

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water system modelling - Concepts	0	0	0	0	0	0	0	0	
1.1	Module introduction and why use models in water resources management	4	0	0	0	0	0	4	12	I. Masih
1.2	Modelling process	4	0	0	0	0	0	4	12	I. Masih
1.3	Calibration and Uncertainty analysis	4	0	0	0	0	0	4	12	I. Masih
1.4	Types of models	2	0	0	0	0	0	2	6	I. Masih
1.5	Software Packages for Water Systems Modelling	2	0	0	0	0	0	2	6	I.I. Popescu
2	River Basin Simulations - Practice	0	0	0	0	0	0	0	0	
2.1	HBV (rainfall-runoff)	0	0	0	10	0	0	10	20	I. Masih
2.2	Waflex (water allocation)	0	0	0	10	0	0	10	20	P. van der Zaag
2.3	Mike 11 (flood)	0	0	0	10	0	0	10	20	I.I. Popescu
3	Analysis of model results	4	0	0	0	0	0	4	12	I. Masih
4	Paper discussion	4	0	0	0	0	0	4	12	I. Masih, I.I. Popescu, P. var der Zaag
5	Case studies	0	0	0	0	0	0	0	0	
5.1	Hydro-economic modelling	0	0	4	0	0	0	4	4	Y. Jiang
5.2	Systems dynamic modelling	0	0	4	0	0	0	4	4	J. Susnik
	Total	24	0	8	30	0	0	62	140	

Education Material

Lecture notes Mul, M.L. – Spreadsheet modelling, UNESCO-IHE Lecture Notes.
Handout Other handouts: Selected background reading.

Scientific Software

HbV Light
Mike 11
WAFLEX

M3437

Water Transport and Distribution

Term	201819T07
Coordinator	N. Trifunovic
Credit points	5.000000000
Specialization	Core Program

Target Group

Mid-career professionals dealing with technical aspects of drinking water transport & distribution, working for water supply companies, municipal assemblies or consulting bureaus.

Prerequisites

BSc degree in Civil Engineering or similar technical background; general PC-computer knowledge; good English command.

Learning Objectives

1	distinguish between different network configurations and supplying schemes; recognise various consumption categories and their growth patterns, including water leakage; define the relation between the main hydraulic parameters
2	demonstrate understanding of the steady-state hydraulics by being able to select appropriate pipe diameters, indicate optimum location of reservoirs and identify pumps capable to supply the demand;
3	apply the above theoretical knowledge by learning to perform computer-aided hydraulic calculations and predict the consequences of demand growth on the hydraulic performance of particular WTD system
4	propose preliminary hydraulic design that will integrate economic aspects, choose adequate components, and judge technical solutions dealing with the network maintenance, rehabilitation, and expansion;
5	distinguish between the main components of non-revenue water and methods of leakage assessment, survey, detection and control;
6	understand the basic corrosion mechanisms and suggest the list of preventive and reactive measures.

Assessments

%	Type	Name
40	Assignment	Design exercise assignment Water Distribution, using EPANET network modelling software. Individual report should be submitted.
20	Written examination (closed book)	Multiple choice test on water loss management and control, and pipe corrosion in distribution networks.
40	Written examination (open book)	The exam includes the part on Chapters 2 to 4 of the introductory subject in relation to hydraulic design of distribution networks.

Topics

1 Introduction to Water Transport and Distribution

Main objectives and components of WTD systems; water demand categories, patterns, calculation and forecasting; steady-state hydraulics of pressurised flows, single pipe calculation, branched and looped networks, pressure driven demand; hydraulics of storage and pumps; hydraulic design: choice of supply scheme, network layouts, design of pumping stations, power requirements and energy consumption; engineering design: choice of pipe materials, valves and other equipment; network construction: pipe laying, testing and disinfection; operation & maintenance: regular & irregular supply, network cleaning and rehabilitation.

2 Water Loss Management and Control

Definition of non-revenue water and IWA terminology used in the sector, components of water losses, methods of reducing and controlling real- and apparent network losses; quantification of leakage in distribution systems, leak location and repair techniques, pressure management.

3 Corrosion in Water Distribution Networks

Corrosion of pipe materials, indices of measure, corrossion assessment, prevention and control, optial water composition, principles of water quality modelling of distribution networks, modelling of chlorine residuals.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to Water Transport and Distribution	23	0	5	0	0	12	40	110	N. Trifunovic, P.D.A. Pathirana
2	Water Loss Management and Control	5	0	3	0	0	0	8	18	S.K. Sharma
3	Corrosion in Water Distribution Networks	4	0	0	0	0	0	4	12	S.K. Sharma
	Total	32	0	8	0	0	12	52	140	

Education Material

Digital files	Electronic materials: slide presentations (MS PowerPoint), design assignment, design network model (EPANET Ver.2), spreadsheet hydraulic lessons (MS Excel)
E-book	N.Trifunovic - Introduction to Urban Water Distribution, Taylor & Francis, 2006, reprint 2008
Lecture notes	S.Sharma - Corrosion of Pipe Materials, lecture notes UNESCO-IHE 2009 (LN/0310/09/1)
Lecture notes	S.Sharma - Water Losses in Distribution Systems, lecture notes UNESCO-IHE 2010 (LN/0346/10/1)

Scientific Software

Epanet

M3439

Climate Change Impacts and Adaptation in Deltas

Term	201819T08
Coordinator	A.A. Milho Semedo
Credit points	5.000000000
Specialization	Core Program

Target Group

Graduates from civil, coastal engineering, environmental engineering, spatial planning, hydrology, and oceanography and ocean sciences, as well as managers with interest in climate change impact on deltas and coastal areas.

Prerequisites

Bachelor degree in a field related to coastal or environmental engineering, spatial planning, hydrology, and oceanography or ocean sciences.

Learning Objectives

1 • Explain the climate system and the principles of climate change and climate modeling.

2 • Understand the physical basis of the natural and anthropogenic greenhouse effect, including the meaning of the term radiative forcing.

3 • Comprehensively describe impacts of climate change on coastal catchments, coasts and deltas.

4 • Develop a theoretical perspective towards the IPCC climate projections and working group reports, as well as th conceptual understanding of climate adaptation.

5 • Provide strategic advice on the quantification of physical impacts and economic/environmental risk posed by climate change on coastal areas and deltas.

6 • Provide strategic advice on how to effectively adapt to change on coastal catchments, coasts and deltas.

Assessments

%	Type	Name
1	Assignment	Presentation and report

Topics

Topic 1 Climate system and climate change

- The climate system, feedbacks, cycles and self-regulation
- The climates of the coasts, coastal catchments, and deltas
- Water cycle and fluvial and coastal sediment supply
- Key principles and signs of climate change
    - Ancient and recent past climate change
    - How the global carbon cycle is changing
- Impacts of climate change on the atmosphere and ocean
- Future climate projections and modelling future scenarios
- Regional and global climate modelling [Guest lecturer: Pedro Soares]
- The IPCC historic background

Topic 2 Hazards and risk assessment

- Climate change impacts and drivers of coastal catchments
- Quantifying climate change in coastal catchments (global to local)
- Climate change impacts and drivers on deltas
- Quantifying climate change in deltas (global to local)
- Climate change impacts and drivers on coasts
- Quantifying climate change driven coastal changes (global to local), including, coastal flooding , and inlets
- Quantitative risk assessment in coastal areas and deltas

Topic 3 Climate adaptation

- IPCC advice on adaptation to climate change on coastal catchments, coasts and deltas
- Urban and rural domains of adaptation [Guest Lecturer Saskia Werner]
- Urbanizing delta's: adapting beyond climate risks
- Climate change and resilient cities
- Different approaches for adaption measures (hard/soft, flexible/rigid, and central/decentralized)
- Cost benefit analysis of climate change adaptation strategies

Topic 4 Preparation of presentation and report

The students will choose a scientific paper or report, from a set of choices, and will have to present and discuss this paper in from of a juri, and hand in a report puting the paper/report findings.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
Topic 1	Climate system and climate change	10	0	4	0	0	0	14	34	A.A. Milho Semedo, P.M.M. Soares
Topic 2	Hazards and risk assessment	18	0	8	0	0	0	26	62	A. Dastgheib, J.A.H. Reyns, P.D.A. Pathirana, R.W.M.R.J.B. Ranasinghe, S. Maskey, T.M. Duong
Topic 3	Climate adaptation	8	0	2	0	0	0	10	26	S. Werners, W. Veerbeek
Topic 4	Preparation of presentation and report	0	18	0	0	0	0	0	18	A.A. Milho Semedo
	Total	36	18	14	0	0	0	50	140	

Education Material

Book	Earth's climate: past and future, by W. F. Ruddiman, New York: W.H. Freeman, 3rd ed. 2013, ISBN-10: 1429255250.
Book	Physics of Climate, by José Pinto Peixoto and Abraham H Oort, New York : American Institute of Physics, 1992, ISBN-10: 0883187124.

Scientific Software

M3009

Dams and Hydropower

Term	201819T08
Coordinator	M. Marence
Credit points	5.000000000
Specialization	Core Program

Target Group

Students interested in principles of dam, reservoir and hydropower structures design

Prerequisites

Working knowledge in Hydraulics, Hydrology and Geoscience

Learning Objectives

1 apply main principles and practices used in the structural and hydraulic design of dams used for storage, level regulation and hydropower development

2 use principles of design, construction and operation, monitoring and maintenance of dam structure together with water and sediment management in reservoirs

3 solve common practical planning issues by definition of hydropower schemes and design of hydropower structures, including power waterways, powerhouses, turbines and electrical equipment.

4 develop and design of all types of hydropower plants including also small power and pump-storage plants

5 implement knowledge in practical design of the hydropower schemes

Assessments

%	Type	Name
45	Written examination (closed book)	Written exam
45	Written examination (open book)	Written exam
10	Assignment	assignment

Topics

1.1 Dams and reservoirs - Introduction

Dams: importance, historical development & trends, examples, failures & lessons learned.

1.2 Embankment dams

Types, layouts and of the embankment dams. Interaction of the dam with other structures. Design of embankment dams, materials and typical cross-sections. Types of sealing and filters. Construction.

Topics

1.3 Gravity dams

Gravity dam types and layouts. Structural features. Mass concrete and roller compacted concrete for dams. Design considerations.

1.4 Dam design considerations and modelling

Systematic engineering approaches for dam design. Actions on dams, stability, static and dynamic analysis, seismic actions.

1.5 Arch dams

Arch dam classification and structural features, Layouts. Construction. Loads and structural analysis and design.

1.6 Dam foundation treatment and grout curtain

Dam foundation preparetion, Grout curtain, Contact and consolidation grouting works.

1.7 Diversion, spillways and bottom outlets

Need and layout of diversion works. Spillway types and design. Bottom outlet function and operation. Plug design.

1.8 Dam safety management

Dam safety management. Dam risk assessment and lessons learned. Dam monitoring.

1.9 Reservoir design and environmental impact

Function of reservoirs and their parts. Freeboard definition. Reservoir management. Losses in reservoir. Impounding. Reservoir indicators

2.1 Hydropower - Introduction

Hydropower: basic concepts, past experience and trends, context society, energy & environment.

2.2 Hydropower schemes - Layouts and design requirements

Hydropower schemes. Conventional low and high head schemes: factors principles and requirements for the design, typical arrangements and layouts. Basic data needed for hydropower definition.

2.3 Open power waterways

Weir, intake and sand trap types and design. Open channels and free flow systems, Forebays. Penstock types, materials and design.

2.4 Power waterways

Definition of the power waterway layout. Hydraulic (static and transient) design of power waterway. principles and experiences in analysis and design, tunnels, surge tanks and penstocks. Tunnel excavation, lining systems and grouting works. Intakes, gate shafts, valves, transitions and manifolds. Safety and monitoring of power waterways.

2.5 Powerhouse

Types of powerhouses. main parts and auxiliary equipment. Transmission lines. Powerhouse design.

2.6 Electromechanical equipment

Turbines, hystory and types. Pelton turbines. CRoss flow turbines. Francis turbines. Kaplan turbines. Turbine design.

2.7 Small hydropower

Definition and benefits of small hydro. Hydropower estimation. Inflatable rubber dam. Tyrolian weir. Special small machines. Small hydropower projects.

2.8 Pump storage powerplants

Need and requirements for pump storage. Typical layouts. Artificial reservoirs. Pumps and machine types. Examples.

2.9 Cost control and financial analysis

Hydropower project development. Project costs schedule. Live costs. Financial analyses. Project risks

2.10 Future developments and perspectives

Refurbishment of HPP, Future and challenges of hydropower

2.11 Hydropower development i developing countries

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1.1	Dams and reservoirs - Introduction	2	0	0	0	0	0	2	6	M. Marence
1.2	Embankment dams	2	0	0	2	0	0	4	10	M. Marence
1.3	Gravity dams	2	0	0	2	0	0	4	10	M. Marence
1.4	Dam design considerations and modelling	2	0	0	4	0	0	6	14	M. Marence
1.5	Arch dams	2	0	0	0	0	0	2	6	M. Marence
1.6	Dam foundation treatment and grout curtain	2	0	0	0	0	0	2	6	M. Marence
1.7	Diversion, spillways and bottom outlets	2	0	0	0	0	0	2	6	M. Marence
1.8	Dam safety management	2	0	0	0	0	0	2	6	M. Marence
1.9	Reservoir design and environmental impact	2	0	0	0	0	0	2	6	M. Marence
2.1	Hydropower - Introduction	2	0	0	0	0	0	2	6	M. Marence
2.2	Hydropower schemes - Layouts and design requirements	2	0	0	2	0	0	4	10	M. Marence
2.3	Open power waterways	3	0	0	2	0	0	5	13	M. Marence
2.4	Power waterways	3	0	0	2	0	0	5	13	M. Marence
2.5	Powerhouse	2	0	0	0	0	0	2	6	M. Marence
2.6	Electromechanical equipment	2	0	0	2	0	0	4	10	M. Marence
2.7	Small hydropower	2	0	0	0	0	0	2	6	M. Marence
2.8	Pump storage powerplants	2	0	0	0	0	0	2	6	M. Marence
2.9	Cost control and financial analysis	1	0	0	0	0	0	1	3	M. Marence
2.10	Future developments and perspectives	2	0	0	0	0	0	2	6	M. Marence
2.11	Hydropower development i developing countries	4	0	0	0	0	0	4	12	R.P. Singh
	Total	43	0	0	16	0	0	59	161	

Education Material

Book	Golze: Design of small dams.
Book	Jorde, K., Sommer, F. 2006: Design of Hydraulic Structures,Hydro Power Schemes.
Book	Mosonyi, E., 1987: Low head hydropower plants, Budapest, Hungary.
Book	Mosonyi, E., 1991: High head hydropower plants, Budapest, Hungary
Lecture notes	Petry, B. & N. Lukovac, 2002: Hydraulic Structures, UNESCO-IHE Lecture notes
Lecture notes	Presentations
Book	Stematiu, D., 2005: Dam engineering, UNESCO-IHE. Stematiu. D., 2005: Concrete Dams, UNESCO-IHE
Book	Stematiu, D.: 2006. Embankments Dams. Conspress, Bucharest.
Book	USBR: Design of arch dams. US Bureau of Reclamation, Denver, US.
Book	USBR: Design of small dams. US Bureau of Reclamation, Denver, US.

Scientific Software

D-geo stability
cadam
mseep

M3187

Environmental Monitoring and Modelling

Term	201819T08
Coordinator	A.L. Zuijdgeest
Credit points	5.000000000
Specialization	Sustainable Urban Water Management

Target Group

Young and mid-career professionals (scientists, consultants, decision makers) with a background in Water management or Environmental science

Prerequisites

Basic background in chemistry, physics, and mathematics. Basic knowledge in computer operations (MS-Windows, Office). Good command of English.

Basic background in GIS is recommended but not required (ES programme modules 1-3).

Learning Objectives

1 Explain the impacts of major pollutants on the quality of natural waters and the air.

2 Select and apply appropriate methods to assess the chemical, biological, and microbial quality in air and in natura waters in relation to their anticipated use.

3 Design and evaluate water quality monitoring networks for different types of surface water, groundwater, and the air in relation to set objectives.

4 Explain the possibilities and limitations of water quality models.

Assessments

%	Type	Name
15	Assignment	Group assignment on air quality
15	Assignment	Group assignment on monitoring networks
15	Assignment	Individual assignment on modelling
55	Written examination (closed book)	Written exam (water quality assessment and monitoring, water quality modelling, groundwater quality monitoring, air quality)

Topics

1 Water Quality Assessment

Chemical and (micro-)biological water quality assessment, pollution.

2 Water Quality Monitoring

Monitoring cycle, physico-chemical and (micro-) biological water quality monitoring, recent trends and techniques, optimizations, excursion (liable to change).

Link between monitoring and Environmental Impact Assessment

3 Water Quality Modelling

Introduction to modelling, types of models, model components, examples, and in-class exercise

4 Groundwater Quality Monitoring

Basics of hydrogeology, pollutant transport in groundwater, monitoring.

5 Air Quality Monitoring

Basics of atmospheric sciences, atmospheric pollution, volatile organic and inorganic pollutants, monitoring equipment, dispersion modelling, excursion (liable to change).

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water Quality Assessment	6	0	4	0	0	0	10	22	A.L. Zuijdgeest, E.D. de Ruijter van Steveninck, J.L.C.M. van de Vossenberg
2	Water Quality Monitoring	4	10	4	0	4	0	12	30	A.L. Zuijdgeest, K.A. Irvine
3	Water Quality Modelling	6	0	6	0	0	0	12	24	J. van der Kwast
4	Groundwater Quality Monitoring	8	0	4	0	0	0	12	28	J.W.A. Foppen
5	Air Quality Monitoring	8	6	2	0	4	0	14	36	E.R. Raj
	Total	32	16	20	0	8	0	60	140	

Education Material

Digital files	Compiled power point slides on all above topics, exercise materials, additional materials, and othe relevant information will be supplied.

Scientific Software

PCRaster

M3450

Food Security, Health and Environment

Term	201819T08
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	Core Program

Target Group

All Land and Water Development participants, and participants from other WSE specialisations intersted in the interactions between food security, agriculture, health and environment.

Prerequisites

None

Learning Objectives

1 Explain the importance of irrigation and drainage for food security and ecosysems in light of climate change

2 Discuss the importance of environmental aspects, including climate change, which define the feasibility, implementation and continuation of land and water development projects

3 Assess the importance and potential of nature-based solutions in agricultural water management

4 Identify major potential health benefits and disease risks of agricultural water management

5 Explain the opportunities and implications of wastewater use for irrigation

Assessments

%	Type	Name
0,7	Written examination (open book)	Ecosystems, CC and FS, Nature-based storage solutions, Wastewater Irrigation, and Irrigation and Health
0,3	Assignment	Environmental aspects

Topics

1 Ecosystems, climate change and food security

Role of water in food security, ecosystem services in agricultural development, and the interactins between irrigated agriculture and climate change.

Topics

2 Environmental aspects: climate change and agriculture

Environment as a system; environmental impacts. Examples; Environmental impact assessment (EIA); social process; legal requirements and the environmental impact statement (EIS); assessment methodologies and procedures. Description of the irrigation environment. Role and impact of cliamte change on agriculture.

3 Nature-based storage solutions

Importance and potential of nature-based storage solutions for irrigated agricultrure, such as alluvial aquifers.

4 Irrigation and health

Assessment and mitigation of impacts of agricultural water management on human health and well-being. Health implications of design of irrigation, drainage and storage infrastructure, its operation & maintenance, as well as the actual water use for multiple purposes. Links with ecology, water quality, behaviour, livelihoods, health and disease. Engineering options for enhancing health benefits and reducing disease risks.

5 Wastewater irrigation

Opportunities and challenges of wastewater irrigation, pathogenic risks and heavy metal contamination in crop production and consumption, multi-barrier approach to risk-mitigating measures, institutional aspects of wastewater use in agriculture.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Ecosystems, climate change and food security	14	0	0	0	0	0	14	42	C.M.S. de Fraiture
2	Environmental aspects: climate change and agriculture	14	0	6	0	0	0	20	48	W.J.R. Buydens
3	Nature-based storage solutions	4	0	8	0	0	0	12	20	A.E.C. Duker
4	Irrigation and health	4	0	4	0	0	0	8	16	E.D.C. Boelee
5	Wastewater irrigation	4	0	4	0	0	0	8	16	A.E.C. Duker
	Total	40	0	22	0	0	0	62	142	

Education Material

Scientific Software

M3096

Groundwater in Adaptation to Global Change Impacts

Term	201819T08
Coordinator	T.Y. Stigter
Credit points	5.000000000
Specialization	Core Program

Target Group

MSc from Joint Master Programme in Groundwater and Global Change - Impacts and Adaptation, and IHE students from other MSc programmes who are interested in the role of groundwater in adaptation to climate and global change.

Prerequisites

Approved BSc degree and basic hydrology/hydraulics and earth sciences subjects.

Learning Objectives

1 assess the impacts of present and future global water consuming and contaminating activities on groundwater resources
2 analyze the occurrence, benefits and challenges of managed aquifer recharge as a tool for climate change adaptation;
3 carry out a feasibility study for the implementation of a managed aquifer recharge project
4 explain feedback mechanisms between groundwater, irrigation agriculture and socio-economics in water stressed regions;
5 use modeling tools for optimal management of coupled groundwater-agricultural systems
6 define the urban water balance concept including the role of groundwater;
7 differentiate between a number of key pollutants and processes in urban groundwater

Assessments

%	Type	Name
30	Assignment	Groundwater in adaptation to global change impacts in agriculture
30	Assignment	Groundwater in adaptation to urbanization and pollution
40	Assignment	Managed aquifer recharge

Topics

1 Impacts of global change on groundwater resources

Global-to-local scale consequences of intensive groundwater (over)exploitation: depletion, seawater intrusion, land subsidence, decline in environmental flows (for rivers and wetlands).

Topics

2 Managed aquifer recharge

Applications of managed aquifer recharge (MAR); methods of MAR; procedures for carrying out a feasibility study for the implementation of a MAR project; case studies of MAR around the world.

3 Groundwater in adaptation to urbanization and pollution

The urban (ground)water balance; adaptation solutions in the context of urban groundwater use and contamination; a closer look at the waste water term in the urban water balance; pollutants in urban groundwater; fate of chemical pollutants and pathogens in urban aquifers.

4 Groundwater in adaptation to global change impacts in agriculture

Global irrigation water use and future demand under global change; discussion of typical management problems using a coastal agricultural region as an example of a groundwater agricultural system; methods for monitoring and simulation to obtain relevant data to estimate water availability and demand under different sources of uncertaint; decision support systems to aggregate the single
elements of the management of a groundwater agricultural system; procedures and optimization tools for an integrative water management assessing potential measures directed at both demand and supply

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Impacts of global change on groundwater resources	4	0	4	0	0	0	8	16	T.Y. Stigter
2	Managed aquifer recharge	8	8	8	0	8	0	24	48	J. Groen, T.Y. Stigter, Y. Zhou
3	Groundwater in adaptation to urbanization and pollution	8	6	8	0	0	0	16	38	J.W.A. Foppen
4	Groundwater in adaptation to global change impacts in agriculture	8	6	8	0	0	0	16	38	
	Total	28	20	28	0	8	0	64	140	

Education Material

Book	Books with specific chapters on the indicated topics
Handout	Handouts from presentations

Scientific Software

Aqtesolv
ArcGIS
Cropwat
QGis
surfer

M3413

Industrial Resource Management and Cleaner Production

Term	201819T08
Coordinator	E.R. Raj
Credit points	5.000000000
Specialization	Core Program

Target Group

EST and IMETE students

Prerequisites

Previous EST and IMETE modules

Learning Objectives

1	Suggest options for preventing pollution within urban and industrial water management settings
2	Describe the responsibilities of companies for their impact on environmental resources and assess the environmental impact of products and processes
3	Compare different methods for industrial wastewater treatment and resource recovery
4	Give examples for the applications of environmental management systems in the industrial context
5	Differentiate between the sustainable use of various resources and its benefits for reducing environmental burden(s)
6	Analyze the different system tools that support industrial ecology and make basic calculations related to life cycle analysis
7	Categorize products designed for sustainability based on their contribution towards the circular economy of a country

Assessments

%	Type	Name
60	Written examination (open book)	Examination is on-line using Ecampus
40	Assignment	Group marks for the group work (a case-study), final presentation and final report submission

Topics

1 Introduction to the field of Cleaner Production (CP)

The different aspects covered in this topic include the following:

(i) Basic concepts of cleaner production (CP)

(ii) Application of CP to the industrial, domestic, institutional and rural environments

(iii) CP in the field of water management, industrial resource management and sustainable consumption

(iv) The benefits of CP - case studies

2 Life Cycle Analysis (LCA), Eco-design

The different aspects covered in this topic include the following:

(i) Introduction to life cycle analysis (LCA)

(ii) The practical significance of LCA

(iii) Economical and environmental benefits of eco-design

3 Environmental Management Systems

The different aspects covered in this topic include the following:

(i) Introduction to environmental management and environmental management systems (EMS)

(ii) Major components of EMS

(iii) EMS and its relation to various environmental issues

(iv) Application of EMS to existing industries

Topics

4 Corporate social responsibility (CSR)

The different aspects covered in this topic include the following:

(i) Introduction to corporate social responsibility (CSR)

(ii) The role of business in today's modern society

(iii) Case studies on the application of CSR in specific industries

5 Material Flow Analysis (MFA)

The different aspects covered in this topic include the following:

(i) Material transfer in selected industrial processes

(ii) Waste prevention strategies for specific industry

(iii) Data sources and data collection strategies to conduct a regional mass flow analysis (MFA)

6 Eco-industrial parks and Industrial ecology (EIP and IE)

The different aspects covered in this topic include the following:

(i) Key concepts of industrial ecology

(ii) Sustainable use of resources in different industries

(iii) Creation of a sustainable eco-industrial park - case study from Ulsan, South Korea

Topics

7 Industrial Water Management - Processes and case studies

The different aspects covered in this topic include the following:

(i) Impact of industry on water resources

(ii) Implementing cleaner production practices and concepts in heavily polluting process industries

8 Simulation game - fun factory

The different aspects covered in this simulation game include the following:

(i) Application of mass balance principles in process industries

(ii) Quantification of waste generated during a production process

(iii) Waste prevention measures and the implementation of new pollution prevention strategies in an existing industry

9 Technologies for the recovery of metals from e-waste

This topic will cover the following aspects:

(i) Commercially available technologies for the recovery of precious and base metals from electronic waste (e-waste)

(ii) Advantages and limitations of physico-chemical and biological metal recovery techniques

Topics

10 Group work

The group work will focus on the following aspects:

(i) Literature review on a specific industry where valuable resources and products can be recovered

(ii) Conduct mass and material balance on a selected industrial unit operation

(iii) Suggestions and recommendations for implementing cleaner production techniques in the selected industry

(iv) Group report submission

(v) Group presentation and discussion

11 Field trip

Field trip to Sims Recycling Solutions, Eindhoven

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to the field of Cleaner Production (CP)	6	0	1	0	0	0	7	19	E.R. Raj
2	Life Cycle Analysis (LCA), Eco-design	4	0	0	0	0	0	4	12	L.F. Dijk
3	Environmental Management Systems	4	0	0	0	0	0	4	12	M. Grashof
4	Corporate social responsibility (CSR)	4	0	0	0	0	0	4	12	E. van Galen
5	Material Flow Analysis (MFA)	5	0	7	0	0	0	12	22	V.S. Rotter
6	Eco-industrial parks and Industrial ecology (EIP and IE)	4	0	0	0	0	0	4	12	E.R. Raj
7	Industrial Water Management - Processes and case studies	2	0	0	0	0	0	2	6	H.A. Garcia Hernandez
8	Simulation game - fun factory	0	0	4	0	0	0	4	4	E.R. Raj
9	Technologies for the recovery of metals from e-waste	2	0	0	0	0	0	2	6	E.R. Raj
10	Group work	3	6	12	0	0	0	15	27	E.R. Raj
11	Field trip	0	0	0	0	8	0	8	8	E.R. Raj
	Total	34	6	24	0	8	0	66	140	

Education Material

Lecture notes	Case study description
Lecture notes	Lecture notes and powerpoints

Scientific Software

M1309

Integrated Hydrological and River Modelling

Term	201819T08
Coordinator	S. Maskey
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participats and short course participants with hydrology/hydraulics/water resources/civil engineering background.

Prerequisites

Approved BSc degree and appropriate hydrology and/or water engineering subjects.

Learning Objectives

1. Understand and describe the structure of physically-based hydrological models and the methods used by these models to simulate the behaviour of distinct hydrological phenomena;
2. Distinguise components of hydrological modelling software for hydrodynamic simulation, catchment process simulation and surface water quality simulation;
3. Translate a given hydrological problem into a model definition using available data;
4. Conduct a model calibration/validation procedure and to interpret the simulation results to assess model performance and to suggest improvement in the model set-up;
5. Independently carry out a hydrological modelling study and to report the results.

Assessments

%	Type	Name
35	Assignment	Catchment modelling
15	Presentation	Hydrological modelling - components/methods/tools
50	Assignment	River flow and water quality modelling

Topics

1 Introduction to integrated hydrological and river Modelling

This part includes definitions of physically-based/conceptual models, distributed/semi-distributed/lumped models; introduces various components of hydrological models and commonly used methods for modelling these components as well as commonly used hydrological modelling tools (software).

Topics

2 River flow and water quality modelling

This part includes both flow- and water quality modelling. The flow modelling deals with the aspects involved in river flow modelling, including the simulation techniques applied in hydrodynamic modelling, river flow model networks, data requirements, and boundary conditions. Practicals are carried out using the Mike 11 flow simulation package (hydrodynamic river flow simulation). For each assignment, the results and findings are elaborated in a concise report. Quality modelling focuses on surface water quality and consists of a series of introductory classes, Excel-based BOD-DO modelling exercises and comprehensive practicals using Mike 11 and ECO lab. Results of the practical assignments are presented in a written report.

2.1 River flow hydrodynamic modelling

Please see in Topic 2.

2.2 River water quality modelling

Please see in Topic 2.

2.3 River water quality modelling (exercise)

Please see in Topic 2.

3 Catchment modelling (lecture and exercise)

This part expands on the river flow modelling and consists of introductory classes and practicals on modelling surface and subsurface catchment processes using Mike SHE/Mike 11. The students elaborate two major assignments, each for a catchment with distinct hydrological characteristics, and present their findings in a written report.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to integrated hydrological and river Modelling	4	0	0	4	0	0	8	20	S. Maskey
2	River flow and water quality modelling	0	0	0	0	0	0	0	0	
2.1	River flow hydrodynamic modelling	4	0	0	12	0	0	16	36	S. Maskey
2.2	River water quality modelling	6	0	0	0	0	0	6	18	A.B.K. van Griensven, S. Maskey
2.3	River water quality modelling (exercise)	0	0	0	8	0	0	8	16	S. Maskey
3	Catchment modelling (lecture and exercise)	4	0	0	18	0	0	22	48	R.G.W. Venneker
	Total	18	0	0	42	0	0	60	138	

Education Material

Lecture notes	Guinot V. and Venneker R., Physically-based hydrological modelling - Lecture notes and tutorials.
Lecture notes	Maskey S., Hydrological/catchment modelling and river flow modelling - Lecture notes and tutorials

Scientific Software

Mike 11

Mike SHE

M3275

Planning and Delivery of Flood Resilience

Term	201819T08
Coordinator	B. Gersonius
Credit points	5.000000000
Specialization	Core Program

Target Group

- Flood risk managers, local planners and river basin council members
- Others (i.e. consultants) involved in supporting decision making with regard to flood risk management

Prerequisites

Basic knowledge of the behaviour of river and delta systems (e.g. discharge variations, floods), and their management. Good command of English.

Learning Objectives

1 Define the concept of flood resilience, together with its added value for flood risk management

2 Define objectives for reducing flood risk and improving flood resilience, and stress-test these objectives against climate change

3 Develop a variety of adaptation strategies, focusing on all aspects of flood risk management: protection, prevention, preparedness, emergency response and recovery

4 Evaluate adaptation strategies and pathways under the influence of climate change

5 Design an adaptive plan based on the developed pathways, including the necesarry arrangements for implementation and monitoring

Assessments

%	Type	Name
3	Assignment	Classroom assignments
2	Homework	Homework assignment (4-page reflection)
5	Presentation	

Topics

1 Resilience of flood risk systems

Flooding can have devastating impacts on societies and their economies. Recovering from these impacts might be very difficult, especially in urban areas where social and technical systems are interdependent. Over the coming decades, it is expected that the frequency and intensity of floods will increase due to climate and socio-economic change. Building resilience to flooding, therefore, is an important need to sustain the liveability and economic competiveness of cities. This topic introduces resilience as the ability of an area or community to remain functioning under a range of flood events.

2 Objectives and stress-testing objectives

This topic deals with the objectives and associated performance indicators for flood risk management, to be identified in consultation with the stakeholders. This also includes the definition of critical threshold values of the performance indicators that are used to indicate vulnerabilities to climate and socio-economic change. The vulnerability assessment is conducted using the "climate stress test" methodology, which systematically tests the flood risk system with climate changes so that the problematic climate changes can be identified.

3 Strategies to improve flood resilience

This topic identifies a range of strategies to reduce flood risks and improve resilience. It focuses on pre-event mitigation: protection, prevention and preparedness. Protection is directed at reducing the likelihood of floods, such by giving rivers more space; prevention involves sustainable spatial planning and protection of infrastructure; and preparedness concerns taking organisational measures, like preparing evacuation and recovery plans. It also deals with the management of flood events: emergency relief and recovery. Emergency relief concerns e.g. evacuating communities and providing assistance, and recovery aims at mitigating the impacts on affected communities.

4 Evaluation within adaptation pathway sequences

This topic provides guidance to evaluate and help justify the choices between different possible adaptation strategies in terms of costs, benefits and tradeoffs in the short and long term through the possible realization of pathways, and considerations of robustness or flexibility build into the flood risk system. It also provides the analytical justifications for choices in the long term or short term.

5 Adaptive plan, incl. institutional and monitoring arrangements

This topic addresses the design of an adaptive plan to improve flood resilience. This plan contains the following elements: 1) a preferred adaptation strategy; 2) actions to be taken on the short term and maybe on the mid term; 3) options to keep open for the long term; 4) arrangements (organizational, financial, legal etc.) to be made for implementing the actions; and 5) a monitoring plan.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Resilience of flood risk systems	6	4	4	0	0	0	10	26	B. Gersonius, W. Veerbeek
2	Objectives and stress-testing objectives	4	4	6	0	0	0	10	22	B. Gersonius, J.S. Rijke
3	Strategies to improve flood resilience	8	2	4	0	8	0	20	38	C. Zevenbergen, K.A. Anema, M.F. van Staveren, W. Veerbeek
4	Evaluation within adaptation pathway sequences	4	4	6	0	0	0	10	22	B. Gersonius, M.H.J.L. Jeuken, W. Veerbeek
5	Adaptive plan, incl. institutional and monitoring arrangements	6	2	4	0	0	0	10	24	C.J.L. Seijger, P. Bloemen
	Total	28	16	24	0	8	0	60	132	

Education Material

E-book Collaborative Risk-Informed Decision Analysis (CRIDA) munual

Scientific journal Key (3-5) relevant scientific articles

Scientific Software

M2709

River Flood Analysis and Modelling

Term	201819T08
Coordinator	I.I. Popescu
Credit points	5.000000000
Specialization	Core Program

Target Group

Water Science and Engineering and Short Course participants

Prerequisites

Hydraulics and hydrology

Learning Objectives

1 Understand and explain the main flood management problems

2 Understand and explain the governing processes of flood generation and propagation

3 Identify the proper modelling methodology for a given problem

4 Utilise their hands-on experience in the step-by-step modelling procedure needed to carry out a practical study with HEC-HMS and HEC-RAS

5 Understand and analyse the main sources of uncertainty in flood modelling

Assessments

%	Type	Name
25	Assignment	HEC-HMS modelling
25	Assignment	HEC-RAS modelling
50	Written examination (closed book)	River Flood Modelling and Flood Routing

Topics

1 Climate change and its impact on hydrology (in common with module8b)

Climate change problematique. Global, regional and local climate models, development of climate change scenarios. Effects of climate variability on the hydrology that affects rainfall-runoff processes in river-basins.

2 Introduction to 1D2D, 2D modelling

Introduction to the basic principles of 1D2D and 2D modelling.

Topics

3 River flood analysis

Nature and characteristics of floods: rainfall and flood generation. Flood analysis, flood probability,return period analysis of hydrological events, design floods, estimation of peak flows, storm hydrographs and unit hydrograph methods. Modelling flood propagation and routing; Hydrological approach: Muskingum, reservoir routing, use of HEC-HMS; 1D hydraulic flood routing/modelling in rivers: use of HEC-RAS, modelling resistance for discharge estimation

4 River flood modelling

Nature and characteristics of floods: rainfall and flood generation. Flood analysis, flood probability,return period analysis of hydrological events, design floods, estimation of peak flows, storm hydrographs and unit hydrograph methods. Modelling flood propagation and routing; Hydrological approach: Muskingum, reservoir routing, use of HEC-HMS; 1D hydraulic flood routing/modelling in rivers: use of HEC-RAS, modelling resistance for discharge estimation

5 River morphology modelling

While modelling of floods is usually considerred without morphological development of the river bed, it is important to understand how river morphology changes in time so that from one flood event to another the geometry of a river might change. This section of the module gives a descrioption on how river morphology changes. Real case studies regarding models of river including morphological aspects will be explained during class.

6 Uncertainty in Flood Modelling

Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Climate change and its impact on hydrology (in common with module8b)	4	0	2	0	0	0	6	14	P.D.A. Pathirana
2	Introduction to 1D2D, 2D modelling	4	0	0	0	0	0	4	12	I.I. Popescu, R.K. Price
3	River flood analysis	20	0	0	0	0	0	20	60	A. Jonoski, R.K. Price, S.J. van Andel
4	River flood modelling	0	0	24	0	0	0	24	24	B. Bhattacharya, I.I. Popescı
5	River morphology modelling	4	0	0	0	0	0	4	12	M. van der Wegen
6	Uncertainty in Flood Modelling	4	0	0	0	0	0	4	12	D. Solomatine
	Total	36	0	26	0	0	0	62	134	

Education Material

Lecture notes	Lecture notes on River flood management and flood routing Presentation slides; Modelling packages with user manuals;

Scientific Software

HEC-HMS

HEC-RAS

Matlab

Mike 11

M3404

Urban Flood Management and Disaster Risk Mitigation

Term	201819T08
Coordinator	Z. Vojinovic
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in WSE programmme; Participants in short course "Urban Flood Management and Disaster Risk Mitigation"

Prerequisites

Basic knowledge of hydrology and hydraulics

Learning Objectives

1 Develop understanding of structural and non-structural flood resilience measures such as, conventional and innovative structures, early warning systems, etc.

2 Learn how to produce different flood risk maps in a GIS environment and how to calculate different types of flood damages, and

3 Develop understanding of how to use the models to assess the performance of existing systems and how to design the new ones within the context of different flood risks (pluvial, fluvial, coastal and flash floods)

4 Propose and judge different adequate technical rehabilitation measures to mitigate urban flooding.

Assessments

%	Type	Name
40	Written examination (closed book)	All Topics
60	Assignment	Urban flood modelling and flood risk assessment in the Dhaka case study area

Topics

1 Application domains of Hydroinformatics: floods, urban systems and environment

Introduction to floods and flooding. Introduction to urban floods and urban water systems. Introduction to environmental systems.

2 Climate change and its impact on hydrology

Introduction to the effects of climate variability on the hydrology that affects urban areas, urban hydrology as a very fast rainfall-runoff process, selection of appropriate time steps in urban runoff modelling, global, regional and local climate models, development of climate change scenarios.

Topics

3 Ethics of risk

Introduction to the basic theory of ethics and its application to the flood risk management.

4 Introduction to 1D2D, 2D modelling

Introduction to the basic principles of 2D modelling, solutions of the 2D shallow-water equations, schemes for dealing with high velocity flows at shallow depths, numerical issues concerning interaction between 1D and 2D flow domains, below ground and above ground flows, subcritical and supercritical flows over urban floodplains, treatment of buildings in 2D models, etc

5 Urban Flood Modelling and Evaluation of Flood Risks

Stormwater collection systems; services provided, beneficiaries, structure and concepts of draiange networks, rainfall input, rainfall-runoff modelling, free-surface and pressurised pipe flows, LIDAR filtering of urban features, rainfall and flow measurements, instrumentation, SCADA, telemetry, weather radar, numerical weather forecasts, build-up, wash-off, surface runoff water quality modeling in pipe networks, familiarisation with MOUSE, MIKE11, MIKE21 and SWMM software, setting up 1D and 1D-2D models, calibrating and verifying models using flow survey data, calculation of flood damages (tangible, intangible, direct, indirect damages), production of flood hazard maps, sensitivity-based flood risk attribution.

6 Structural and Non-structural Urban Flood Management Measures

Sustainable structural and nonstructural urban flood management measures such as: amplification of pipe networks, open channels, detention/retention basins, on-site-detention, on-site-infiltration, on-site-retention, SUDS, stormwater sensitive urban design, asset management and multi-objective optimization of rehabilitation measures (use of computational intelligence), design and employment of early warning systems.

7 Managing urban flood disasters

Framework for urban flood disaster management (pre-disaster, during disaster, post disaster phase), disaster morphology, evaluation of disaster scenarios, development and testing of plans, emergency preparedness and response activities, use of GIS and communication and information systems.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Application domains of Hydroinformatics: floods, urban systems and environment	4	0	2	0	0	0	6	14	Z. Vojinovic
2	Climate change and its impact on hydrology	4	0	2	0	0	0	6	14	M. Radhakrishnan, P.D.A. Pathirana
3	Ethics of risk	2	0	0	0	0	0	2	6	N. Doorn
4	Introduction to 1D2D, 2D modelling	7	0	7	0	0	0	14	28	S. Djordjevic
5	Urban Flood Modelling and Evaluation of Flood Risks	9	3	0	3	0	0	12	36	A. Sanchez Torres, Z. Vojinovic
6	Structural and Non-structural Urban Flood Management Measures	4	0	0	2	0	0	6	16	B. Gersonius, Z. Vojinovic
7	Managing urban flood disasters	6	0	0	4	0	0	10	26	A. Sanchez Torres, D. Sakulski, Z. Vojinovic
	Total	36	3	11	9	0	0	56	140	

Education Material

Scientific Software

ArcGIS
Mike 11
Mike 21
Mike Flood
Mike Urban
SWMM

M3241

Water Resources Planning

Term	201819T08
Coordinator	N.J.M. van Cauwenbergh
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals, managers, engineers and technicians who have the ambition to judge, participate in and guide multi-disciplinary water resources planning studies.

Prerequisites

Understanding of the water resources physical system. Understanding of water use for agriculture, water supply, hydropower and environment. Understanding of water governance. Computer literacy. Good command of English.

Learning Objectives

1 Explain basic concepts and notions in water resources planning.

2 Describe major steps in the participatory and integrated water resources planning process.

3 Identify and apply tools and models, such as stakeholder integration, environmental impact assessment (EIA), decision support systems, role plays and water system models, while engaging in water resources planning activities.

4 Develop alternative water management strategies and compare and evaluate them by applying multi-criteria analysis.

5 Discuss water resources planning and implementation in basins for specific context with special attention to basin in a developing country context.

Assessments

%	Type	Name
40	Assignment	
60	Written examination (closed book)	Written Exam

Topics

1 Introduction to Module and Framework for analysis

Principles of integrated water resources planning. Common notions used in planning (e.g. water resources system analysis, water policy, national/river basin/project plans, strategy, measures, scenarios, robustness, with and without project, sustainability). Analysis of existing plans in groups and discussion of planning boundaries, scales and approaches. Introduction to the case studies used in the module.

2 Models, methods and tools for Water Resources Planning:

Role of modelling in water resources planning at different steps of the planning process. Discussion of data and selection of models. Tools and methods for stakeholder participation in key steps of the planning process including participatory decision support systems. The evolution of and experience with participatory and integrated planning methods will be demonstrated through case study examples.

LIBRA role play as method for multi-criteria analysis and discussion of strategy selection.

3 Key steps in participatory water resources planning

Steps in a participatory planning process - simulation of Participatory Integrated Planning in a semi-arid basin.

Workshop style elaboration and discussion of situation and function analysis including multi-level stakeholder and water sector analysis, planning objectives and criteria, scenario and strategy development, evaluation (screening) of alternatives and strategies with/without indicators and multi-criteria analysis. Negotiation and compensation in group decision making. Plan implementation and evaluation. Discussion of importance of stakeholder participation in the planning process, opportunities and limitations.

4 Environmental Impact Assessment

Environmental impacts of water resources development projects, principles and methods of environmental impact assessment (EIA). Introduction to EIA and its application in water resources planning based on case study analysis. Discussion of links between EIA and strategy evaluation in water resources planning.

5 Experience in water resources planning in the global south-case studies and discussion

Case studies and discussion on practices, challenges and opportunities for water resources planning in the global south.

Experienced guest lectures present water resources plans from different parts of the world and focus discussion on implementation issues and importance of context for planning. Participants prepare and present a group assignment on participatory integrated planning in which they propose an approach for participatory planning for a case study of choice. Debate with group on concepts and approaches in water resources planning based on all the case studies.

Topics

6 Field trip

Visit to Dutch Water Board (Rijkswaterstaat) to discuss water resources planning in the Netherlands: role of stakeholders, use of data and models, how different alternatives are compared and negoatiated, role of finance and political context. Apart from discussion with Dutch water officials, the group will visit 1 or 2 areas where planned strategies have been implemented. These can go from relative recent innovative hydro-ecological measures (such as Room for the River or Markermeer eilanden) or older hydraulic infrastructures (such as Barrier dam or Sluices) that are now being renewed. Participants are asked to reflect on the influence of Dutch context (socio-economic, political, bio-physical) on the planning process and its outcomes and compare this to situations in the Global South.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to Module and Framework for analysis	4	0	4	0	0	0	8	16	I. Masih, N.J.M. van Cauwenbergh
2	Models, methods and tools for Water Resources Planning:	2	0	8	0	0	0	10	14	I. Masih
3	Key steps in participatory water resources planning	10	5	8	0	0	0	18	43	N.J.M. van Cauwenbergh
4	Environmental Impact Assessment	4	5	8	0	0	0	12	25	A. Mendoza - Sammet
5	Experience in water resources planning in the global south-case studies and discussion	4	16	10	0	0	0	14	38	A. Mendoza - Sammet, E. van Beek, I. Masih, N.J.M. van Cauwenbergh, W.J.A.M Douven
6	Field trip	0	0	0	0	7	0	7	7	I. Masih, M.A. Hofstra, N.J.M van Cauwenbergh
	Total	24	26	38	0	7	0	69	143	

Education Material

E-book	CapNet and GWP (2005). Integrated Water Resources Management Plans: Training manual and operational guide. http://www.cap-net.org/sites/cap-net.org/files/Manual_english.pdf.
Book	D. P. Loucks, E. van Beek, J. R. Stedinger, J. P. M. Dijkman, and M. T. Villars. 2005. Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications. UNESCO Publishing, Paris.
Lecture notes	J.C. Heun and N. Van Cauwenbergh – Participatory Integrated Water Resources Planning: Framework for Analysis and Stakeholder integration, UNESCO-IHE Lecture Notes.
Lecture notes	L. C. Beevers and H. Clouting - Environmental Assessment: Environmental Impact Assessment (EIA) & Strategic Environmental Assessment (SEA), UNESCO-IHE Lecture Notes.
Handout	Other Handouts: Examples of case studies, Selected background reading.
Handout	Software: LIBRA River Basin Planning Simulation, Excel Spreadsheets (for MCA), Altaguax DSS.

Scientific Software

LIBRA

M3167

Fieldtrip and Fieldwork WSE

Term	201819T09
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	Core Program

Target Group

WSE participants

Prerequisites

Knowledge about water management, hydraulic engineering, hydrology and water and environment

Learning Objectives

1. Demonstrate a multidisciplinary overview of actual technical, research and organizational activities in the field of water management, hydraulic engineering and hydrology.
2. Report detailed technical information received.
3. Select and apply different, appropriate field instrumentation and measurement methods in practice and organise the measurements.
4. Critically analyse field results, and identify/recognise possible areas of error or uncertainty.
5. Integrate quantitative measurements with qualitative terrain observations and prior information to evaluate and analyse the relevant predominant processes in a study area.
6. Apply this assimilation of data to engineering cases.

Assessments

%	Type	Name
1	Assignment	Fieldwork

Topics

1 Field trip and fieldwork

Field trip (Various staff IHE Delft) - One week study tour (specializations HWR, HERBD, HECEPD, LWDFS). Visits to organizations and institutions active in hydraulic engineering and/or hydrology, for instance contractors, consultancy offices, governmental institutions, research laboratories, water resources and hydraulic engineering projects in development and operation. Depending on the number of participants of the specializations within the Water Engineering Department, the fieldtrip will be multidisciplinary with the aim of integrating specializations within the department and enabling a holistic view of Water Engineering. Travel is by coach and the accommodation is hotel (shared rooms) with breakfast.

Two week study tour in Florida, USA (HI) - Exposure tour with "on site" explanation of hydrological, hydraulic and environmental projects , particularly the Everglades Comprehensive Restoration project. Specific supplements to the taught part of the programme are the visits to projects with implemented Hydroinformatics components, or various centres involved in Hydroinformatics research.

Fieldwork (Various staff IHE Delft) - Field measurements will be focusing on getting hands-on experience with the execution of measurements in a coastal environment: flow velocity, bottom profiles, sediment transport, drifter measurements. Introduction to combined use of field data and modelling. LWDFS specialization: Field experiments in irrigation, various types of measuring equipment, hydraulic characteristics of field channels, soil characteristics, various irrigation methods, water balance measurements, discharge-depth relationship for measuring structures, measurement of pump characteristics and of head losses in pipe systems, hydrometric measurements including current metering, salt dilution method and slope-area method, discharge calculations by various methods (mean and mid-section method).

HWR specialization - Two week fieldwork in southeast France focuses on integrating field observations of geology, geomorphology and physiography with surface and subsurface water data collection. Training in field instruments and measurement techniques is an integral part of the activities. ICT facilities for field data processing are provided. Small groups of students work partly under supervision but also carry out independent field assignments. At the end, each group will give a presentation.

HERBD specialization - The course focuses on developing field observation/measurement skills and integrating this with engineering knowledge. Measurements, observation, assimilation and critical analysis will be of key importance. Training in field instruments and techniques will be an integral part of the activities, followed by a period of group work where students will study a stretch of river in more depth with the purpose of gathering information to input into engineering designs.

HECEPD specialization - Field measurements will be focusing on getting hands-on experience with the execution of measurements in a coastal environment: flow velocity, bottom profiles, sediment transport, drifter measurements. Introduction to combined use of field data and modelling.

LWDFS specialization: Field Experiments in Irrigation - Various types of measuring equipment. Hydraulic characteristics of field channels. Soil characteristics. Various irrigation methods. Water balance measurements. Discharge-depth relationship for measuring structures. Measurement of pump characteristics and of head losses in pipe systems. Hydrometric measurements, current metering, salt dilution method and slope-area method. Discharge calculations by various methods; mean and mid-section method.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Field trip and fieldwork	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Handout Fieldtrip Information and Documentation, (handout)

Scientific Software

M3353

Applied Groundwater Modelling

Term	201819T10
Coordinator	Y. Zhou
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in Hydrology and Water Resources specialisation and professionals working in water and environmental resources assessment and management

Prerequisites

Approved BSc degree and appropriate groundwater and/or water engineering subjects

Learning Objectives

1. describe process and procedures of applied groundwater modelling;
2. construct numerical groundwater models using popular modelling tools with hands-on exercises;
3. use groundwater models to simulate groundwater flow, contaminant transport, and saltwater intrusion with hypothetical examples;
4. apply groundwater models for groundwater resources management and protection in real-world case studies.

Assessments

%	Type	Name
30	Assignment	Density Dependent Groundwater Flow
70	Assignment	Groundwater Modelling

Topics

1 Groundwater Modelling

Purposes of groundwater modelling; conceptual model: conceptualisation of aquifer-aquitard systems; specification of boundary conditions; hydrological stresses; design of numerical model: finite-difference solutions of flow problems; steady versus unsteady model; one layer versus multi-layer model; lay-out of grids; stress period/ time steps; model inputs: initial conditions; boundary conditions; hydrogeological parameters; hydrological stresses; model calibration and validation: selection of model code; calibration procedures; model prediction: purposes of prediction; simulation of scenarios; determination of capture zones. Contaminant transport processes and mechanisms: advective transport; dispersion; diffusion; sorption; degradation; contaminant transport models: mass fluxes; mass balance equations; initial conditions; boundary conditions; analytical solutions: 1D advective-dispersion-sorption-degradation; numerical solutions: Finite difference; method of characteristics; applied modelling of contaminant transport: problem definition; purpose of modelling; conceptual model; selection of model code; design of numerical model; model calibration; sensitivity analysis; model application.

Topics

2 Saline Groundwater Modelling

Salt water intrusion in coastal aquifers; density dependent flow equations of a fresh-saline interface: Badon Ghijben-Herzberg principle; sharp interface; transition zone; numerical modelling: interface models; solute transport model; benchmark problems; applied modelling of seawater intrusion.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater Modelling	16	0	0	24	0	0	40	96	Y. Zhou
2	Saline Groundwater Modelling	10	0	0	8	0	0	18	46	
	Total	26	0	0	32	0	0	58	142	

Education Material

Lecture notes Oude Essink, G., Density Dependent Groundwater Flow, Lecture notes, LN0302/04/1.

Lecture notes Zhou, Y., Applied Groundwater Modelling, Lecture notes, LN0113/09/1.

Scientific Software

M3036

Drought Management and Reservoir Operations

Term	201819T10
Coordinator	M.G.F. Werner
Credit points	5.000000000
Specialization	Core Program

Target Group

Students and professionals interested in drought and water scarcity, how drought can be monitored, forecasted, and managed, and how reservoirs can be operated to meet multiple objectives such as water supply, flood protection, hydropower, and environmental requirements.

Prerequisites

Working knowledge in hydrology and water resources management; Familiar with statistical principles such as distributions and probability theory. Familiarity with simple optimisation methods an advantage

Learning Objectives

1 Be able to identify and describe the concept of drought, and describe the different types of drought, the influence of society on drought, and the relationship between drought and water scarcity

2 Be familiar with concepts of drought monitoring and forecasting, and data and modelling systems used.

3 Be able to describe the principles of reservoir operations and optimisation, and develop operational rules for (mult purpose) reservoir systems.

Assessments

%	Type	Name
30	Written examination (closed book)	Drought, Drought Management, Monitoring and Forecasting (30%)
30	Written examination (closed book)	Reservoir optimisation and control (30%)
20	Assignment	on Drought Characterisation and Drought Management (20%)
20	Assignment	on Reservoir Simulation and Establishing and Testing Reservoir Rule Curves (20%)

Topics

1 Drought and Drought Managament

Introduction to the concept of drought and the different types of drought. How these are related in time. Drought as a natural phenomenon and the influence of society on drought. Concepts of drought risk, and the consituent components of drought hazard and drought vulnerability. Drought Management and the development of drought management planning.

This topic will inlcude lectures and

2 Drought Monitoring and Forecasting

Concepts of drought indicators and the use of drought indicators in monitoring different types of drought. Drought Monitoring systems. Drought Forecasting and drought Forecasting systems. Data requirements. Exercise in using global data to characterise drought in different parts of the world.

3 Reservoir Control and Optimisation

Principles of reservoir operation rules, including standard operation policy, hedging and flood control rules. Designing reservoir operation policies using optimisation techniques such as linear and (stochastic) dynamic programming. Long term versus short term reservoir operation. Establishing objective functions for multiplie-purpose reservoirs. Planning and implementation of environmental flows.

Exercise using reservoir simulation package (HEC-ResSim) to model a reservoir system, and developing operational rule curves through dynamic programming and testing these through simulation.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Drought and Drought Managament	12	4	8	0	0	0	20	48	I. Masih, M.G.F. Werner, S. Maskey
2	Drought Monitoring and Forecasting	8	0	12	0	0	0	20	36	M.G.F. Werner, S. Maskey
3	Reservoir Control and Optimisation	14	0	12	0	0	0	26	54	M.G.F. Werner
	Total	34	4	32	0	0	0	66	138	

Education Material

Handout	Handouts on drought and drought management
Lecture notes	Reader on reservoir operations
Scientific journal	Selected scientific papers

Scientific Software

M3243

Flood Risk Management

Term	201819T10
Coordinator	B. Bhattacharya
Credit points	5.000000000
Specialization	Core Program

Target Group

The course is designed for MSc participants in Water Science and Engineering at IHE, Erasmus Mundus MSc in Flood Risk Management (HIFRM) and Short course 'Flood Risk Management'

Prerequisites

Hydraulics, hydrology, river basin and flood modelling, statistics

Learning Objectives

1. Understand and apply the main principles of flood risk management; conceptualise and apply the main principles of flood risk assessment
2. Understand the Hydroinformatics tools available for flood risk management
3. Conceptualise the main principles of EU flood directive and have knowledge about European experience in flood risk management
4. Understand and explain the main principles of flood forecasting and warning and uncertainty issues associated with flood forecasts
5. Utilise their hands-on experience in the step-by-step modelling procedure to build flood inundation models

Assessments

%	Type	Name
40	Assignment	Assignment reports on 1D-2D modelling, mapping and risk mapping (40%)
30	Assignment	Presentation and assignment report on case-studies (30%)
30	Written examination (closed book)	Written exam (30%)

Topics

1 Introduction to flood risk management

Introduction to FRM: Introduction to flood risk management, basic principles, sources of risk, modelling for FRM, flood risk mapping: principles and practices in different EU countries, EU Flood Directive.

2 Flood risk analysis and case studies

Risk analysis and case studies: Flood risk management practices (Pre-, post- and during flood), quantifying flood risk, risk analysis, climate change impacts, uncertainty issues, risk mitigation measures, case studies.

Topics

3 **Dutch experiences in FRM**

Dutch experiences in FRM: Dutch practices of FRM, history, principles and practices, Room for the River project.

4 **Flood forecasting**

Flood forecasting: Flood forecasting, principles and approaches, examples, workshop, flood damage assessment

6 **1D-2D modelling**

1D-2D modelling of flood inundation with Sobek-Rural; flood inundation and mapping with HEC-RAS

7 **Flood risk mapping**

Flood risk representation and mapping (using HEC-RAS and ArcGIS).

8 **Fieldtrip**

Visit to storm surge barrier (Maeslantkering)

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to flood risk management	8	0	2	0	0	0	10	26	B. Bhattacharya
2	Flood risk analysis and case studies	11	0	1	0	0	0	12	34	P. Samuels
3	Dutch experiences in FRM	0	0	4	0	0	0	4	4	K.M. de Bruijn
4	Flood forecasting	5	0	3	0	0	0	8	18	M.G.F. Werner
6	1D-2D modelling	0	0	14	6	0	0	20	26	I.I. Popescu, S.J. van Andel
7	Flood risk mapping	0	0	0	10	0	0	10	20	B. Bhattacharya
8	Fieldtrip	0	0	0	0	4	0	4	4	B. Bhattacharya
	Total	24	0	24	16	4	0	68	132	

Education Material

Lecture notes — Lecture notes on Hydroinformatics for flood management, EU framework directive, flood risk management Lecture notes on Flood modelling Presentation slides; Publications and reports; Modelling packages with user manuals

Scientific Software

ArcGIS

HEC-RAS

sobek-RUR

M2214

Geotechnical Engineering and Dredging

Term	201819T10
Coordinator	M. van der Wegen
Credit points	5.000000000
Specialization	Core Program

Target Group

Students interested in interaction between structures and geotechnics, dredging operations, dredging projects tender procedures and marine geotechnical investigations

Prerequisites

basic knowledge in soil mechanics and coastal dynamics (waves/tides) (see for example WSE/HECEPD/03/s)

Learning Objectives

1 assess geo-engineering aspects of different hydraulic engineering activities such as structure soil interaction and foundation methods and to apply standard soil mechanical calculation methods

2 assess the use of sheet piling in quay wall design and will be able to apply analytical end numerical methods usec in designing a sheet pile

3 assess the need of dredging, project phasing, soil investigation and production, survey systems, cost estimating and pricing, tender procedures and contracts;

4 assess the technical and contractual aspects of geomarine investigations and will be able to set up and organise a survey programme;

Assessments

%	Type	Name
40	Assignment	Exercise Geo-Engineering and Sheetpile Design
60	Oral examination	Geo-Engineering and Sheet-pile design - Open Book

Topics

1 Geo-Engineering and Sheet Pile Design

Geo-Engineering - Earth retaining structures; gravity wall, analysis of sliding and overturning and allowable soilpressures; sheet pile wall, analytical and (Winkler) spring models, screwed anchors, grout anchors, anchor walls, struts, and anchor piles. Shallow foundations, calculations of bearing capacity under vertical and inclined loads according to Prandt, Buisman and Meyerhof-s theory, settlement calculations, allowable deformations, mutual influencing of foundations. Deep foundations, overview of piling systems, determination of end bearing capacity and of positive and negative friction. Slope stability, according to Bishopâ€™s theory including the effect of an earthquake load and groundwater flow. General exercise with a cantilever wall, a sheet pile, a shallow and a pile foundation and slope stability of an embankment. Detailed analysis is made on a specific topic. The calculations are analytical and some numerical by use of the Delft Geosystems software (DSTAB).

Sheetpile design - For the design of quay walls the knowledge of sheet piling gained in Geo-Engineering A and B is deepened and extended. Several mechanisms are dealt with in detail: piping, Kranz stability, heave, anchorage and special load cases. An overview of the different kind of quay walls and examples of repair and upgrade of existing structures is given and lessons learned are presented. In the assignment a quay wall is designed: sheet pile length, strength, deformation and anchorage. In the assignment, analytical and numerical methods (computer program DSHEET) are used.

2 Marine Geotechnical Investigations

Characteristics of marine geotechnical investigations, geotechnical requirements, critical-path items, project planning, desk studies, existing sources, available geotechnical data, specification for engineering geophysics and/or ground investigation, geotechnical hazards identified by desk studies, marine engineering geophysics, positioning, side scan sonar technique, seismic reflection magnetometer survey, marine ground investigations, investigation techniques, working platforms, seabed in-situ testing techniques, downhole in situ testing techniques, seabed and downhole sampling techniques, common pitfalls, integration into contracts.

3 IADC Dredging Seminar

The seminar focuses on the need of dredging, project phasing, soil investigation and production, survey systems, cost estimating and pricing, tender procedures and contracts. The programme includes various workshops on identifying the need for dredging, preparation of a dredging and landfill project and preparing in competing groups a tender bid for a dredging contract as well as two field visits to the execution of a dredging and reclamation project and a yard of a dredging contractor (contractor logistics).

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Geo-Engineering and Sheet Pile Design	18	0	0	0	0	8	26	78	J.R. Salazar
2	Marine Geotechnical Investigations	0	0	6	0	0	0	6	6	J. Molle
3	IADC Dredging Seminar	0	0	32	0	0	8	40	56	
	Total	18	0	38	0	0	16	72	140	

Education Material

Book	Dredging Seminar Handbook, 2010, IADC
Lecture notes	Peuchen J. : Marine Geotechnical Investigation, Lecture notes.

Scientific Software

D-geo stability
D-sheet piling

M3448

Innovative Water Systems for Agriculture

Term	201819T10
Coordinator	P. Karimi
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants and from other programmes with specific interest.

Prerequisites

General knowledge about irrigation and an interest in innovative solutions

Learning Objectives

1 Critically reflect on the different aspects of the use of groundwater in irrigation and managed aquifer recharge

3 Discuss the merits and the limitations of the use of solar energy as a renewable resource to support energy demand in irrigation systems

4 Identify problems, constraints and potentials of lowland and flood prone areas for sustainable development

5 Discuss the design principles of the lowland, flood prone areas and polder water management systems

6 Explain the contribution that drones can make to improved agricultural practices

Assessments

%	Type	Name
0,2	Assignment	Flying sensors and Agriculture
0,2	Assignment	GIS and polder systems
0,4	Written examination (open book)	Groundwater and Managed Aquifer Recharge
0,2	Assignment	Solar powered irrigation and drainage

Topics

1 Groundwater and Managed Aquifer Recharge

The topic will discuss: potential and challenges of groundwater use in agriculture, evaluationg aquifers and harnessing them through Managed Aquifer Recharge.

Topics

2 GIS and polder systems

Introduction to Flood prone areas, development of land use in flood prone areas, GIS application for land use zoning in flood prone areas, interaction between land use, water management and flood control.

Definition of Polder, basic components of polder system, modelling of the relationship between outlet capacity and temporary storage area.

3 Solar Powered Irrigation Systems

Energy use and carbon footprint of groundwater irrigation, Introduction to the use of renewable energy in irrigation and drainage, Solar powered irrigation systems; characteristics, opportunities and limitations

4 Flying sensors and agriculture

The topic focuses on the use of unmanned aerial vehicles (UAV's) in monitoring agriculture. It is composed of one day filed trip followed by in-class lectures and hands on computer exercise to process the collected imagery. During the lectures the participants will be familiarized with the theory of the use of flying sensors to collect visible and near infra-red images. They learn by doing how these images can then be used to derive agricultural relevant information such as vegetation index that shows the crop growth.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater and Managed Aquifer Recharge	12	0	4	0	0	0	16	40	A. Sterckx, J.W.A. Foppen, X Cai
2	GIS and polder systems	12	0	4	0	0	0	16	40	F.X. Suryadi
3	Solar Powered Irrigation Systems	6	0	6	0	0	0	12	24	P. Karimi
4	Flying sensors and agriculture	8	0	4	0	8	0	20	36	P. Karimi, S. Pareeth
	Total	38	0	18	0	8	0	64	140	

Education Material

Book	Man made lowlands, G.P. van de Ven (Ed), 2004
Book	Suryadi, 2010. GIS and computer modelling of Water Management Systems.
Book	Urban polder guideline, Vol 1,2, 3 and 4, UNESCO-IHE, 2009

Scientific Software

M3405

Urban Water Systems

Term	201819T10
Coordinator	Z. Vojinovic
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Urban Drainage and Sewerage, Water distribution, (recommended, but not essential)

Learning Objectives

1 Describe the processes that are necessary for analysis and planning of urban water systems.

2 Explain the processes that are necessary for modelling, analysis and planning of water distribution systems.

3 Give a detailed decription of the processes that are necessary for modelling, analysis and planning of sewerage and drainage systems.

4 Explain in detail the processes that are necessary for the modelling, analysis and planning of wastewater treatment plants.

5 Understand and evaluate the impacts of urban water systems on the receiving environment.

6 Analyse an integrated urban water systems model and judge among different multifunctional measures

Assessments

%	Type	Name
30	Assignment	Exercise on integrated modelling of urban drainage and river networks. Assesment of impacts on receiving environments and remedial options analysis (balance between flooding and water pollution)
30	Assignment	Water distribution epanet modeling exercise
40	Written examination (closed book)	Written exam

Topics

1 Introduction to urban water systems

Introductory lecture, the urban water cycle, urbanization, urban growth, impacts of the urban water cycle, different components and integration

2 Water distribution modelling

Components of water distribution systems. input data and water distribution networks modelling, pump schedulling, introduction to optimization.

3 Urban drainage and sewerage modelling

Introduction to urban drainage and sewerage modelling, estimation of loads, sewer measurement and data collection, dry weather flow estimation and model calibration, wet weather flow, rainfall runoff, wastewater quality load parameters and estimation, CSOs, reducing pollutant loads.

4 Wastewater treatment modelling

Wastewater treament modelling, introduction to WEST, input data, wastewater parameters and model settings.

5 Impacts on receiving environment

Characterisation of pollutants, effect of pollutants on receiving water bodies, urban runoff characteristics

6 Site visit

Guided site visit to the City of Dordrecht

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to urban water systems	2	0	0	0	0	0	2	6	Z. Vojinovic
2	Water distribution modelling	8	8	4	0	0	0	12	36	D.A. Savic, N. Trifunovic
3	Urban drainage and sewerage modelling	12	10	4	0	0	0	16	50	B. Tomicic, F.H.L.R. Clemens, Z. Vojinovic
4	Wastewater treatment modelling	8	0	8	0	0	0	16	32	I. Nopens
5	Impacts on receiving environment	4	0	0	0	0	0	4	12	A.B.K. van Griensven, M.E. McClain
6	Site visit	1	0	0	0	3	0	4	6	B. Gersonius
	Total	35	18	16	0	3	0	54	142	

Education Material

Lecture notes — Lecture notes (provided by each lecturer) Workshop material (including the case study date) Additional material provided on the module web site.

Scientific Software

ArcGIS
Epanet
Mike Flood
Mike Urban
West

M3438

Advanced Water Transport and Distribution

Term	201819T11
Coordinator	N. Trifunovic
Credit points	5.000000000
Specialization	Core Program

Target Group

Engineers and scientists with keen interest in modern methods, technologies and tools used in design, operation and maintenance of water transport & distribution networks.

Prerequisites

BSc degree in Civil Engineering or similar; a few years of relevant experience; knowledge of steady-state hydraulics of pressurised flows; basic use of network models; good English command. Students without any WTD experience should first complete the module Water Transport and Distribution.

Learning Objectives

1. understand the theory of advanced hydraulic and water quality modelling; apply state-of-the-art network software for assessment of irregular operational scenarios and develop a reliability-based and cost effective design using computer model.
2. select modern tools for monitoring of operation, and planning of maintenance of WTD systems.
3. recognise the GIS and remote sensing technologies, and familiarise with the GIS-based techniques for sustainabl planning and management of WTD systems;
4. understand the theory of transient flows, and plan the measures to prevent/control water hammer;
5. distinguish between various sources of water quality problems in distribution networks;understand the basic mechanisms of biological stability and suggest the list of preventive and reactive measures;

Assessments

%	Type	Name
12	Assignment	GIS assignment on the exercise using ArcGIS
60	Written examination (closed book)	Multiple choice test covering theoretical aspects of (1) advanced water distribution modelling, (2) water quality in distribution networks and (3)water hammer (20%each)
28	Assignment	Short assignments on advanced water distribution modelling done in WaterGEMS software: (1) Network design using GA optimiser, (2) Network criticality analysis, (3) Water quality analysis, (4) Water hammer.

Topics

1 Advanced Water Distribution Modelling

Principles of genetic algorithm; pressure-driven demand calculations; network calibration; failure analysis and calculation of demand losses; economic aspects of capital investments and network operation.

2 Advanced O&M Practices in Water Distribution

Monitoring of network condition and operation; data collection and management; organisation of maintenance, emergency water supply, asset management plans, water company organisation.

3 GIS in Water Distribution

The aim of this course is to provide both a solid theoretical understanding and a comprehensive practical introduction of how to use geographic information systems and remote sensing technologies for the analysis and solution of water distribution related problems. The course focuses on the analysis of digital spatial data, preparation for numerical modelling, presentation of modelling results and support to the decision making process. The topics covered in the course include the following: introduction to geographic information systems and remote sensing technologies, active and passive remote sensing,data structures, map projections and coordinate systems, processing of digital geographic information, creation of digital elevation models, visualisation, mapping of water related features features, delineation of pressure zone areas, digitisation, soil and land use mapping,map algebra, export of GIS layers into a modelling package, incorporation of modelling results in GIS.

4 Introduction to Water Hammer

Basic equations and applications; computer modelling: model building, simulations of simple cases (full pump trip, emergency shut down; protection devices: practical methods of surge suppression, direct action, diversionary tactics, choice of protection strategy.

5 Water Quality in Distribution Networks

Bacterial growth in drinking water, influence of water treatment and distribution on biological stability of drinking water, optimal water composition, principles of water quality modelling of distribution networks, modelling of chlorine residuals.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Advanced Water Distribution Modelling	9	0	10	0	0	8	27	61	D. Ferras, N. Trifunovic, S. Velickov, Z. Kapelan
2	Advanced O&M Practices in Water Distribution	0	0	4	0	8	0	12	12	C.G. van der Drift, D. Ferras N. Trifunovic
3	GIS in Water Distribution	0	0	9	0	0	0	9	9	A. Sanchez Torres
4	Introduction to Water Hammer	4	0	4	0	0	4	12	28	D. Ferras, S. Velickov
5	Water Quality in Distribution Networks	6	0	0	0	0	4	10	30	D. Ferras, E. Prest, S. Velickov
	Total	19	0	27	0	8	16	70	140	

Education Material

Scientific Software

ArcGIS

WaterGEMS

M2810

Decentralised Water Supply and Sanitation

Term	201819T11
Coordinator	S.K. Sharma
Credit points	5.000000000
Specialization	Core Program

Target Group

Mid-career professionals, involved in planning and management aspects of decentralised, small-scale or low-cost water supply or sanitation systems, working for municipalities, universities, research institutes, government ministries, water supply agencies, NGOs and consultancies

Prerequisites

MSc. programme entry requirements

Learning Objectives

1 know different technologies/methods for small-scale water abstraction and water treatment that can be used at household or small community level

2 understand the basics of sustainable sanitation technologies including nutrient reuse in agriculture, soild waste management and fecal sludge management and their implementation in small towns, peri-urban and urban poor areas of developing countries

3 prepare concept design for small-scale water supply treatment and ecosan technology

4 facilitate planning, financing, implementation and operation and maintenance of decentralised water supply and sanitation infrastructures based on stakeholder participation and community management

Assessments

%	Type	Name
30	Assignment	
10	Presentation	
60	Written examination (closed book)	

Topics

1 Introduction

Introduction to the module; Water Supply and Sanitation situations in small towns, peri-urban areas and urban poor areas. Rationale for decentralised water supply system

1.1 Module introduction

Introduction of the module

1.2 Introduction to decentralised water supply and sanitation

Topics

2 Decentralised Water Supply and Treatment Systems

Water Supply Systems (water sources,source selection,service levels, suitability of types of water supply systems under different conditions); Rainwater Harvesting (introduction, collection systems, advantages and limitations, design considerations). Small-scale Water Treatment Methods (design water treatment systems for small community or household. Roughing filtration, slow sand filters, small-scale disinfection)

2.1 Water supply systems

2.2 Rain water harvesting

2.3 Small-scale water treatment

3 Decentralised Sanitation Systems

Sanitation Systems (introduction to sanitation syst5ems, characteristics of urine, faeces and greywater; overview of technologies for sanitation technologies; conventional on-site sanitation; storage and transport logistics); Sanitation Planning and Stregic Tools (institutional, social and policy aspects). Faecal Sludge Management (treatment goals and standards, treatment options, faecal sludge management (planning, financial, economic, agronomic, institutional and legal aspects), transmission of excreta-related infections and risk management). Solid waste management in developing countries (technical and practical aspects of collection, transport, segregation, disposal and reuse)

3.1 Sanitation Systems

3.2 Soild waste management in small towns and urban poor areas

3.3 Sanitation planning and strategic tools

3.4 Fecal sludge management

4 Management Aspects of DWSS

Participatory Planning and Evaluation (demand responsive approach); Institutional Arrangements (community based management; small-scale independent providers), Operation and Maintenance Aspects (operation and maintenance plan, financing and cost recovery)

4.1 Participatory planning and evaluation

4.2 Institutional arrangements

4.3 Operation and Maintenance aspects

5 Presentation of the Participants

All participants make a presentation of 10 minutes in the field of decentralised water supply and sanitation in order to share experiences or problems they are facing now and learn from each others experience.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction	0	0	0	0	0	0	0	0	S.K. Sharma
1.1	Module introduction	0	0	1	0	0	0	1	1	S.K. Sharma
1.2	Introduction to decentralised water supply and sanitation	3	0	0	0	0	0	3	9	S.K. Sharma
2	Decentralised Water Supply and Treatment Systems	0	0	0	0	0	0	0	0	S.K. Sharma
2.1	Water supply systems	3	0	0	0	0	0	3	9	S.K. Sharma
2.2	Rain water harvesting	4	0	2	0	0	0	6	14	
2.3	Small-scale water treatment	8	0	2	0	0	4	14	38	S.K. Sharma
3	Decentralised Sanitation Systems	0	0	0	0	0	0	0	0	
3.1	Sanitation Systems	2	0	2	0	0	0	4	8	S. Singh
3.2	Soild waste management in small towns and urban poor areas	2	0	2	0	0	0	4	8	E.D. van Hullebusch
3.3	Sanitation planning and strategic tools	2	0	2	0	4	0	8	12	
3.4	Fecal sludge management	2	0	2	0	4	0	8	12	S. Singh
4	Management Aspects of DWSS	0	0	0	0	0	0	0	0	
4.1	Participatory planning and evaluation	2	2	0	0	0	0	2	8	L. Taing
4.2	Institutional arrangements	2	0	2	0	0	0	4	8	A. Cabrera Flamini
4.3	Operation and Maintenance aspects	2	0	2	0	0	0	4	8	S.K. Sharma
5	Presentation of the Participants	0	0	5	0	0	0	5	5	S.K. Sharma
	Total	32	2	22	0	8	4	66	140	

Education Material

Lecture notes — Sharma, S.K. (2017) Rainwater Harvesting. IHE Lecture Notes LN0357/17/1

Handout — Sharma, S.K. (2018) Decentralised Water Supply and Sanitation: Selected Topics. IHE Handouts

Scientific Software

M3217

Faecal Sludge Management

Term	201819T11
Coordinator	S. Singh
Credit points	5.000000000
Specialization	Core Program

Target Group

This course is a specialist course fitting within Sanitary Engineering. It is designed for sanitary, civil / wastewater and environmental engineers who are facing challenges with faecal sludge. As on-site sanitation is by far the most applied sanitation technology, faecal sludge management is of paramount importance globally.

Prerequisites

Preceding modules in Sanitary Engineering; an interest in and working knowledge of the business of faecal sludge management help to bring this module to a good end.

Learning Objectives

1 Describe the way how excreta and faecal sludge are characterised.

2 Know which technologies can be applied for which type of faecal sludge (settling tanks, planted and unplanted drying beds, etc)

3 Name the key stakeholders in FSM.

5 Name the challenges in emergency sanitation and know how emergency sanitation can be addressed.

6 Be familiar with the latest developments in sustainable (on-site) sanitation solutions that can be applied in high density low income areas.

Assessments

%	Type	Name
100	Written examination (closed book)	

Topics

1. Faecal Sludge Management and Shit Flow Diagram
2. FS containment, emptying and transportation systems
3. FS characterization and quantification
4. FS treatment systems
5. Operation and Maintenance
6. FSM feasibility - Financial and Technical Assessment

Topics

7. FSM business models
8. Sanitation/FSM in emergencies

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1.	Faecal Sludge Management and Shit Flow Diagram	4	0	4	0	0	0	8	16	C. Furlong, S. Singh
2.	FS containment, emptying and transportation systems	4	0	2	0	0	0	6	14	S. Singh
3.	FS characterization and quantification	3	0	0	0	0	0	3	9	C. Furlong, S. Singh
4.	FS treatment systems	7	0	6	0	0	0	13	27	C.E. Luethi, L. Strande, S. Singh
5.	Operation and Maintenance	2	0	0	0	0	0	2	6	S. Singh
6.	FSM feasibility - Financial and Technical Assessment	4	0	4	0	0	0	8	16	S. Singh
7.	FSM business models	4	0	4	0	0	0	8	16	V.C.K.A.M. Post
8.	Sanitation/FSM in emergencies	8	0	12	0	0	0	20	36	C.M. Hooijmans, J. van der Kroft
	Total	36	0	32	0	0	0	68	140	

Education Material

Book	Faecal Sludge Management Book (IWA; Editors Linda Strande, Mariska Ronteltap, Damir Brdjanovic)
Digital files	Financial and Techincal Assessment Tool
Handout	Handouts.

Scientific Software

M3420

Hydroinformatics for Decision Support

Term	201819T11
Coordinator	A. Jonoski
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants from all Master Programmes of IHE Delft.

Prerequisites

Hydrological and hydraulic modelling concepts; Basic programming skills

Learning Objectives

1 Identify the role of system analysis in water resources planning and management

2 Formulate and solve water resources problems using optimization and multi criteria analysis methods

3 Distinguish and properly use different types of decision support methods for water problems, with inclusion of uncertainty

4 Interpret the role of different software technologies for developing integrated web and mobile applications for the water domain

5 Build simple software applications that integrate data and models across Internet

Assessments

%	Type	Name
0,3	Assignment	Exercise report on Decision Support Systems
0,3	Assignment	Exercise report on Software technologies for integration
0,4	Assignment	Exercise report on Systems analysis in water resources

Topics

1 Decision support systems

Introduction to decision making process; objectives and alternatives. Optimisation in decision support (single and multi-objective). Multi-criteria decision methods and tools: formulation of decision matrix, generating and using criteria weights. Exercises and assignments with multi-criteria analyses case studies. General structure of decision support systems (DSSs). Examples of DSSs.

Topics

2 Systems analysis in water resources

Definition and role of systems analysis in water resources. Water and environmental decision making using decision support methods (modelling, optimization, multi-criteria analysis) under deterministic conditions and with inclusion of uncertainty. Linear and Dynamic programming methods with example applications (e.g. reservoir operation, water allocation), extended to conditions with uncertainty in design/planning and in operational tasks (e.g. forecasting using ensemble model predictions). Individual and group decision making problems and their analysis. Exercises with decision making problems in deterministic and uncertain conditions.

3 Software technologies for integration

Introduction to methods and tools for software integration of models and data: Object-oriented integration approaches. Software integration across networks: Client-server programming, Web protocols, Web services.Technologies for integrating distributed resources: web-interfaces technologies; creating web-based and mobile phone applications with assignment exercise.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Decision support systems	6	0	4	4	0	0	14	30	A. Jonoski, I.I. Popescu
2	Systems analysis in water resources	14	0	8	6	0	0	28	62	A. Jonoski, J.L. Alfonso Segura, S.J. van Andel
3	Software technologies for integration	4	0	10	10	0	0	24	42	A. Jonoski, J.L. Alfonso Segura
	Total	24	0	22	20	0	0	66	134	

Education Material

Digital files	A. Jonoski, L. Alfonso and S. J . van Andel: Systems analysis in water resources (PowerPoint Slides)
Digital files	A. Jonoski, L. Alfonso, J. Craven: Handouts - Software technologies for Integration exercises
Handout	A. Jonoski, S.J van Andel and L. Alfonso: Systems analysis in water resources - exercise handout
Digital files	A. Jonoski: Introduction to Decision Making and Decision Support Systems (PowerPoint Slides)
Digital files	A. Jonoski: Software Technologies for Integration (PowerPoint Slides)
Book	D.P Loucks and E. van Beek: Selected chapters of "Water resource systems planning and management"
Handout	I.Popescu: Handout DSS exercises with multi-criteria analysis
Digital files	Software for the subject Software technologies for integration: PMWin, Notepad++ text editor, Apache web server with PHP, Openlayers API, Phonegap

Scientific Software

M3014

MSc Preparatory Course and Thesis Research Proposal

Term	201819T11
Coordinator	Y.M. Slokar
Credit points	5.000000000
Specialization	Core Program

Target Group

Students in the joint programme with Universidad del Valle, Cali, Clombia

Prerequisites

Previous Modules of UWS Programme

Learning Objectives

Assessments

%	Type	Name
1	Assignment	MSc Research Proposal

Topics

Study load

Nr	Topic		Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
		Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3428

Modelling River Systems and Lakes

Term	201819T11
Coordinator	A. Cattapan
Credit points	5.000000000
Specialization	Core Program

Target Group

All participants in the WSE programme

Prerequisites

Hydrology and Hydraulics & Basic mathematics

Learning Objectives

1. Translate hydrodynamic systems into a structure of equations used to reproduce their behavior and explain how these can be solved numerically in modelling tools.
2. Understand rainfall-runoff processes and apply a hydrological model to define the flow hydrograph of a river.
3. Apply a selection hydrodynamic models to simulate water flow in river systems and lakes.
4. Critically evaluate the quality of a model calibration and validation.

Assessments

%	Type	Name
20	Assignment	Assignment on hydrological modelling. (20% of the final mark)
20	Assignment	Assignment on modelling lakes. (20% of the final mark)
20	Assignment	Assignment on modelling rivers. (20% of the final mark)
40	Written examination (closed book)	Written exam on Computational Hydraulics. (40% of the final mark)

Topics

1 Computational Hydraulics

The course aims to introduce numerical aspects of modelling, so that students become aware of the limitations and characteristics of hydrodynamic numerical models. The course starts with a short overview of the differential equations used in hydraulics, principles of discretisation of shallow water equations in 1D and 2D. Further the concept of Courant number, stability and accuracy, will be introduced for both implicit and explicit schemes. Emphasis will be on river and lake applications and short wave propagation.

Topics

2 Modelling lakes

The objective of this component is for the students to acquire the ability to apply a numerical 3D hydrodynamic model to simulate water flow in lakes.

The software used in this part is MOHID.

"**MOHID** is a three-dimensional water modelling system, developed by MARETEC (Marine and Environmental Technology Research Center) at Instituto Superior Técnico (IST) which belongs to the Universidade de Lisboa in Portugal. **MOHID** has been applied to different study cases, as coastal and estuarine areas, as well as oceanic processes and reservoirs, and it has showed its ability to simulate complex features of the flows." [www.mohid.com]

3 Hydrological modelling

Students will gain practical experience in working with a hydrological model (HEC HMS) which simulates processes at basin scale and will allow them to integrate the outputs of their simulations with the software they are going to use for modelling rivers (HEC RAS), so to provide them with a complete modelling framework to solve practical problems they might encounter in their professional life.

"The Hydrologic Modeling System (HEC-HMS) is designed to simulate the complete hydrologic processes of dendritic watershed systems. The software includes many traditional hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing. HEC-HMS also includes procedures necessary for continuous simulation including evapo-transpiration, snowmelt, and soil moisture accounting." [http://www.hec.usace.army.mil/software/hec-hms/]

4 Modelling rivers

Students will gain practical experience in working with an hydrodynamic model (HEC RAS). Students will learn how to set up a model using georeferenced data for the definition of the geometry of the system (HEC GeoRAS) and how to model the presence of different types of structures (bridges, in-line and lateral structures, culverts, gates etc.). Depending on time availability they will also learn how to simulate the propagation of floods on floodplains using a combined 1D/2D approach. An introduction to model calibration and validation will also be provided.

"The HEC-RAS system contains several river analysis components for: (1) steady flow water surface profile computations; (2) one- and two-dimensional unsteady flow simulation; (3) movable boundary sediment transport computations; and (4) water quality analysis. A key element is, that all four components use a common geometric data representation and common geometric and hydraulic computation routines. In addition to these river analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed." [http://www.hec.usace.army.mil/software/hec-ras/features.aspx]

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Computational Hydraulics	14	0	0	2	0	0	16	46	I.I. Popescu
2	Modelling lakes	2	0	0	16	0	0	18	38	F.A. Bastos da Cruz Martins
3	Hydrological modelling	2	0	0	10	0	0	12	26	B. Bhattacharya
4	Modelling rivers	0	0	0	16	0	0	16	32	A. Cattapan, I.I. Popescu
	Total	18	0	0	44	0	0	62	142	

Education Material

Handout	Handouts
Book	MOHID - Hydrodynamics user manual, 2009
Lecture notes	Martins, F., 2011: Modelling river and lakes using MOHID. UNESCO-IHE. Lecture notes
Lecture notes	Popescu, I., 2004: Differential Equations and Numerical Methods.UNESCO-IHE Lecture notes.

Scientific Software

ArcGIS
HEC-HMS
HEC-RAS
Mohid

M3400

Remote Sensing for Agricultural Water Management

Term	201819T11
Coordinator	P. Karimi
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants and student from other programmes in IHE Delft with a general interest in application of remote sensing in water resources managment, hydrology and irrigation management.

Prerequisites

General knowledge about remote sensing and GIS and their application in water realted issues.

Learning Objectives

1 The students will be able to explain RS theory, technology, typical applications, and be able to identify and download relevant RS data and products

2 The students will be able to pre-process, extract and analyse common indices, design and collect groundtruth points, and conduct land cover classification

3 The students will be able to extract biophysical, infrastructure and management features of agricultural system

4 The students will be able to explain the theory and implement pySEBAL model to estimate ET, yield, and WP

5 The students will be able to assess the irrigation performance using remote sensing, Interpret them to identify gaps, diagnose water management problems, and attribute to relevant factors for improvements

6 The students will be able to produce water accounts for an irrigation system using remote sensing information anc evaluate the performance of the system.

Assessments

%	Type	Name
0,6	Assignment	Irrigation and remote sensing
0,4	Written examination (open book)	RS theory and applications

Topics

1 Introduction to Remote sensing

Basics of RS, introduction to common data portal, satellites, typical application od RS and existing products, Hands-on exercises on need analysis and acquiring of relevant data.

2 Remote Sensing data analysis for land cover classification

Overview of RS data processing flow, common indices, and classification theory; Ground Truthing methods; Hands-on exercises (1) GT collection, (2) Landsat data pre-processing, extracting common indices, categorize them, and (3) Land cover classification and accuracy assessment. A case study is introduced to which these skills will be applied by the students.

3 Mapping agricultural systems

RS for agricultural management, Hands-on exercise on mapping agriculture infrastructure, crop intensity and irrigation command, integrating RS data and secondary data

4 Remote sensing for Evapotransipration, yield and WP assessment (SEBAL)

Theory of SEBAL, Introduction to pySEBAL model, hands-on exercise on running pySEBAL to estimate ET, biomass, and WP. The skills aquired will be aplied to the case study/assignment in progress during the class.

5 Remote sensing for enhancing performance of irrigation systems

Assessment of the irrigation performance using remote sensing, Interpret WP and other performance indicators results to identify gaps, diagnose water management problems, and attribute to relevant factors for improvements

6 Remote Sensing for Irrigation water Accounting

Theory of producing water accounts for an irrigation system using remote sensing information is discussed. The knowleadge will be applied to the hands-on and form the concluding section of the assignement.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to Remote sensing	6	0	2	0	0	0	8	20	S. Pareeth
2	Remote Sensing data analysis for land cover classification	6	0	4	0	0	0	10	22	S. Pareeth
3	Mapping agricultural systems	4	0	2	0	0	0	6	14	S. Pareeth, X Cai
4	Remote sensing for Evapotransipration, yield and WP assessment (SEBAL)	6	0	8	0	0	0	14	26	P. Karimi, S. Pareeth
5	Remote sensing for enhancing performance of irrigation systems	10	0	6	0	0	0	16	36	P. Karimi
6	Remote Sensing for Irrigation water Accounting	6	0	4	0	0	0	10	22	P. Karimi
	Total	38	0	26	0	0	0	64	140	

Education Material

Scientific journal	A remote sensing surface energy balance algorithm for land (SEBAL). 1. Formulation
Scientific journal	Diagnosing irrigation performance and water productivity through satellite remote sensing and secondary data in a large irrigation system of Pakistan
Scientific journal	Irrigation performance indicators based on remotely sensed data: a review of literature
Book	Tutorial: Fundamentals of Remote Sensing, http://www.nrcan.gc.ca/node/9309 (Open)
Book	Wegmann, M., B. Leutner, and S. Dech. Remote Sensing and GIS for Ecologists: Using Open Source Software. Data in the Wild. Pelagic Publishing, 2016

Scientific Software

QGis

M3417

Solid Waste Management

Term	201819T11
Coordinator	C.D.M. Dupont
Credit points	5.000000000
Specialization	Core Program

Target Group

IHE students and external participants (engineers, scientists, academicians, staff from Non-Governmental Organizations, Community based

Organizations, politicians, health officials, students, teachers, local, regional or national government officials, etc., involved or interested in the management of solid waste.)

Prerequisites

Involvement in - or more than average - interested in one or more of the key elements of solid waste management.

Learning Objectives

1 Present an overview of the steps of solid waste management from generation to final use/disposal
2 Select the most suitable solid waste management options in a specific local context
3 Conceptually design waste conversion/treatment processes
4 Assess the environmental impact of solid waste management options and criticize the results
5 Assess the economic impact of solid waste management options and criticize the results
6 Develop innovative solutions of solid waste management in urban areas

Assessments

%	Type	Name
35	Assignment	Group report (group mark) on the innovative SWM solution designed for a city
15	Presentation	Oral presentation (group presentation with individual mark) on the innovative SWM solution designed for a city
50	Written examination (closed book)	Questions and exercises about the course

Topics

1 Introduction: context and waste material

Debate about the key issues related to waste and its origin

Discussion about the connections between SWM and the Sustainable Development Goals

Lecture about definition, classification and characterization of waste

Exercise based on a data research in literature: assessment of solid waste amount at different levels (city, country), as well as uncertainties and trends related

Exercise based on an Excel file: analysis of a database of waste properties extracted from literature

2 Stakeholders

Lecture giving the theoretical framework of a stakeholder analysis as well as its applicability to SWM, including the main stakeholders in SWM, their specific interests and relationships

Exercise about stakeholder analysis in SWM of a case study

3 Collection

Lecture giving an overview of the collection step and the options vs context

Exercise: design of a collection system

4 Biological conversion processes

Lecture giving the basics of biological conversion processes and including examples

5 Landfill

Lecture about the basics of landfill

Exercise about the design of a landfill

Field trip to a landfill

Topics

6 Mechanical Biological Treatment

Lecture giving the basics of Mechanical Biological Treatment

Exercise about Mechanical Biological Treatment design

7 Anaerobic digestion and composting

Lecture giving of an overview of anaerobic digestion and composting

Exercise about the design of anaerobic digestion and composting units

Field trip to anaerobic digestion and composting units

8 Thermal conversion: incineration and advanced processes

Lecture giving the basics of thermal conversion processes as well as an overview of incineration and advanced processes (gasification, pyrolysis)

Exercise about the design of waste thermal conversion units

Field trip to an incineration unit

9 Prevention/minimization

Lecture discussing prevention/minimization at different levels (from household to national)

Visit to a fablab/repair café

10 Recycling

Lecture giving the basics about recycling with focus on plastics

Exercise about plastics recycling

Field trip to a recycling unit

Topics

11 Legislation, policy and finance

Lecture giving an overview of legislation and policy on SWM in the Netherlands, including its evolution over the last 40 years

Debate about the legislation and policy on SWM in the countries of the participants, including a comparison with the Netherlands and ideas for possible future evolution

Lecture giving the basics of economic assessment applied to SWM

Exercise about economic assessment of SWM options in a case study

12 Life Cycle Analysis

Lecture giving the basics of Life Cycle Analysis applied to SWM

Exercise about environmental impact of SWM options in a case study (based on an Excel tool)

13 Integrated Sustainable Waste Management

Lecture describing the conditions of a sustainable waste management system and the methodology to design it

Discussion about the challenges associated to ISWM, in particular in the countries of the participants

14 Group project: development of innovative solid waste management solutions in a city

Development of a group project, which consists in an assessment of an innovative SWM solution in the context of a specific city, covering technical, economic, environmental, social and legislative aspects

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction: context and waste material	2	0	6	0	0	0	8	12	C.D.M. Dupont
2	Stakeholders	1	0	3	0	0	0	4	6	J. IJgosse
3	Collection	1	0	2	0	0	0	3	5	C.D.M. Dupont
4	Biological conversion processes	2	0	1	0	0	0	3	7	E.D. van Hullebusch
5	Landfill	1	0	5	0	2	0	8	10	C.D.M. Dupont, E.D. van Hullebusch
6	Mechanical Biological Treatment	1	0	2	0	0	0	3	5	E.D. van Hullebusch
7	Anaerobic digestion and composting	2	0	6	0	6	0	14	18	C.D.M. Dupont, E.D. van Hullebusch
8	Thermal conversion: incineration and advanced processes	2	0	4	0	4	0	10	14	C.D.M. Dupont
9	Prevention/minimization	1	0	0	0	2	0	3	5	C.D.M. Dupont
10	Recycling	2	0	2	0	2	0	6	10	S. van den Berg
11	Legislation, policy and finance	2	0	7	0	0	0	9	13	A. Passenier, J. IJgosse
12	Life Cycle Analysis	1	0	3	0	0	0	4	6	C.D.M. Dupont
13	Integrated Sustainable Waste Management	1	0	2	0	0	0	3	5	J. IJgosse
14	Group project: development of innovative solid waste management solutions in a city	0	24	0	0	0	0	0	24	C.D.M. Dupont, E.R. Raj
	Total	19	24	43	0	16	0	78	140	

Education Material

E-book	Chapters from Solid Waste Technologies and Management (Christensen, 2011)
E-book	Chapters from What A Waste 2.0 : A Global Snapshot on Solid Waste Management to 2050. Urba Development (Kaza, 2018)
Lecture notes	ppt

Scientific Software

M3422

Strategic Planning for River Basins and Deltas

Term	201819T11
Coordinator	J.G. Evers
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals (scientists, decision-makers) with a background in water management, environmental management, and / or river basin management.

Prerequisites

Affinity with integrated river basin / delta planning and management, spatial planning, hydrology, development economics, agronomy or geography (preferably a relevant environmental or water management / science / engineering related bachelor’s degree or equivalent) and preferably experience in river basin management.

Learning Objectives

1 Explain strategic and adaptive planning and management concepts for river basin and delta planning

2 Describe and analyze social-physical relations and interdependencies using a socio-economical-ecological-technical systems approach

3 Apply adaptive and strategic planning concepts and tools for river basin and delta planning

Assessments

%	Type	Name
15	Assignment	Adaptive pathways (ind. assignment)
40	Assignment	Case study (group assignment)
15	Assignment	Scenario planning (ind. assignment)
15	Assignment	Strategic assessment (ind. assignment)
15	Assignment	Systems analysis (ind. assignment)

Topics

1 Introduction to the course

In this session the participants are introduced to the course' learning objectives, learning activities , and the assessment method

Topics

2 River basins as complex systems

River basins and deltas are considered as complex socio-economical-ecological-technical systems. The students will learn how to use a systems approach to analyze the complex system.

3 Strategic assessment and planning for river basins and deltas

The students will be trained in using tools related to Strategic environmental assessment to develop and assess strategic options for river basin and delta planning

4 Dealing with Uncertainties

Students will be introduced to concepts of adaptive delta management. The first tool and method is scenario planning. The second is adaptive pathways. During the session students will be trained in how to use these planning tools and apply them on the case study.

5 Case study

During the course, students will work in small groups on integrated application of the concepts, theories and methods introduced in this course on a case. A case will be presented to the students to work and devleop a strategic plan for the area. Case options may include deltas and/or basins with different characteristics, such as heavy urbanisation; flooding problems; drought and water scarcity, subsidence, pollution and water quality, etc.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to the course	0	0	2	0	0	0	2	2	J.G. Evers
2	River basins as complex systems	6	8	8	0	0	0	14	34	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
3	Strategic assessment and planning for river basins and deltas	4	8	4	0	0	0	8	24	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen
4	Dealing with Uncertainties	8	16	8	0	0	0	16	48	B. Gersonius, C. Zevenbergen, W.A.H. Thissen
5	Case study	0	32	0	0	0	0	0	32	A. Mendoza - Sammet, B. Gersonius, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
	Total	18	64	22	0	0	0	40	140	

Education Material

Scientific journal	Additional reading materials
Lecture notes	Lecture Notes
Digital files	Lecture powerpoint slides

Scientific Software

M3433

Urban Water Governance

Term	201819T11
Coordinator	T. Acevedo Guerrero
Credit points	5.000000000
Specialization	Core Program

Target Group

MA students with an interest in urban flows of potable water, rain-water, and sewerage.

MA students with an interest in processes of urban socio-economic change and the construction of inequality through water access/lack of access.

The resource of this report item is not reachable.

Medellín. Comunas (2017). Photo by Federico Ríos.

Prerequisites

Mandatory: High level of ability to read and discuss academic articles and book chapters in English; willingness to engage in social science theory and new conceptual frameworks; willingness to engage in cross-disciplinary discussions and applications.

Students outside the WM stream might take the module, but they will need to consult (have a short discussion with the coordinator) I am happily open to students registering in it from virtually any discipline. The key thing is that you love cities in all their speed and complexity.

Learning Objectives

1 Recognize the ways in which history (e.g. of colonialism, capitalism, segregation, post-war internal migrations, market-driven reform) matters in our understanding of and actions to address contemporary urban water problems

2 Identify the social, economic, demographic, and biophysical factors that affect water access and quality in urban settings

3 Appreciate critical social theories in urban political ecology and environmental justice scholarship.

4 Familiarize with qualitative methods used by scholars, practitioners, and activists to research urban water inequality, including ethnographic research, case study research, archival research, and oral history

Assessments

%	Type	Name
10	Attendance	Class participation 10% - throughout the module
5	Assignment	Final research paper (outline) 5%
25	Assignment	Final research paper 25%
10	Assignment	Prepare a Handout of 1 chapter of the book "Evicted: poverty and profit in the American City, Crown Publishers, 2016". 10%
30	Presentation	Reading discussion facilitation 30% - 3x during the module
20	Assignment	Written blog with visuals 20%

Topics

1 Urban environments in the 21st Century

What is the place of cities and “the urban imaginary” in recent global and national policy conversations? What do environmental justice and political ecology lenses brings to the table?

Lecture: What do we mean when we say "sustaibanle city"?

Introduction to the module: learning objectives, rules of the game, assessments, schedule.

-

Wachsmuth, D, DA Cohen, and H Angelo. 2016. “Expand the Frontiers of Urban Sustainability”, Nature, 23 August. http://www.nature.com/news/expand-the-frontiers-of-urban-sustainability- 1.20459

2 The evolution of urban environments in the west

What is the modern city? What is the modern city’s relationship to “nature”?

Lecture: Broad historical account of the evolution of urban environments in the west and the people who produced them.

*

Harvey, D. 2008. “The Right to the City”. New Left Review, https://newleftreview.org/II/53/david-harveythe-right-to-the-city [READ ONLY UP TO THE END OF THE ‘URBAN REVOLUTIONS’ SECTION]

Heynen, N., M. Kaika and E. Swyngedouw. 2006. “Urban political ecology: Politicizing the production of urban natures” in N. Heynen, M. Kaika & E. Swyngedouw (eds). In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism. New York: Routledge.

Topics

3 Land, Housing, and Water in an Age of Inequality

How does the theory of urban informality help us better understand the city in all its complexity? Why are land dispossession and forced eviction such an important arena of struggle today?

Class activity: Evicted. Poverty and profit in the American City

Lecture: Urban informality: Everyday negotiations and political practices to claim basic services, such as water, land, and housing.

*

Desmond, M. *Evicted: poverty and profit in the American City*, Crown Publishers, 2016. (One part each).

Simone, A. The Informal. In: *For the city yet to come.* Duke University Press. 2004.

4 The Colonial City: Segregation, Discourse, and Health

Why was discourse so central to racialized planning in colonial cities? How does such discourse matter today?

Lecture: Cities in the Global South as products of processes of capitalist urbanization, as well as enduring legacies of the colonial encounter

Lecture: Constituting Subjectivities, Spaces, and Infrastructures in Colonial and Contemporary Jakarta. By: Michelle Kooy

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Kooy, M. and K Bakker. 2008. "Technologies of Government: Constituting Subjectivities, Spaces, and Infrastructures in Colonial and Contemporary Jakarta". International Journal of Urban and Regional Research, 32 (2): 375-391.

(Further reading: Swanson, M. 1977. "The Sanitation Syndrome: Bubonic Plague and Urban Native Policy in the Cape Colony", 1900-1909. The Journal of African History, 18 (3): 387-410).

Topics

5 In the nature of the city

City and country are inextricably connected. Cities exist only through particular productions of nature and space, both internally and in their hinterlands. This ecological unbounding of the city challenges conceptual dualisms – urban/rural, city/nature.

Periods 1 &2. Fieldwork Rotterdam – Making Urban Nature. Natuurhistorisch Museum Rotterdam. Westzeedijk 345 (Museumpark)*

Periods 3&4. Peace palace; Dunes – Den Haag. Making Urban Nature.

*

Gandy, M., 2004. Rethinking urban metabolism: water, space and the modern city. *City*, v. 8, p.363-379.

(Further reading: Pateland, R. & J. W Moore. How the chicken nugget became the true symbol of our era. *The Guardian* Tue 8 May 2018).

6 Environmental Racism and Environmental Justice

What is the difference between environmental racism and environmental justice? What is the difference between environmental justice and urban political ecology? Why does the history of racial segregation matter so much to the contemporary urban environment?

Lecture: The rise of environmental justice as an activist movement and, subsequently, as a field of policy and scholarly analysis.

Lecture: Words to narrate the resistance. The struggles for water and territory in Santander, Colombia. By: Tatiana Roa-Avendano (CENSAT Agua Viva)

*

Holifield, R. 2001. Defining Environmental Justice and Environmental Racism. Urban Geography 22 (1): 78-90.

Heynen, N. 2015. “Urban Political Ecology II: The abolitionist century”: Progress in Human Geography 40 (6): 839: 845.

Topics

7 Urban Water and Sanitation Politics

What does the hydro-social cycle lens bring to the study of urban water access? & What does a feminist political ecology lens bring to the study of urban water access?

Lecture: Formative works that theorize the relationship between water and urbanization

Lecture: *Acueductos comunitarios,* small providers, and water mafias: delivering water in informal settlements

Lecture: The intimacy of the household in urban political ecology

*

Swyngedouw, E. 2009. “The Political Economy and Political Ecology of the Hydro-Social Cycle”. Journal of Contemporary Water Research & Education, (142): 56-60.

Ranganathan, M. 2014. “Mafias in the Waterscape: Urban Informality and Everyday Public Authority in Bangalore”. Water Alternatives 7 (1): 89-105.

Truelove, Y. 2011. “(Re-)Conceptualizing water inequality in Delhi, India through a feminist political ecology framework”. Geoforum 32: 143-152.

8 Governance and the urban water crisis

Which have been the implications of water privatization and market-based reform on access and sustainability, as well as the forms of political struggle that take root at sites of water policy change?

Lecture: the implications of water privatization and market-based reform on access and sustainability, as well as the forms of political struggle that take root at sites of water policy change.

*

Bakker, K. 2010. Governance Failure and the World's Urban Water Crisis. Cornell University Press, New York (selections).

Topics

9 Urban Waste Politics

Why is waste such a powerful resource through which to examine contemporary urban politics? Yet, why is waste so neglected in academic and policy work?'

Lecture: The generation of municipal solid waste: threats to urban health and sustainability

In class documentary – Wasteland

*

McFarlane, C. & J. Silver (2017) The Poolitical City: "Seeing Sanitation" and Making the Urban Political in Cape Town. *Antipode* Vol. 49 No. 1. pp. 125–148

10 Re-theorizing cities from the Urban South

Why so some authors advocate for a comparative approach to theory building? Which are the ways to do this?

Lecture: Comparative Urbanism: New Geographies and Cultures of Theorizing the Urban

Lecture: Habits and Habitats of *Aedes aegypti* in Maputo city. By: Angela Bayona

*

Robinson, J. 2015. Comparative Urbanism: New Geographies and Cultures of Theorizing the Urban. *International Journal of Urban and Regional Research*, 40: 1, 187-199

Topics

11 What Kind of Urban Politics?

<u>What kind of politics do we need for creating cities that are both sustainable and just?</u>

Lecture. Political practices that seek to challenge, subvert, or parody dominant forms of rule and subjectivities: the case of Afrodescendant domestic workers in Medellín, Colombia.

Lecture: Defining, researching, and struggling for water justice. By Margreet Zwarteveen

Lecture: Urban service provision. Insights from pragmatism and ethics. By: Kathryn Furlong

Wrap-up Discussion –Come prepared to discuss your favourite quotes, theories, and concepts from the readings.

*

Zwarteveen, M. & R. Boelens (2014) Defining, researching, and struggling for water justice: some conceptual building blocks for research and action, *Water International,* 39(2), 143-158

Pieterse, E. Chapter 1, in City Futures: Confronting the Crisis of Urban Development. Zed, London

Furlong, K., Carré, M. & T. Acevedo Guerrero. Urban service provision. Insights from pragmatism and ethics. *Environment and planning A.* 0(0) 1–13.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Urban environments in the 21st Century	4	2	0	0	0	0	4	14	
2	The evolution of urban environments in the west	4	1	0	0	0	0	4	13	
3	Land, Housing, and Water in an Age of Inequality	4	2	0	0	0	0	4	14	
4	The Colonial City: Segregation, Discourse, and Health	4	1	0	0	0	0	4	13	
5	In the nature of the city	0	5	0	0	6	0	6	11	
6	Environmental Racism and Environmental Justice	4	1	0	0	0	0	4	13	
7	Urban Water and Sanitation Politics	6	2	0	0	0	0	6	20	
8	Governance and the urban water crisis	2	1	0	0	0	0	2	7	
9	Urban Waste Politics	2	1	2	0	0	0	4	9	
10	Re-theorizing cities from the Urban South	4	1	0	0	0	0	4	13	
11	What Kind of Urban Politics?	4	1	0	0	0	0	4	13	
	Total	38	18	2	0	6	0	46	140	

Education Material

Handout — Students are provided a Handout on Urban Water Governance

Scientific Software

M3048

Water Sensitive Cities

Term	201819T11
Coordinator	P.D.A. Pathirana
Credit points	5.000000000
Specialization	Core Program

Target Group

All participants and external professionals dealing with urban water and flood risk management working for municipalities, water management organisation, consulting firms, educational institutions and NGOs.

Prerequisites

BSc degree in Engineering or Social Sciences background; basic knowledge of urban water and flood risk management; good command of English.

Learning Objectives

1 Describe the historical transition of cities from the viewpoint of water management. List salient features of that transition (both positive and negative). (ILO1:History)

2 Argue that the three main components of the urban water cycle (UWC) management are interdependent. Describe the interactions with other important aspects of UWC like groundwater, urban atmosphere, etc., and how they affect each. (ILO2:Integration)

3 Identify interactions between water system components, while following 'thematic' topics (e.g. urban hydrology, water transport and distribution). Describe how to exploit such interactions to enhance livability, sustainability and resilience of cities.

4 Argue that considering multiple aspects of the water systems could provide opportunities to add extra value and create substantial additional benefits related to water management projects. Estimate such benefits using toolkits. (ILO4:MultipleValues)

5 Illustrate the importance of 'mainstreaming' water sensitive elements to general urban development process. Describe concrete examples (real-world and hypothetical) of such mainstreaming. (ILO5: Mainstreaming)

6 Analyse the stakeholder involvement in the management of water in city. Argue that for effective embedding of water-sensitive features to urban development, stakeholders should also include traditionally 'non-water' domains. (ILO6:Stakeholders)

7 Reflect on the relationship of WSC principals and practice to existing cities and their sub-components (e.g. neighbourhoods). Propose (conceptual) next steps in moving towards a more water-sensitive state for a given concrete case-study. (ILO7:Vision)

Assessments

%	Type	Name
50	Assignment	Case study reflection reports
25	Oral examination	
25	Presentation	

Topics

T1 Introduction to water sensitive cities

This module's structure is quite different from the 'traditional model' of teaching modules here at IHE. The Learning objectives are realized via a series of 'Cast Studies' (between 10 and 14) each taking a half a day or full day. Each case study has a hands-on, workshop type part as well.

This section which precedes those case studies describe:

1. What is a water sensitive city? Why it is important? How cities can strive to arrive at more water sensitive states?

2. The components of the urban water cycle (Water supply, Surface/storm water system, Wastewater system + groundwater), each as a brief inroduction and how they interact with each other and the borader urban processes that are outside the domain of water.

T2 Case studies (change every year)

List of case studies. Each case study has

1. Lecture/discussion part

2. Workshp - hands-on part.

Since the number and content of the case studies change every year this section represents the 'collection' of the case studies.

T3 Field trip

In most years, the module has a one day field trip.

T4 Final presentations

Here students present their own impressions about the concept of WSC, its implementation, challenges, suitability, etc. They do peer-assessment.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
T1	Introduction to water sensitive cities	8	0	0	0	0	0	8	24	P.D.A. Pathirana
T2	Case studies (change every year)	28	12	28	0	0	0	56	124	
T3	Field trip	0	0	0	0	8	0	8	8	P.D.A. Pathirana, W. Veerbeek
T4	Final presentations	0	0	4	0	0	0	4	4	M. Radhakrishnan, P.D.A. Pathirana
	Total	36	12	32	0	8	0	76	160	

Education Material

Lecture notes: Every year a set of scientific papers, reports and book chapters will be provided in addition to the slides used in the class.

Scientific Software

M3214

Wetlands for Livelihoods and Conservation

Term	201819T11
Coordinator	E.M.A. Hes
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 understand the framework of ecosystem functions and services, and means of assessing it
2 develop adaptive management for wetlands in response to change
3 analyse the socioecological system by applying DPSIR and Agency Network Analysis
4 assess the state of the wetland ecosystem on the basis of HydroGeoMorphological units and applying WETHealth
5 develop and carry out stakeholder interviews and surveys
6 conduct and communicate a research project.

Assessments

%	Type	Name
10	Presentation	Group presentation
10	Attendance	Individual performance during fieldweek
80	Assignment	Individual research assignment (report)

Topics

1 Ecosystem services framework

2 Wetland Assessment

3 Driver Pressure State Impact Response

4 Agency Network Analysis

5 Stakeholder Analysis and Participatory Approaches

6 Research Assignment

7 Group Presentation

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Ecosystem services framework	8	0	4	0	0	0	12	28	A.A. van Dam, E.M.A. Hes, K.A. Irvine
2	Wetland Assessment	4	0	2	0	8	0	14	22	A.A. van Dam, E.M.A. Hes
3	Driver Pressure State Impact Response	2	0	2	0	4	0	8	12	E.M.A. Hes
4	Agency Network Analysis	4	0	4	0	6	0	14	22	L.E. Charli Joseph
5	Stakeholder Analysis and Participatory Approaches	4	0	2	0	6	0	12	20	G.J.M. Gevers
6	Research Assignment	0	24	0	0	6	0	6	30	E.M.A. Hes, G.J.M. Gevers, L.E. Charli Joseph
7	Group Presentation	0	0	0	0	6	0	6	6	E.M.A. Hes, G.J.M. Gevers, L.E. Charli Joseph
	Total	22	24	14	0	36	0	72	140	

Education Material

Scientific Software

M3367

Groupwork WSE

Term	201819T13
Coordinator	W. Veerbeek
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

All previous modules

Learning Objectives

1 Organize an integrated team including a division of roles, individual and shared responsibilities, a transparent decision-making process, and a monitoring and evaluating procedure of the produced outputs and deliverables

2 Develop inter- and multi-disciplinary project activities in integrated teams.

3 Provide a diagnosis of the main challenges and interlinkages between those challenges for the case study area.

4 Develop a shared strategy to answer the challenges based on a coherent programme of measures.

5 Present, argue and report the strategy as well as the corresponding programme of measures in an integrated and interdisciplinary manner.

Assessments

%	Type	Name
33	Presentation	Group mark determined by report and presentation
34	Presentation	Individual mark Phase 3 determined by requirements specification
33	Presentation	Individual mark determined by contribution in group

Topics

1 Groupwork

The groupwork simulates the elaboration of (a first outline of) an Integrated Coastal Area and River Basin Management (ICARM) Plan for a specific area by multidisciplinary consulting firms. Such an ICARM Plan starts with a thorough characterization of the area with regard to the natural system and human activities, and a detailed diagnosis of the current situation (problems, threats) with regard to the different disciplines linked to WSE. These include river basin, coastal zone, land and water development and water resources exploitation and management. During the diagnosis the interlinkages between the different problems and threats need to be clearly addressed. The plan
continues with defining and prioritising the main opportunities and objectives with regard to each of the disciplines (including environmental objectives) and then goes on to suggests a strategy and associated programme of (structural and/or non-structural) measures to address the problems/threats and achieve the objectives/ opportunities identified for the different disciplines. A fundamental step towards the proposition of measures to be implemented in an area is to asses if they are appropriate in relation to the objectives. This is done by developing the Terms of Reference for further research.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Groupwork	0	0	140	0	0	0	140	140	
	Total	0	0	140	0	0	0	140	140	

Education Material

Handout Handouts group work, information and data

Scientific Software

M3014

MSc Preparatory Course and Thesis Research Proposal

Term	201819T14
Coordinator	Y.M. Slokar
Credit points	5.000000000
Specialization	Core Program

Target Group

Students in the joint programme with Universidad del Valle, Cali, Clombia

Prerequisites

Previous Modules of UWS Programme

Learning Objectives

Assessments

%	Type	Name
1	Assignment	MSc Research Proposal

Topics

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3231

MSc research, thesis and defence

Term	201819T14
Coordinator	E.A. de Jong
Credit points	30.000000000
Specialization	Core Program

Target Group

for GroundwatCH and Flood Risk Management (30 ECTS)

Prerequisites

Learning Objectives

1 Explore the background of the research problem by critically reviewing scientific literature; Evaluate relevant theories and applying these theories to a relevant scientific problem; Assure adequate delineation and definition o the research topic

2 Formulate research questions and hypotheses

3 Conduct research, independently or in a multidisciplinary team by selecting and applying appropriate research methodologies and techniques, collecting and analysing data.

4 Formulate well-founded conclusions and recommendations based on a comprehensive discussion of the results.

5 Demonstrate academic attitude and learning skills (incl thinking in multidisciplinary dimensions & distinguishing main issues from minor ones), to enhance & keep up-to-date the acquired knowledge and application skills in a largely independent manner.

6 Communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rationa underpinning of these in oral and written presentations to a variety of audiences.

Assessments

%	Type	Name
100	Presentation	Defence

Topics

Study load

Nr	Topic		Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
		Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3284

Thesis Research Proposal Development for WSE

Term	201819T14
Coordinator	G.A. Corzo Perez
Credit points	9.000000000
Specialization	Core Program

Target Group

All students of the Water Science and Engineering programme

Prerequisites

Learning Objectives

1 concisely define the intended research topic, state precise aims and objectives, describe the research methodology, argue expected relevance and justification, and identify boundary conditions and self- or externally imposed limitations

2 list available literature and replicate main arguments expounded in the literature on the specified research topic

3 demonstrate analytical problem-analysis skills and the ability to distil the strategic issues to be addressed in the research phase

4 plan, using the project management approach, the research process in weekly time-steps and indicate essential milestones, targets and indicators, required human, financial and other resources, deliverables and perceived threats and constraints at eac

5 develop and formulate the research proposal in a clearly written, well argued and convincing report, submitted within a set deadline

6 successfully present and defend individual work, cross-reference it to and critically evaluate it in light of contemporary thinking in a specific field of study

Assessments

%	Type	Name
100	Assignment	Research proposal

Topics

1 Selection of research topic

The initial research topic of study will be selected in a consultative process with a mentor, the MSc coordinator and a professor.

Topics

2 Proposal drafting

Research is likely to be based primarily on a review of selected literature, to a limited extent other methods of data gathering and analysis may also be applied (e.g. interviews, laboratory and field work, computer modelling, expert consultations, etc). One hour weekly meetings with the tutor form the main stay of the proposal development process. It is however expected that the MSc candidate will be self-motivated and pro-active, taking all necessary initiatives to reach the set target in a timely fashion.

3 Proposal presentation

The resulting proposal will be presented in written form and orally defended before an audience of critical peers and a panel of staff members

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Selection of research topic	0	0	0	0	0	0	0	0	
2	Proposal drafting	0	188	0	0	0	0	0	188	
3	Proposal presentation	0	0	0	4	0	0	4	8	
	Total	0	188	0	4	0	0	4	196	

Education Material

Scientific Software

M2927

MSc research, thesis and defence

Term	201819T15
Coordinator	E.A. de Jong
Credit points	36.000000000
Specialization	Core Program

Target Group

All students of the MSc programmes

Prerequisites

Learning Objectives

1 Explore the background of the research problem by critically reviewing scientific literature; Evaluate relevant theories and applying these theories to a relevant scientific problem; Assure adequate delineation and definition o the research topic

2 Formulate research questions and hypotheses

3 Conduct research, independently or in a multidisciplinary team by selecting and applying appropriate research methodologies and techniques, collecting and analysing data.

4 Formulate well-founded conclusions and recommendations based on a comprehensive discussion of the results.

5 Demonstrate academic attitude and learning skills (incl thinking in multidisciplinary dimensions & distinguishing main issues from minor ones), to enhance & keep up-to-date the acquired knowledge and application skills in a largely independent manner.

6 Communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rationa underpinning of these in oral and written presentations to a variety of audiences.

Assessments

%	Type	Name
100	Presentation	Defence

Topics

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3231

MSc research, thesis and defence

Term	201819T15
Coordinator	E.A. de Jong
Credit points	30.000000000
Specialization	Core Program

Target Group

for GroundwatCH and Flood Risk Management (30 ECTS)

Prerequisites

Learning Objectives

1	Explore the background of the research problem by critically reviewing scientific literature; Evaluate relevant theories and applying these theories to a relevant scientific problem; Assure adequate delineation and definition o the research topic
2	Formulate research questions and hypotheses
3	Conduct research, independently or in a multidisciplinary team by selecting and applying appropriate research methodologies and techniques, collecting and analysing data.
4	Formulate well-founded conclusions and recommendations based on a comprehensive discussion of the results.
5	Demonstrate academic attitude and learning skills (incl thinking in multidisciplinary dimensions & distinguishing main issues from minor ones), to enhance & keep up-to-date the acquired knowledge and application skills in a largely independent manner.
6	Communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rationa underpinning of these in oral and written presentations to a variety of audiences.

Assessments

%	Type	Name
100	Presentation	Defence

Topics

Study load

Nr	Topic		Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
		Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3452

Data Acquisition, Preprocessing and Modelling using SWAT

Term	
Coordinator	I. Masih
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

Assessments

%	Type	Name
	Attendance	

Topics

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3298

Data Assimilation for Operational Hydrological Modelling

Term	
Coordinator	M. Mazzoleni
Credit points	0.000000000
Specialization	

Target Group

Target groups are both scientists and practitioners in the field of operational reservoir management. Water Authorities interested in improving their early warning system by means of model updating techniques are also welcome.

Prerequisites

Participants should have a good background with hydrological and mathematical theories. They are expected to be familiar with the contents of standard operational forecasting and reservoir management. Basic programming skills are also required.

Learning Objectives

1. Recognise the main challenges in operational hydrological forecasting in case of reservoir management
2. Explain the concept of model updating using data assimilation techniques
3. Identify the advantages and disadvantages of each updating method to improve operational forecasting
4. To be able to apply different data assimilation approaches to operational reservoir management applications and analyses their usefulness
5. Discuss the concept of forecast uncertainty

Assessments

%	Type	Name
1	Attendance	

Topics

1 Overview to operational forecasting

2 Introduction to hydrological modelling

Topics

3 Assessment of forecast uncertainty

4 Introduction to Data Assimilation

1. Kalman Filter,
2. Ensemble Kalman Filter,
3. Particle Filter,
4. Asynchronous FIltering

5 Hands-on Exercise: practical applications

1. A simple update exercise and comparison of techniques
2. Assimilation of a single observation variable
3. Hindcasting experiments using operational forecasting systems
4. Simultaneous assimilation of multiple observations (e.g. discharge, soil moisture)

6 Outlook and further applications

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Overview to operational forecasting	2	0	0	0	0	0	2	6	
2	Introduction to hydrological modelling	3	0	0	0	0	0	3	9	
3	Assessment of forecast uncertainty	3	0	0	0	0	0	3	9	
4	Introduction to Data Assimilation	14	0	0	0	0	0	14	42	
5	Hands-on Exercise: practical applications	0	0	14	0	0	0	14	14	
6	Outlook and further applications	4	0	0	0	0	0	4	12	
	Total	26	0	14	0	0	0	40	92	

Education Material

Scientific Software

Gewin Excel

Matlab

M3312

Google Earth Engine for Spatio-Temporal Analysis of Hydrological Extremes

Term	
Coordinator	M. Mazzoleni
Credit points	0.000000000
Specialization	

Target Group

Prospective participants are both scientists and practitioners in the field of hydrological extremes (floods and droughts) management and remote sensing. Water Authorities interested in improving water resources management by means of multiple remote sensing sources and Google Earth Engine are also welcome.

Prerequisites

Participants should have a good background with hydrological theories. Basic programming skills are also required

Learning Objectives

1 To acquire a theoretical understanding of the remote sensing products available for water resources managemen purposes

2 To master the Google Earth Engine platform for data collection, visualization and classification.

3 To be able to perform complex spatial-temporal analysis with Google Earth Engine using the latest remote sensin products.

4 To apply Google Earth Engine for large scale hydrological extremes management

Assessments

%	Type	Name
1	Attendance	

Topics

1 Theoretical background on remote sensing

2 Introduction to Google Earth Engine and Java scripting

3 Data collection, visualization and classification with Google Earth Engine

Topics

4 Time series analysis

5 Hydraulic modelling for flood management

6 Application of Google Earth Engine in flood management

7 Drought analysis

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Theoretical background on remote sensing	4	0	0	0	0	0	4	12	
2	Introduction to Google Earth Engine and Java scripting	2	0	2	0	0	0	4	8	
3	Data collection, visualization and classification with Google Earth Engine	1	0	3	0	0	0	4	6	
4	Time series analysis	2	0	2	0	0	0	4	8	
5	Hydraulic modelling for flood management	3	0	5	0	0	0	8	14	
6	Application of Google Earth Engine in flood management	3	0	5	0	0	0	8	14	
7	Drought analysis	3	0	5	0	0	0	8	14	
	Total	18	0	22	0	0	0	40	76	

Education Material

Scientific Software

Gewin Excel

HEC-RAS

M3186

International Port Seminar

Term
Coordinator M. van Schuylenburg
Credit points 4.000000000
Specialization

Target Group

Preferably participants have a technical background and some years of working experience in a port environment.

Professionals in (or on their way to) management positions in the field of port management, port planning and development, port consultancy, port policy making, construction and maintenance are especially welcome at the seminar.

A bachelor level and a workable knowledge of English are required to benefit fully from the International Port Seminar.

Prerequisites

Bachelor degree in hydraulic engineering, mechanical engineering or technical management or a comparable level obtained by 3-5 years working experience in the field of port management or port planning and engineering

Learning Objectives

1 Get acquainted with incorporating uncertainty in port planning (Adaptive Port Planning)
2 Learn about the international character of ports in the global supply chain and port logistics, economic and financial aspects of ports and port organisation models
3 Get acquainted with modern port planning tools as simulation and serious gaming
4 Get acquainted with stakeholder management, sustainability, security and safetyin ports

Assessments

%	Type	Name
1	Attendance	Attendance
1	Presentation	Presentation about development plan of port of their home country

Topics

1 Port management, Adaptive Port Planning, Port economics, Port Finance, Stakeholder management, Security and Safety in ports

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Port management, Adaptive Port Planning, Port economics, Port Finance, Stakeholder management, Security and Safety in ports	40	8	8	0	16	0	64	152	
	Total	40	8	8	0	16	0	64	152	

Education Material

Book Ports and terminals, H.Ligteringen

Scientific Software

M3453

River basin modelling using SWAT

Term
Coordinator I. Masih
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

Assessments

%	Type	Name
	Attendance	

Topics

Study load

Nr	Topic		Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
		Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M1837

Short Course on Design of Hydropower Schemes

Term	
Coordinator	M. Marence
Credit points	0.000000000
Specialization	

Target Group

The course is designed for scientists, engineers and water managers involved in hydropower development and water resources management, or interested in these topics.

Prerequisites

Basic knowledge of hydraulics, geotechnics and structural engineering

Learning Objectives

1 get overview and working knowledge in design of the hydropower schemes and practical design of hydropower structures including power waterways, powerhouses, turbines and electrical equipment.

2 get overview of development and design of all types of hydropower structures including also small power plants and pump-storage plants

Assessments

%	Type	Name
1	Attendance	

Topics

1 Hydropower - Introduction

Hydropower: basic concepts, past experience and trends, context society, energy & environment.

Topics

2 Hydropower schemes - Layout and design requirements

Hydropower schemes. Conventional low and high head schemes: factors principles and requirements for the design, typical arrangements and layouts. Basic data needed for hydropower definition.

3 Open power waterways

Weir, intake and sand trap types and design. Open channels and free flow systems, Forebays. Penstock types, materials and design.

4 Power waterways

Definition of the power waterway layout. Hydraulic (static and transient) design of power waterway. principles and experiences in analysis and design, tunnels, surge tanks and penstocks. Tunnel excavation, lining systems and grouting works. Intakes, gate shafts, valves, transitions and manifolds. Safety and monitoring of power waterways.

5 Powerhouse

Types of powerhouses. main parts and auxiliary equipment. Transmission lines. Powerhouse design.

6 Electromechanical equipment

Turbines, hystory and types. Pelton turbines. CRoss flow turbines. Francis turbines. Kaplan turbines. Turbine design.

7 Small hydropower

Definition and benefits of small hydro. Hydropower estimation. Inflatable rubber dam. Tyrolian weir. Special small machines. Small hydropower projects.

8 Pump storage powerplants

Need and requirements for pump storage. Typical layouts. Artificial reservoirs. Pumps and machine types. Examples.

9 Cost control and financial analysis

Hydropower project development. Project costs schedule. Live costs. Financial analyses. Project risks

10 Future developments and perspectives

Refurbishment of HPP, Future and challenges of hydropower

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydropower - Introduction	2	0	0	0	0	0	2	6	M. Marence
2	Hydropower schemes - Layout and design requirements	2	0	0	2	0	0	4	10	M. Marence
3	Open power waterways	3	0	0	2	0	0	5	13	M. Marence
4	Power waterways	3	0	0	0	0	2	5	15	M. Marence
5	Powerhouse	2	0	0	0	0	0	2	6	M. Marence
6	Electromechanical equipment	2	0	0	0	0	2	4	12	M. Marence
7	Small hydropower	2	0	0	0	0	0	2	6	M. Marence
8	Pump storage powerplants	2	0	0	0	0	0	2	6	M. Marence
9	Cost control and financial analysis	1	0	0	0	0	0	1	3	M. Marence
10	Future developments and perspectives	2	0	0	0	0	0	2	6	M. Marence
	Total	21	0	0	4	0	4	29	83	

Education Material

Scientific Software

M2292

Short Course on Hydropower Water Conduit Design

Term
Coordinator M. Marence
Credit points 0.000000000
Specialization

Target Group

Participants (scientists, engineers) interested in design principles of hydropower or interested in these topics

Prerequisites

Working knowledge in Hydraulics, Geoscience and structural engineering

Learning Objectives

1 select proper power waterway type and layout integrating geological, geo-morphological and hydraulic characteristics of the site
2 implement hydraulic and structural design of the power waterway and all their parts
3 predict the construction and operational costs of the power waterway and identify the environmental impacts of the power waterway
4 implement knowledge in practical design of the hydropower schemes

Assessments

%	Type	Name
1	Attendance	

Topics

1 Introduction

2 Layout selection

3 Hydraulics of PWW

4 Civil structure

5 Environmental impact

6 Workshop

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction	2	0	0	0	0	0	4	6	M. Marence
2	Layout selection	2	0	0	0	0	0	2	6	M. Marence
3	Hydraulics of PWW	10	0	0	0	0	0	10	30	A. Cattapan, D. Ferras, I.I. Popescu
4	Civil structure	20	0	0	0	0	0	20	60	M. Marence
5	Environmental impact	4	0	0	0	0	0	4	12	A. Mendoza - Sammet
6	Workshop	8	0	0	0	0	0	8	24	A. Cattapan, M. Marence
	Total	46	0	0	0	0	0	48	138	

Education Material

Scientific Software

M2630

Short Course on Where there is Little Data: How to Estimate Design Variables in Poorly Gauged Basins

Term
Coordinator P. Paron
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

1. To apply the latest new Open Source GIS and Remote Sensing software and data for deriving hydro-geomorphological and hydro-meteorological information
2. To apply an advanced theoretical understanding of selected hydrological variables: flow duration curves, hydrological extremes, mean annual flow
3. To evaluate, select and apply different advanced statistical and geo-statistical methods for estimating hydrological variables in poorly gauged basins

Assessments

%	Type	Name
1	Attendance	

Topics

Study load

Nr	Topic		Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
		Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software