UNESCO-IHE
Institute for Water Education

MASTER PROGRAMME WSE 2016-2018

WSE General description UNESCO-IHE

Study guide part 1

Table of contents

- 1 UNESCO-IHE
    - 1.1 Introduction
    - 1.2 MSc Degree Programmes
    - 1.3 Research and PhD Programmes
    - 1.4 Organisation

- 2 Programme framework
    - 2.1 Introduction
    - 2.2 Academic Regulations
    - 2.3 Structure of the Programmes
    - 2.4 Curriculum Information
    - 2.5 Final Qualifications
    - 2.6 Teaching Methods
    - 2.7 Examinations
    - 2.8 Study Load
    - 2.9 Planning and Scheduling
    - 2.10 Participation in coursework and lunch seminars
    - 2.11 Evaluation of the Programme by Students

- 3 Regulations
    - 3.1 Education and Examination regulations
    - 3.2 Library regulations
    - 3.3 Code of conduct
    - 3.4 Plagiarism

- 4 Facilities
    - 4.1 Location
    - 4.2 Student Affairs (office)
    - 4.3 Student Association Board
    - 4.4 ICT services
    - 4.5 General Facilities in the Building
    - 4.6 UNESCO-IHE Library and Information Services
    - 4.7 Laboratories
    - 4.8 Study Materials
    - 4.9 English support courses

1 UNESCO-IHE

1.1 Introduction

UNESCO-IHE 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.

In November 2001, UNESCO's 31st General Conference decided to make IHE an integral part of the Organisation. By March 2003, the necessary treaties and agreements between the IHE Delft Foundation, UNESCO and the Netherlands Government were signed, allowing for the entry into operation of the new UNESCO-IHE Institute for Water Education. UNESCO-IHE is governed by a thirteen-member Governing Board appointed by the Director General, and is managed by a Director and Deputy Director. The IHE Delft Foundation provides all other staff and facilities to UNESCO-IHE.

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.

UNESCO-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 WL/Delft Hydraulics, GeoDelft, and The Netherlands Organisation for Applied Scientific Research are situated nearby. UNESCO-IHE 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
- 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

UNESCO-IHE 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 UNESCO-IHE together with a Dutch university. Candidates should preferably hold a UNESCO-IHE 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. The organisation is structured into departments, which are further subdivided into various sections. Within the organisation structure, three academic departments are distinguished:

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

These departments have one or more academic cores in the major fields, each with a leading professor, who is assisted by academic staff and research fellows. Process management support units and a education bureau provide administrative support.

Besides the academic staff of UNESCO-IHE, 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 Master of Science Degree Programmes

The Institute provides 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
- the master programme in Water Science and Engineering.

These programmes have a nominal duration of 18 months and are leading towards a Master of Science (MSc) degree in the respective field upon successful completion. Each programme has several distinct specialisations, in which students follow a programme curriculum best suited to their preference.

The minimum study load of the programmes is 106 credit points, expressed in units defined by the European Credit Transfer and Accumulation System (ECTS).

2.2 Academic Regulations

The *Education and Examination Regulations* (separately included in this handbook) provide the basic data of the programme, including the major rules around the examinations and the rights of students to inspect the results of the examination assessment.

The 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.

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

2.3 Structure of the Programmes

The curriculum follows 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 is formed by 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 defense, followed by a period of six months of individual research and writing of the thesis. The MSc thesis is defended publically at the end.

2.4 Curriculum Information

All components of the programme curriculum are described by a syllabus (summary) in the programme-specific part of the handbook providing the following information, which is further detailed in the sections below:

- the name and code of the subject;
- 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.

2.5 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 subjects in the modules usually aim to achieve a further detailed subset of the module learning objectives.

2.6 Teaching Methods

The programmes are conducted using a combination of lectures, exercises, assignments and examinations. The latter are described separately in the next section.

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 groupwork 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 Examinations

Examinations serve to test if students have achieved the learning objectives of a module, and ultimately those of the programme itself. The examination for a module may be composed of multiple parts. For example, a combination of a written or oral test and one or more assignments to handed in separately.

Examination work can also be produced by (small) groups of students working together on an assignment, e.g. the groupwork 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 examination, students are informed about the assessment results via e-mail. When all examinations 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

Lectures and exercises 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 educational activities;
- required lecture notes, textbooks and other course-related material;
- announcements of examination planning details; and
- statements on examination 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 Education and Examination regulations

See for the Education and Examination regulations the separate part after the Academic Calendar

3.2 Library regulations

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

The UNESCO-IHE 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 UNESCO-IHE 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' are 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 UNESCO-IHE

In consideration of the need for rules and regulations concerning the safety and the proper use of the buildings, grounds and facilities of UNESCO-IHE 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 Director

The director of UNESCO-IHE

1.3 the Rectorate

The director and the deputy director

1.4 Central services department

The central services department of UNESCO-IHE

1.5 Facilities

The institute buildings, the interior and equipments as well as rented office and accommodation facilities

1.6 Buildings

The buildings of UNESCO-IHE, located at Westvest 7, Delft

1.7 Student

Anyone who is enrolled at UNESCO-IHE for the purpose of education provided by UNESCO-IHE and who uses the educational and examination facilities of UNESCO-IHE 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 UNESCO-IHE 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 UNESCO-IHE 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 UNESCO-IHE or to other persons who are present on the grounds or in the buildings of UNESCO-IHE or who make use of the facilities of UNESCO-IHE, nor that he or she causes nuisance or annoyance;

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

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 UNESCO-IHE 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 UNESCO-IHE or from one or more parts of UNESCO-IHE, 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 UNESCO-IHE;

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 UNESCO-IHE and/or the facilities or use of the facilities of UNESCO-IHE 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 non-compliance.

Article 5 Termination of the exclusion order

5.1 T he 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 UNESCO-IHE”.

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 UNESCO-IHE's 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 UNESCO-IHE, 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' (see annex). 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.[Oxford English Dictionary]

This act is considered as academic fraud. (in the sense of the word as established by Article 2.1 of the Education and Examination Regulations.) 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, (as stipulated by 17. 2 of the Education and Examination Regulations.) 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

UNESCO-IHE uses a computer program called Turnitin® to assist with the detection of plagiarism. The plagiarism detection service is an online service that enables UNESCO-IHE 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 UNESCO-IHE 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 UNESCO-IHE 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 UNESCO-IHE buildings and facilities are located on a single compound at the Westvest 7 in the centre of Delft. The buildings provide a pleasant and 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 well being. 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

UNESCO-IHE provides modern computing (IT) facilities for education and research. A local wired- and wireless network is available in UNESCO-IHE's building. Through UNESCO-IHE's networks all computers have access to a fast Internet connection. Besides that, participants have unlimited access to Internet in all hostels provided by UNESCO-IHE.

All UNESCO-IHE desktop and laptop PCs are Intel based with Microsoft Windows operating system. The UNESCO-IHE laptop PC will be provided in order to get access to the IT-facilities. The laptop is on loan for use during studying at UNESCO-IHE. At the end of the study, UNESCO-IHE 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 UNESCO-IHE 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 UNESCO-IHE e-mail account which enables you to make use of all relevant computing facilities at the Institute. Your account will be revoked when you will have ended your study at UNESCO-IHE. 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 UNESCO-IHE.

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 UNESCO-IHE Library and Information Services

UNESCO-IHE’s Library provides access to over 35,000 printed titles, among which the complete collection of UNESCO-IHE 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 UNESCO-IHE portal. For more information please visit the Library's Internet page http://www.unesco-ihe.org/library

The library is open to all UNESCO-IHE 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 UNESCO-IHE 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, M.Sc 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 Delft University of Technology and other educational and research institutions, research possibilities 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 environmental field 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 'eCampus XL', 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 (CEFR) 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 B2 choose 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

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.

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.

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.

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 proof-reading; Elements of Writing – writing skills such as making comparisons, describing results and paraphrasing; Accuracy in Writing – to improve common problems, eg 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.

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.

MASTER PROGRAMME WSE 2016-2018

WSE programme description UNESCO-IHE

Study guide part 1

Table of contents

- Introduction Water Science & Engineering Masters Programme
- Domain specific framework
- Objectives of the Water Science & Engineering Masters Programme and intended learning outcomes
- Curriculum and structure of the Water Science & Engineering Masters Programme
- Didactical concept
- Hydrology and Water Resources
    - Learning objectives
- Hydroinformatics – Modelling and Information Systems
    - Learning objectives
- Hydraulic Engineering and River Basin Development
    - Learning objectives
- Hydraulic Engineering – Coastal Engineering and Port Development
    - Learning objectives
- Land and Water Development for Food Security
    - Learning objectives
- Programme staff

Introduction Water Science & Engineering Masters Programme

The Water Science & Engineering Masters 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 Masters 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 Masters 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;

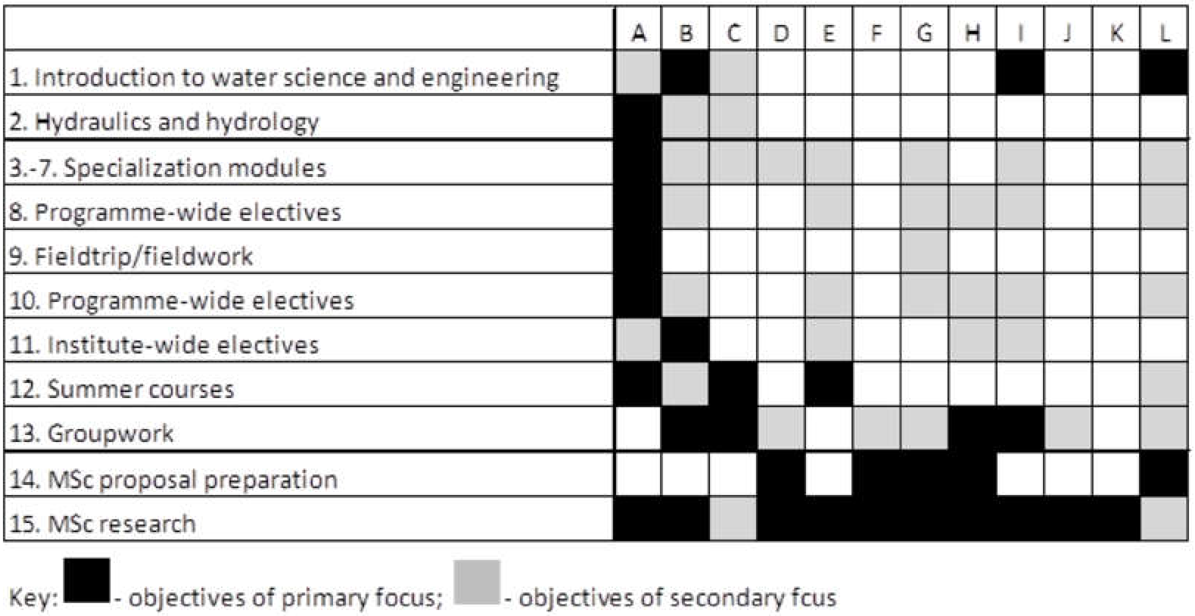
Learning skills

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

Curriculum and structure of the Water Science & Engineering Masters 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 seven specializations:

- Hydrology and Water Resources (HWR);
- Hydraulic Engineering and River Basin Development (HERBD);
- Hydraulic Engineering – Coastal Engineering and Port Development (HECEPD);
- Land and Water Development for Food Security (LWDFS);
- Hydroinformatics: Modelling and Information Systems for Water Management (HI);
- 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 UNESCO-IHE 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. AIT in Thailand, UNL in the USA, and Sriwijaya in Indonesia. HECEPD, HWR and HI offer the possibility to start in China by following the first three modules at Hohai University. In addition HI offers the possibility to start at Universidad del Valle in Colombia. In all these cases, the modules offered abroad are the same as the ones offered at UNESCO-IHE, using largely the same course materials.

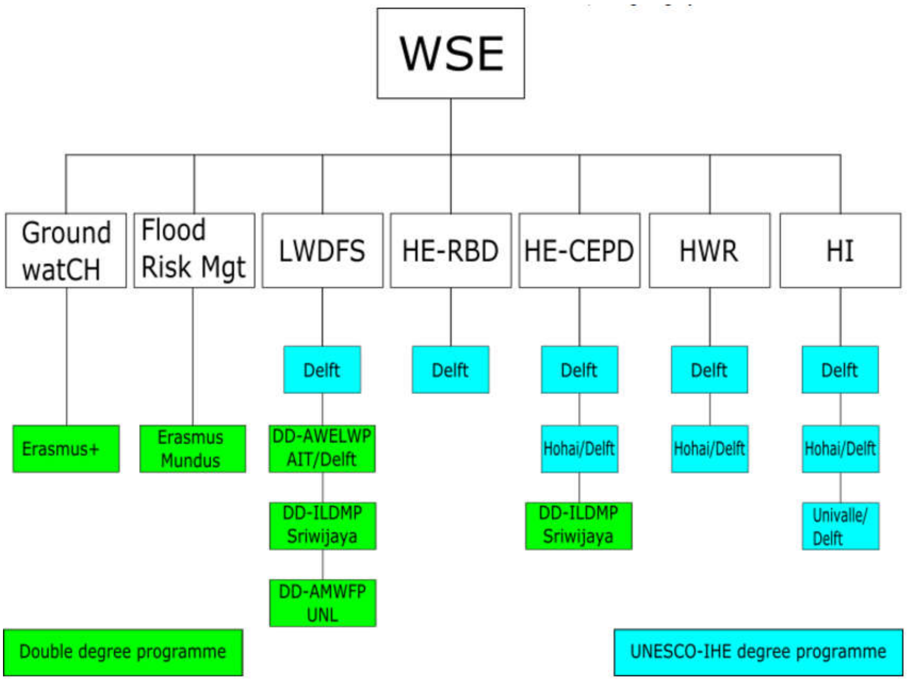


Figure 1: Water Science & Engineering Masters Programme: specializations and double degree programmes

The five 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, UNESCO-IHE 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 Masters 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 UNESCO-IHE 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 the UNESCO-IHE supervisor/mentor throughout the project.

Hydrology and Water Resources

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.

Learning objectives for Hydrology and Water Resources

See:

Education and Examination Regulations for cohort 2016– 2018

Appendix A Qualifications of Graduates

Hydroinformatics – Modelling and Information Systems

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 1):

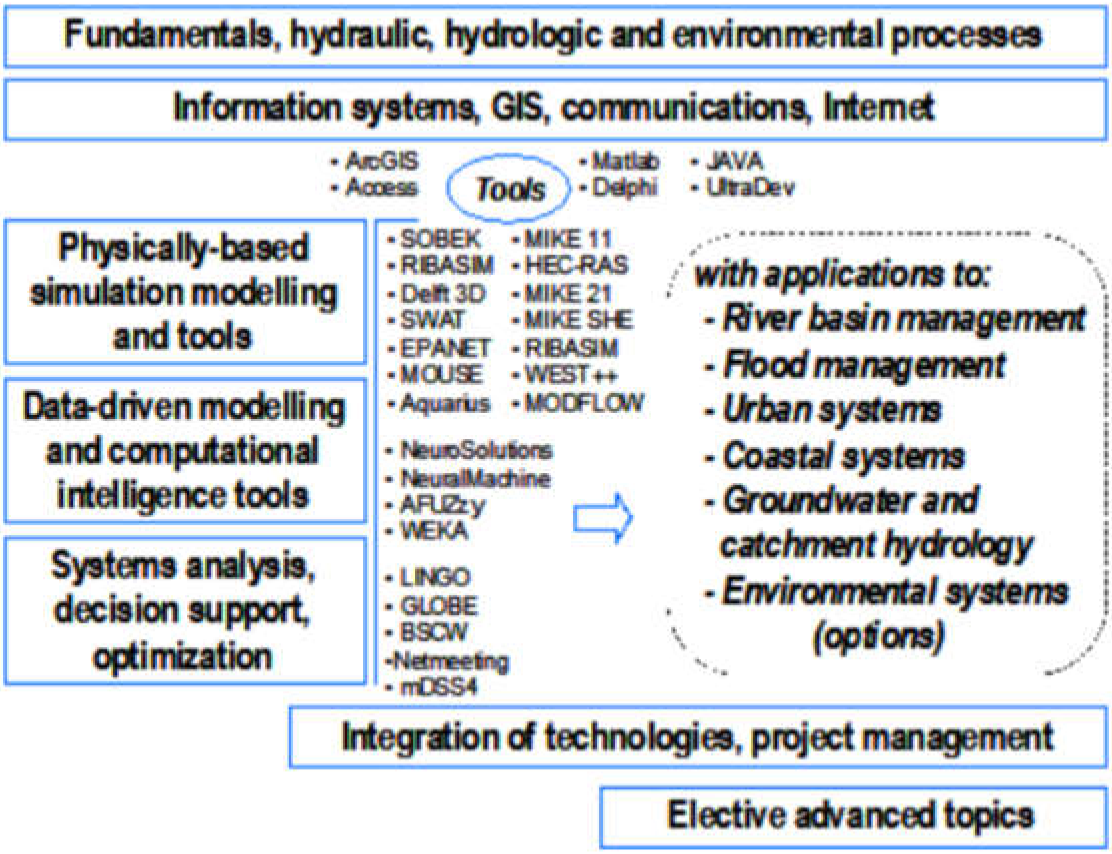


Figure 1: The general thematic structure of the Hydroinformatics specialization

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.

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.

International Masters in Hydroinformatics (IMHI): programme description and organisation

In the academic year 2011-2013 the Hydroinformatics specialization will also be offered as a joint programme between two core partners: UNESCO-IHE and Hohai University (HU) in Nanjing, China. This variant of the Hydroinformatics Masters studies is entitled International Masters in Hydroinformatics (IMHI) and has the following description:

- IMHI has the same number of ECTS as the regular Hydroinformatics specialization (106 ECTS).
- IMHI has the same study curriculum and module descriptions as the regular Hydroinformatics specialization.
- The framework of the programme, the organisation of the programme and the examination procedures, as described in chapters 3, 4 and 5 of the General part of this Handbook also apply to IMHI.
- The examination rules and guidelines approved by the UNESCO-IHE Academic Board on August 31, 2006, as they are described in the second section of this Handbook are used in the IMHI variant.
- In the IMHI variant the taught part of the Hydroinformatics specialization is divided in two blocks:

Block 1, consisting of the first three modules: Introduction Water Science and Engineering, Hydrology and Hydraulics and Information Technology and Software Engineering. It consists of 15 ECTS. This block is implemented and delivered by Hohai University in Nanjing, China.

Block 2, consisting of all remaining taught modules of the Hydroinformatics specialization (modules 4-14, consisting of 55 ECTS). This block is implemented at UNESCO-IHE and is identical to the regular Hydroinformatics specialization.

- The lecturing material in Block 1 is same as the one used in the regular Hydroinformatics specialization.
- The students enrolled in IMHI need to obtain passing marks for the first three modules (Block 1) before they can continue to Block 2.
- If re-examinations are required in some of the first three modules (Block 1) they will be scheduled before the beginning of Block 2.

The organisation of the IMHI variant is carried out by the IMHI Joint Committee (IMHI-JC), which consists of the following members:

Hydroinformatics Head of Core:	Prof. Dimitri Solomatine
IMHI coordinator at UNESCO-IHE:	Dr. Andreja Jonoski
IMHI coordinator at Hohai University:	Dr. Yiqing Guan
Hydroinformatics specialization coordinator at UNESCO-IHE:	G.A. Corzo Perez

The IMHI-JC is responsible for the organisation and implementation of the IMHI variant in the Hydroinformatics specialization. More specifically IMHI-JC has the following responsibilities:

- to implement the IMHI variant of the Hydroinformatics specialization, in particular Block 1 at Hohai University
- to serve as a link between all IMHI-related study activities and the WSE Programme Committee and the Examination Board
- to monitor, evaluate and maintain the quality of the IMHI variant
- to assist in development of the composition and content of the Hydroinformatics specialization

Through IMHI-JC, UNESCO-IHE and Hohai University share the responsibility for the MSc research phase of the students in the IMHI variant (in Year 2), including their preparation of MSc research proposal (Modules 13 and 14 in Year1).

The IMHI coordinators at UNESCO-IHE and at Hohai University have joint responsibility for the IMHI variant as described in Chapter 4.3 of the General part of this Handbook.

The academic calendar for Block 1, at Hohai University is shown below:

Module number	**Calendar weeks**	**Module title**	**Module Mentor**
IMHI Block 1 – at Hohai University			
1	41-43	Introduction Water science and Engineering	Dr. Guan, HU
-	44	Examination week	
2	45-47	Hydraulics and hydrology	Dr. Guan, HU
3	48 –50	Geo-information systems	Prof. Chen, HU
-	51	Examination week	
-	52-1	*Christmas recess*	.
4-14	2	Block2 at UNESCO-IHE	

Subjects and the respective lecturers for the IMHI Block 1 are provided below (details of the course contents are provided subsequently in the Tables for Module 1, 2 and 3).

Module number	Module title	Subjects	Lecturer
1	Introduction Water science and Engineering	Review of mathematics and statistics	Prof. X. Xiaoming (Hohai Univ.)
		The Water System	
2	Hydraulics and hydrology	Hydraulics	Prof. Y. Guan (Hohai Univ.)
		Engineering Hydrology	Dr. Z. Danrong (Hohai Univ.)
		GIS and remote sensing	Dr. Y. Tao (Hohai Univ.)
3	Information Technology and Software Engineering	Information and communication technology	**Prof. Chen (Hohai Univ.)**
		GIS and remote sensing	Dr. Y. Tao (Hohai Univ.)
		Software Engineering	Prof. Chen (Hohai Univ.)

- Starting from week 38, Hohai University will provide remedial lectures in English language. These lectures will be offered for a period of 5 weeks, till week 42.
- The academic calendar in this handbook is valid for Block 2, at UNESCO-IHE.
- Part two of the handbook presents the module descriptions of the Hydroinformatics specialisation. The descriptions of modules 1, 2 and 3, in addition to the regular variant of the Hydroinformatics specialisation, present also the IMHI variant (particularly the responsible lecturers and module mentors).

Learning objectives for Hydroinformatics:

See:

Education and Examination Regulations for cohort 2016– 2018

Appendix A Qualifications of Graduates

Hydraulic Engineering and River Basin Development

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 of the course

- Aims of the specialization Hydraulic Engineering and River Basin Development

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.

Learning objectives for Hydraulic Engineering and River Basin Development

See:

Education and Examination Regulations for cohort 2016– 2018

Appendix A Qualifications of Graduates

Hydraulic Engineering – Coastal Engineering and Port Development

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, UNESCO-IHE 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 of the course

In the courses 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 courses concentrate on the planning, design and construction of ports and harbours. A seminar on port management forms part of the course. 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 course.

Furthermore the execution of coastal and port works and environmental aspects are discussed.

Aim of the Course

The overall aim of the Coastal Engineering and Port Development course is to train engineers such that after the course 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 Masters course is practically oriented.

Approach to the course

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 can not 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 the UNESCO-IHE 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.*

Learning objectives for Hydraulic Engineering-Coastal Engineering and Port Development:

See:

Education and Examination Regulations for cohort 2016– 2018

Appendix A Qualifications of Graduates

Land and Water Development for Food Security

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 of the course

In keeping with the academic domain and normative activities, the overall aim of the LWDFS Master 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 to the course

- Given the importance of both technical and non-technical aspects in land and water development and management, the LWDFS Masters 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.

Course content and description

The LWDFS Masters 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 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.

Specialisation modules

The specialisation modules - modules 3 to 7 - deal with the following subjects:

Module 3 *Introduction to Land and Water Development*: conceptualizes and analyses the demand and supply of land and water resources on a global and regional scale to meet the present and future food requirements; discusses basic functions, elements and needs of and for irrigation and drainage systems and illustrates layout and design of primary and secondary irrigation and drainage networks, including canals, drains, roads and farms.

Module 4 *Design Aspects of Irrigation and Drainage*: introduces applied hydraulics of irrigation and drainage systems, soil-water-crop yield relationships, agronomy, and water and drainage requirements, leading to the design of an irrigation and drainage network at a tertiary unit (on-farm) level.

Module 5 *Tertiary Unit Design and Hydraulics:* gives participants a comprehensive understanding of applied hydraulics in irrigation and drainage systems, water-crop yield relationships, and the ability to select appropriate irrigation and drainage methods and to estimate crop water requirements and devise complex irrigation schedules matching water demand and supply.

Module 6 *Socio-economic and Environmental Aspects of LWD*: covers economic, financial, and sociological aspects of irrigation and drainage, assessment of environmental impacts of land and water development projects, and drainage management for salt control.

Module 7 *Conveyance and Irrigation Structures*: Includes unsteady flow equations, hydrodynamic models, DUFLOW, wave propagation, and the characteristics and hydraulic design of irrigation and flow control structures.

Module 9 *Field work part (1 week)*: this practical course focuses on various types of flow measuring equipment, methods and techniques, pumps and pipes, field canals, irrigation methods and soil characteristics. *International field trip part (2 weeks)*: familiarises the participants with various layout, design and management of irrigation, drainage and other hydraulic systems in different parts of Europe or the USA.

These specialisation modules are preceded with two WSE common modules that acquaint the participants with broad practices and principles for managing and developing land and water resources. These common modules also introduce some important land and water analysis techniques such as GIS and remote sensing.

Elective WSE modules

To give an added depth and breadth to certain specific technical, management and socio-economic aspects of land and water development and management, three elective modules are offered:

Module 8 *Management of Irrigation and Drainage Systems*: demonstrates how to formulate objectives for irrigation and drainage, define water delivery systems, apply (inter)national water law, and develop an irrigation management plan considering conflictive water uses, water rights frameworks, cost recovery, and monitoring and evaluation for performance assessment.

Module 10 *Innovative Water Systems for Agriculture*: covers groundwater flows and use for agriculture, Darcy equations, precision irrigation such as drips and sprinklers, solar-powered irrigation, management of floods for productive use, and pumps and lifting devices.

Module 11 *Remote Sensing, GIS, and Modelling for Agricultural Water Use*: deals with irrigation and remote sensing, water system modelling and GIS, lowlands and flood prone areas including polder systems, land subsidence, and sediment in canals.

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.

Institute-wide modules

In Module 12 the participant can chose a summer course from different specialisations (institute-wide).

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:**
    - *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.
    - *Sediment transport in irrigation canals.* Research focused on the analysis of sediment movement in irrigation canals under different conditions and operation rules.
    - *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:**
    - *Water saving in irrigation.* Research is focused on improvements in water use in irrigation in light of prevention of environmental degradation.
    - *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:**
    - *Performance analysis and accountability mechanisms.* Research on institutional and socio-economic aspects of irrigation and drainage system management.
    - *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:**
    - *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.
    - *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.

Learning objectives for the LWDFS Specialisation

See:

Education and Examination Regulations for cohort 2016– 2018

Appendix A Qualifications of Graduates

Programme staff

Hydrology and Water Resources

Michael McClain	Head of Chair Group
Jochen Wenninger	Specialization coordinator
Thom Bogaard	
Jan Willem Foppen	
Ann van Griensven	
Hans van der Kwast	
Shreedar Maskey	
Tibor Stigter	
Raymond Venneker	
Yangxiao Zhou	

Hydroinformatics

Dimtri Solomatine	Head of Chair Group
Gerald Corzo Perez	Specialization coordinator
Leoardo Alfonso Segura	
Schalk Jan van Andel	
Giuliano Di Baldassarre	
Biswa Bhattacharya	
Andreja Jonoski	
Ioana Popescu Zoran Vojinovic	

Hydraulic Engineering and River Basin Development

Arthur Mynett	Head of Chair Group
Paolo Paron	Specialization coordinator
Eelco van Beek	
Luigia Brandimarte	
Allesandra Crosato	
Miroslav Marence	
Micha Werner	

Hydraulic Engineering - Coastal Engineering and Port Development

Dano Roelvink	Head of Chair Group
Ali Dastgheib	Specialization co-ordinator
Han Ligteringen	
Rosh Ranasinghe	
Johan Renys	
Mick van der Wegen	

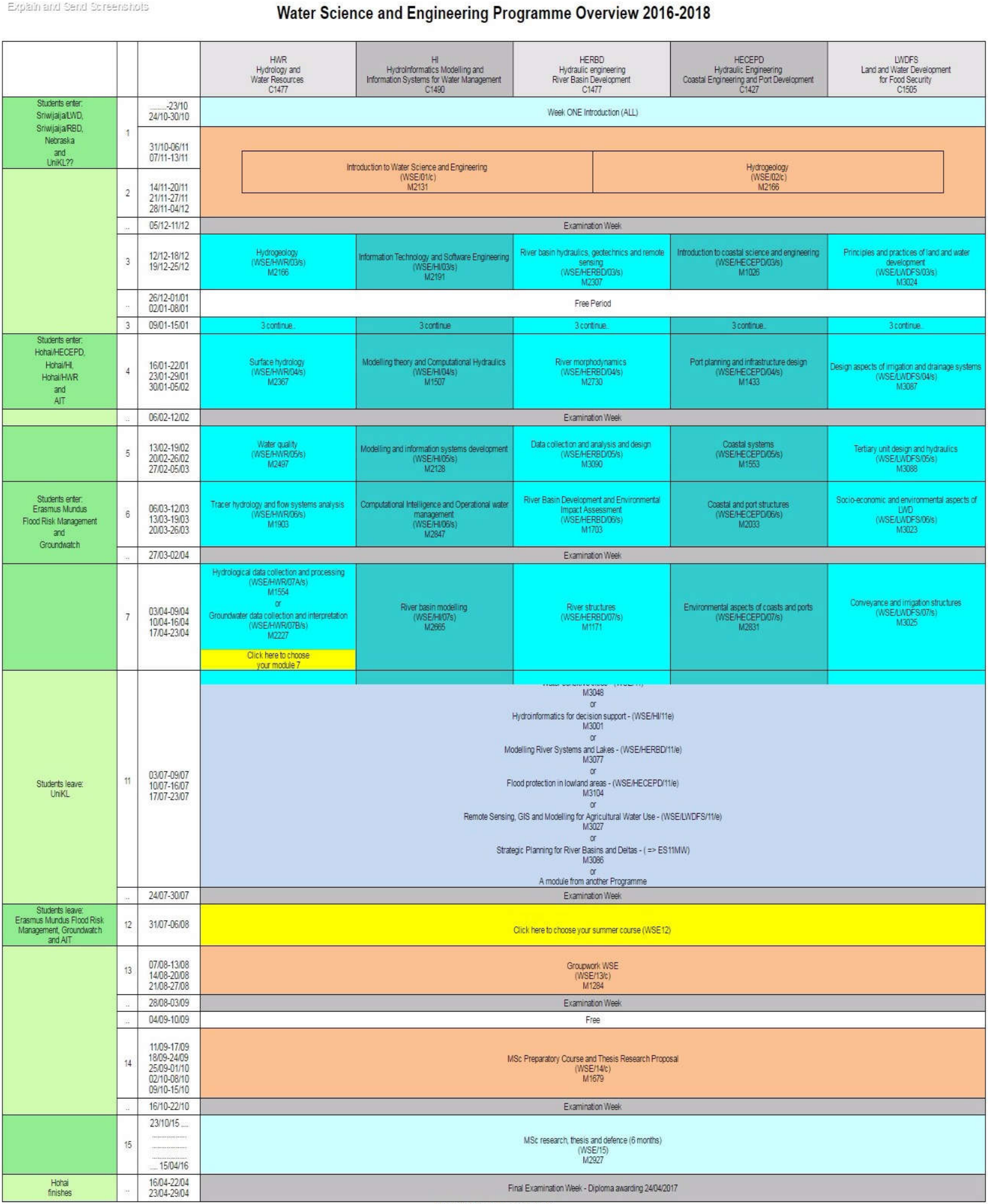
Hydraulic Engineering - Land and Water Development

Charlotte de Fraiture	Head of Chair Group
Annelieke Duker	Specialization coordinator
László Hayde	
Abraham Mehari Haile	
Sur Suryadi	
Poolad Karimi	

Flood Resilience

Chris Zevenbergen	Head of Chair Group
Berry Gersonius	
Assela Pathirana	

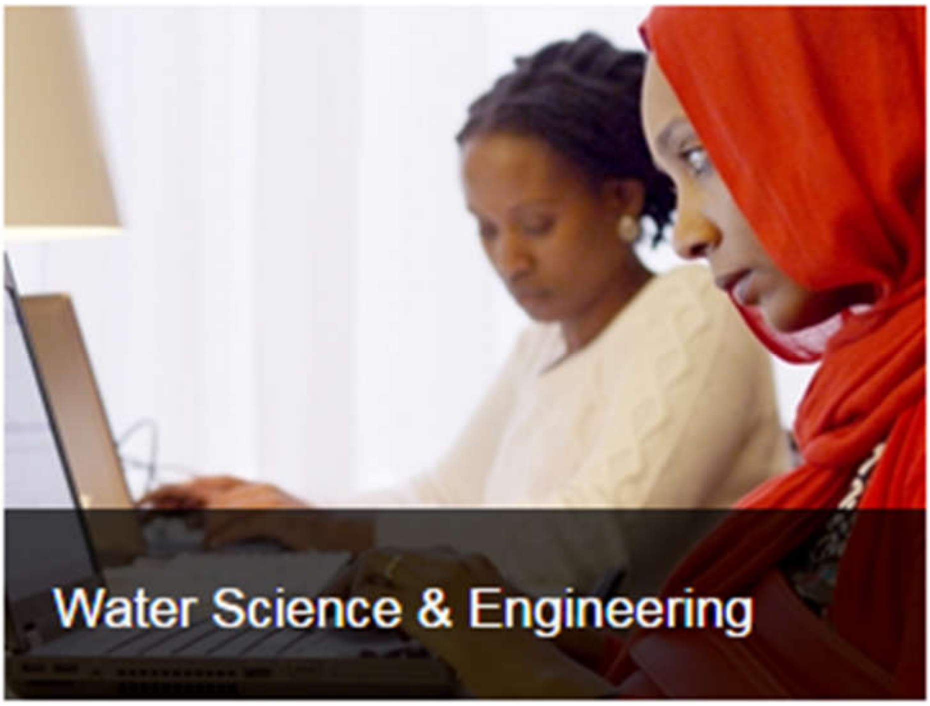
Programme co-ordinator Jan Willem Foppen



Water Science and Engineering Programme Overview 2016-2018

			HWR Hydrology and Water Resources C1477	HI HydroInformatics Modelling and Information Systems for Water Management C1490	HERBD Hydraulic engineering River Basin Development C1477	HECEPD Hydraulic Engineering Coastal Engineering and Port Development C1427	LWDFS Land and Water Development for Food Security C1505
Students enter: Sriwijaja/LWD, Sriwijaja/RBD, Nebraska and UniKL??	1	.........-23/10 24/10-30/10	Week ONE Introduction (ALL)				
		31/10-06/11 07/11-13/11	Introduction to Water Science and Engineering (WSE/01/c) M2131			Hydrogeology (WSE/02/c) M2166	
	2	14/11-20/11 21/11-27/11 28/11-04/12					
	..	05/12-11/12	Examination Week				
	3	12/12-18/12 19/12-25/12	Hydrogeology (WSE/HWR/03/s) M2166	Information Technology and Software Engineering (WSE/HI/03/s) M2191	River basin hydraulics, geotechnics and remote sensing (WSE/HERBD/03/s) M2307	Introduction to coastal science and engineering (WSE/HECEPD/03/s) M1026	Principles and practices of land and water development (WSE/LWDFS/03/s) M3024
	..	26/12-01/01 02/01-08/01	Free Period				
	3	09/01-15/01	3 continue..	3 continue	3 continue..	3 continue..	3 continue..
Students enter: Hohai/HECEPD, Hohai/HI, Hohai/HWR and AIT	4	16/01-22/01 23/01-29/01 30/01-05/02	Surface hydrology (WSE/HWR/04/s) M2367	Modelling theory and Computational Hydraulics (WSE/HI/04/s) M1507	River morphodynamics (WSE/HERBD/04/s) M2730	Port planning and infrastructure design (WSE/HECEPD/04/s) M1433	Design aspects of irrigation and drainage systems (WSE/LWDFS/04/s) M3087
	..	06/02-12/02	Examination Week				
	5	13/02-19/02 20/02-26/02 27/02-05/03	Water quality (WSE/HWR/05/s) M2497	Modelling and information systems development (WSE/HI/05/s) M2128	Data collection and analysis and design (WSE/HERBD/05/s) M3090	Coastal systems (WSE/HECEPD/05/s) M1553	Tertiary unit design and hydraulics (WSE/LWDFS/05/s) M3088
Students enter: Erasmus Mundus Flood Risk Management and Groundwatch	6	06/03-12/03 13/03-19/03 20/03-26/03	Tracer hydrology and flow systems analysis (WSE/HWR/06/s) M1903	Computational Intelligence and Operational water management (WSE/HI/06/s) M2847	River Basin Development and Environmental Impact Assessment (WSE/HERBD/06/s) M1703	Coastal and port structures (WSE/HECEPD/06/s) M2033	Socio-economic and environmental aspects of LWD (WSE/LWDFS/06/s) M3023
	..	27/03-02/04	Examination Week				
	7	03/04-09/04 10/04-16/04 17/04-23/04	Hydrological data collection and processing (WSE/HWR/07A/s) M1554 or Groundwater data collection and interpretation (WSE/HWR/07B/s) M2227 Click here to choose your module 7	River basin modelling (WSE/HI/07s) M2665	River structures (WSE/HERBD/07/s) M1171	Environmental aspects of coasts and ports (WSE/HECEPD/07/s) M2831	Conveyance and irrigation structures (WSE/LWDFS/07/s) M3025
Students leave: UniKL	11	03/07-09/07 10/07-16/07 17/07-23/07	M3048 or Hydroinformatics for decision support - (WSE/HI/11e) M3001 or Modelling River Systems and Lakes - (WSE/HERBD/11/e) M3077 or Flood protection in lowland areas - (WSE/HECEPD/11/e) M3104 or Remote Sensing, GIS and Modelling for Agricultural Water Use - (WSE/LWDFS/11/e) M3027 or Strategic Planning for River Basins and Deltas - (=> ES11MW) M3086 or A module from another Programme				
	..	24/07-30/07	Examination Week				
Students leave: Erasmus Mundus Flood Risk Management, Groundwatch and AIT	12	31/07-06/08	Click here to choose your summer course (WSE12)				
	13	07/08-13/08 14/08-20/08 21/08-27/08	Groupwork WSE (WSE/13/c) M1284				
	..	28/08-03/09	Examination Week				
	..	04/09-10/09	Free				
	14	11/09-17/09 18/09-24/09 25/09-01/10 02/10-08/10 09/10-15/10	MSc Preparatory Course and Thesis Research Proposal (WSE/14/c) M1679				
	..	16/10-22/10	Examination Week				
	15	23/10/15 .... 15/04/16	MSc research, thesis and defence (6 months) (WSE/15) M2927				
Hohai finishes	..	16/04-22/04 23/04-29/04	Final Examination Week - Diploma awarding 24/04/2017				

MASTER PROGRAMME WSE 2016-2018



Exam regulation UNESCO-IHE

Study guide part 1

UNESCO-IHE
Institute for Water Education

Education and Examination Regulations for cohort 2016– 2018

For:
- the Master Programmes in
  a. Urban Water and Sanitation
  b. Environmental Science
  c. Water Management
  d. Water Science and Engineering
- short and online courses which are part of these programmes (starting Sep 2016, and ending Sep 2017)
- Graduate professional diploma programmes

Approved by the Rectorate of UNESCO-IHE, [19-07-2016]

Table of Contents

1 Definition of terms 2
2 General Information 4
3 Content of the Programme 7
4 Assessments 8
5 Results of Assessments 12
6 Thesis Examination 14
7 Criteria, degrees and certificates 16
8 Appeals 20
9 Final Articles 20
Appendix A Qualifications of Graduates 23
  1. Urban Water and Sanitation Programme 23
  2. Environmental Science Programme 27
  3. Water Management Programme 31
  4. Water Science and Engineering Programme 36
Appendix B Examination Procedures 45
Appendix C Grading Systems used by partner institutes 47
Appendix D MSc modules: names, credits & assessment methods 50
Appendix E MSc thesis marking guidelines 77
Appendix F Appeal procedure 78

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;
Consent agreement:	a negotiated agreement of examining committee members to an examination which resolves the disputed issues;
Co- mentor:	a staff member from an external institute or different chair group within UNESCO-IHE 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;
ECTS transfer:	the procedure of granting credits to a student for studies completed at another institute;
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 student's 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;
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 or ideas 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;
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.

2 General Information

Article 1 Scope of the regulations

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

a. Urban Water and Sanitation
b. Environmental Science
c. Water Management
d. Water Science and Engineering

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

referred to hereafter as 'the programmes'.

The programmes are executed by the UNESCO-IHE 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 4 joint degree specialisations 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);
- Environmental Technology for Sustainable Development (ETSuD).

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 The following Master of Science programmes and specialisations are offered:

1. Urban Water and Sanitation programme:

Specialisation	Offered by	Type of degree
1. Water Supply Engineering	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Kwame Nkrumah University of Science and Technology, Ghana	Double degree
	• UNESCO-IHE • Universidad de Valle, Cali, Colombia	Double degree
2. Sanitary Engineering	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Kwame Nkrumah University of Science and Technology, Ghana	Double degree
	• UNESCO-IHE • Universidad de Valle, Cali, Colombia	Double degree
3. Urban Water Engineering and Management	• UNESCO-IHE • Asian Institute of Technology,Thailand	Joint degree

2. Environmental Science programme:

Specialisation	Offered by	Type of degree
1. Environmental Science and Technology	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Universidad de Valle, Cali, Colombia	Double degree
2. Environmental Planning and Management	UNESCO-IHE	UNESCO-IHE degree
3. Water Quality Management	UNESCO-IHE	UNESCO-IHE degree
4. Limnology and Wetland Management	• UNESCO-IHE • BOKU - University of Natural Resources and Life Sciences, Vienna, Austria • Egerton University, Egerton, Kenya	Joint degree
5. Environmental Technology for Sustainable Development	• UNESCO-IHE • Asian Institute of Technology,Thailand	Joint degree
6. Environmental Technology and Engineering (Erasmus Mundus programme)	• UNESCO-IHE • Ghent University, Belgium, • ICTP, Prague, Czech Republic	Joint degree

3. Water Management programme:

Specialisation	Offered by	Type of degree
1. Water Management	UNESCO-IHE	UNESCO-IHE degree
2. Water Resources Management	UNESCO-IHE	UNESCO-IHE degree
3. Water Services Management	UNESCO-IHE	UNESCO-IHE degree
4. Water Quality Management	UNESCO-IHE	UNESCO-IHE degree
5. Water Conflict Management	UNESCO-IHE	UNESCO-IHE degree

4. Water Science and Engineering programme:

Specialisation	Offered by	Type of degree
1. Hydrology and Water Resources	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Hohai University, China P.R.	UNESCO-IHE degree
2. Hydraulic Engineering - River Basin Development	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • University of Kuala Lumpur	Double degree
3. Coastal Engineering and Port Development	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Hohai University, China P.R.	UNESCO-IHE degree
4. Land and Water development	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Asian Institute of Technology Thailand	Double degree
	• UNESCO-IHE • University of Nebraska -Lincoln, USA	Double degree
5. Hydroinformatics- Modelling and information systems for water management	UNESCO-IHE	UNESCO-IHE degree
	• UNESCO-IHE • Hohai University, China P.R.;	UNESCO-IHE degree
	• UNESCO-IHE • Universidad del Valle, Colombia	UNESCO-IHE degree

6. Flood Risk Management (Erasmus Mundus programme).	• UNESCO-IHE • 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).	• UNESCO-IHE • TU Dresden, Germany • University of Lisbon, Portugal	Multiple degree

5. **Graduate professional diploma programmes**:

Name	Offered by	
Sanitation and Sanitary Engineering	• UNESCO-IHE	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 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.

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 UNESCO-IHE 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 of the study guides.

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.

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 Students cannot sit for a module assessment more than twice per academic year.

6.5 Students of a short and online course can sit for the assessment only once.

6.6 In case a student fails the examination of a GPDP module twice, the student can either redo the whole module again, or choose another module. In both cases agreement of the programme coordinator is needed.

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

6.8 Written and oral examinations for short and online course participants are held within two weeks after the end of the module.

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

6.10 Students of short courses or online courses are eligible to sit for the assessment of the course they are registered for provided that the fee to sit for these assessments has been paid.

6.11 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 examination work 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.

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

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.

7.2 Written and oral re-examinations take place during the following examination period as indicated in the academic calendar. Dates and times of written re-examinations are announced in the programme schedules. Not reading or misreading the schedules is not accepted as legitimate reason for failure to participate in a re-examination. All students will take the re-sit of a written examination at the same time.

7.3 The dates and times of written and oral (re-)examinations during the thesis period are set by the module coordinator in collaboration with the programme coordinator and the education bureau.

7.4 Students will only be allowed to re-sit an assessment for which a fail (i.e. mark lower than 6.0) has been obtained. The highest mark obtained (first assessment or re-sit) for the assessment will be used to compute the final module mark.

7.5 Students are not allowed to sit for further assessments during the programme period they are registered for, if they failed three separate modules (after re-assessments) during the taught part of the programme ('modules' does not include the MSc proposal defence).

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

7.7 The latest moment to sit for a re-examination is one month before the submission date of the MSc thesis.

Article 8 The organisation of the examinations

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

8.2 In the case of an oral or written examination 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 examinations

9.1 Oral examinations are taken individually (only one student at a time). During oral examinations, a second staff member is present as an observer.

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

9.3 Oral examinations 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 2 modules.

10.3 The MSc thesis proposal defence is assessed as a pass or a fail. In the case of a fail, the student may present their defence 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 their MSc thesis work.

Article 11 Exemptions and transfer of credit points

11.1 Exemptions for assessments are 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 and/or the examination itself 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.

12.4 For all cases mentioned under art 12.2 and 12.3 the programme coordinator will inform the Examination Board and the planning office.

Article 13 Fraud

13.1 If a student is caught in an attempt to take unfair advantage during an examination, the invigilators or examiners will inform the Academic Registrar who will submit 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 exclude the student concerned 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.

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. 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 All written examination work of the students will, where feasible, be blind marked by the examiners involved.

14.5 Students will be informed on the outcome of their examination work as soon as possible, but at least three weeks before the planned re-examination.

14.6 The examination committee for the thesis examination shall determine the result immediately after the defence. The mark shall be formally communicated to the student before the diploma awarding by the Education Bureau.

14.7 After the assessment of a module has been completed, the student receives a written statement from the Education Bureau mentioning the overall module mark, the marks given for the different assessments, and if successful also the credit points granted for the module.

14.8 After a successful re-sit of an assessment, the mark for the module is recalculated according to the weighted average of the assessment results. However, the maximum module mark which can be awarded when there has been a re-assessment is 7.0.

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 Upon request, students will be provided with a written summary of the study results obtained in the programme to date.

6 Thesis Examination

Article 18 The organisation of the thesis examination

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

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

a) If the UNESCO-IHE mentor is a PhD fellow, mentoring the MSc student in the context of his/her own research, is a member of the committee, an additional staff member is compulsory.

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

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

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.

External examiners:
- are not involved in the thesis work (independent)
- are from outside the institute or are in exceptional cases from a chair group within the institute, but not involved in the supervision of the research work.
- have to possess at least a Master degree.

18.2 The opportunity to sit the thesis examination is offered once every calendar month.

18.3 All students have to submit the examination version of the thesis report on the same date, and defend their thesis in the designated period, as annually announced by the Examination Board.

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

18.5 If the outcome of the thesis examination, including the defence, is negative, 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 has to finalize the work without further supervision nor financial support.
The re-sit shall be taken within three months after the first attempt and will, in principle, be assessed by the same committee as for the first attempt.
In special circumstances 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 their mentor.

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:

SINGLE DEGREES:

- For the single UNESCO-IHE degree programmes:
  - Successfully completed all modules of the programme; and
  - Obtained a minimum of 106 ECTS.

- For the single UNESCO-IHE GPDP diploma:
  - Successfully obtained a minimum of 20 ECTS for the programme.

JOINT DEGREES:

- For the joint degree Limnology and Wetland Management programme (LWM):
  - Successfully completed all modules of the programme, according to the grading rules of BOKU, Egerton University and UNESCO-IHE; and
  - Obtained a minimum of 120 ECTS.

- For the joint degree International Master of Science in Environmental Technology and Engineering programme (IMETE) (Erasmus Mundus programme):
  - Successfully completed all modules of the programme, according to the grading rules of Ghent University, Institute of Chemical Technology in Prague and UNESCO-IHE; and
  - Obtained a minimum of 120 ECTS.

- For the joint degree Environmental Technology for Sustainable Development (ETSuD) conducted with the Asian Institute of Technology (AIT):
  - Obtained a minimum of 48 AIT credits / 125 ECTS credits, and
  - Obtained a minimum cumulative GPA of 2,75 for courses taken at AIT, and
  - Passed all modules taken at UNESCO-IHE, and
  - Has obtained a grade 'fair' or higher for their Master's thesis at AIT.

- For the joint degree Urban Water Engineering and Management (UWEM) conducted with the Asian Institute of Technology (AIT):
  - Obtained a minimum of 48 AIT credits / 120 ECTS credits, and
  - Obtained a minimum cumulative GPA of 2,75 for courses taken at AIT, and
  - Passed all modules taken at UNESCO-IHE, and
  - Has obtained a grade 'fair' or higher for their Master's thesis at AIT.

DOUBLE / MULTIPLE DEGREES:

- For the double degree programme Land and Water development conducted with the Asian Institute of Technology (AIT):
  - Obtained a minimum of 48 AIT credits / 120 ECTS credits, and
  - Obtained a minimum cumulative GPA of 2,75 for courses taken at AIT, and
  - Passed all modules taken at UNESCO-IHE, and
  - Has obtained a grade 'fair' or higher for their Master's thesis at AIT.

- For the double degree programmes in Water Supply Engineering, Sanitary Engineering, and Environmental Science and Technology conducted with Universidad del Valle:
  - Obtained a GPA of 3.5 or higher for the course work done at Univalle; and

  - Successfully completed all modules at UNESCO-IHE; and
  - Achieved a mark '6' or higher for the thesis examination; and
  - Obtained a minimum of 113,36 ECTS.

- For the double degree programmes in Water Supply Engineering, and Sanitary Engineering conducted with KNUST:
  - Obtained a CWA of 55% or higher for the course work done at KNUST; and
  - Successfully completed all modules at UNESCO-IHE; and
  - Achieved a pass for the thesis examination at KNUST; and
  - Obtained a minimum of 118 ECTS.

- For the double degree programme Land and Water development conducted with the University of Nebraska-Lincoln:
  - Successfully completed all modules of the programme; and
  - Obtained a minimum of 112 ECTS.

- For the double degree programme River basin development conducted with the University of Kuala Lumpur:
  - Successfully completed all modules of the programme; and
  - Obtained a minimum of 108.7 ECTS.

DOUBLE / MULTIPLE DEGREES (Erasmus Mundus programmes):

- For the multiple degree programme on Flood Risk Management:
  - Successfully completed all modules of the programme, according to the grading rules of TU-Dresden, University of Ljublijana, TU-Catalonia and UNESCO-IHE; and
  - Obtained a minimum of 120 ECTS.

- For the double degree programme Water Co-operation and Peace conducted with the University of Peace and University of Oregon:
  - Successfully completed all modules of the programme, according to the grading rules of UPEACE, University of Oregon, and UNESCO-IHE; and
  - Obtained a minimum of 120 ECTS.

- For the multiple degree programme in Groundwatch:
  - Successfully completed all modules of the programme, according to the grading rules of the University of Lisbon, Technical University Dresden, and UNESCO-IHE; and
  - Obtained a minimum of 120 ECTS.

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 at the next scheduled degree awarding ceremony. The degree is signed by the Chairman 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, 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 The Master of Science degree can be awarded with distinction by the Examination Board if:

For single degree programmes:

- the candidate obtained a mark of 8.5 or higher for the thesis examination, and an arithmetic average mark at UNESCO-IHE of 8.0 or higher for all modules that are assessed on a numerical scale, conform article 14.1,
- there were no re-assessments during the taught part, and
- a recommendation is made by the chair of the examination committee.

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

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

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

For double / multiple degree programmes where student sits for the thesis examination at a partner institute:

- the candidate obtained an arithmetic average mark at UNESCO-IHE of 8.0 or higher for all modules that are assessed on a numerical scale, conform article 14.1.
- a recommendation is made by the professor responsible for the specialization concerned.

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

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 body or person that has taken the disputed decision.

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.

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 2016 – 2018. Approved by the Rectorate of UNESCO-IHE on 19-07-2016

Appendix A Qualifications of Graduates

1. Urban Water and Sanitation Programme

1.1 Sanitary Engineering

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. understand and explain the role of sanitation in urban water cycle and its relation to public health and environment; 2. develop rational approaches towards sustainable waste(water) management via pollution prevention, appropriate treatment, resources recovery and re-use on both centralized and decentralized level; 3. understand in-depth relevant physical, chemical and biological processes, and their mutual relationships within various sanitation components;
Applying knowledge and understanding	1. apply gained knowledge and skills in practice; 2. prepare conceptual engineering and process design of sanitation components; 3. apply modern tools for technology selection and carry out modelling of sanitation components; 4. identify, develop and conduct independent research including formulation of hypotheses selection and application of research methodologies, and the formulation of conclusions and recommendations; 5. carry out desk studies, field work, and laboratory based research; 6. 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. define and critically analyse, assess and evaluate various urban drainage and sewerage schemes, and wastewater, sludge and solid waste treatment process technologies; 2. analyse, synthesise, 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. clearly communicate concerning both oral and written skills;
Lifelong learning skills	1. continuously acquire knowledge and assimilate and implement innovative learning methods and skills in an independent manner; 2. operate both autonomously and in a multidisciplinary and multinational environment.

1.2 Water Supply Engineering

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. understand the structure of drinking water supply systems, including water transport, treatment and distribution; 2. understand water quality criteria and standards, and their relation to public health, environment and urban water cycle; 3. understand in-depth occurring physical, chemical and biological phenomena and their mutual relationships, within water supply systems; 4. understand water quality concepts and their effect on treatment process selection; 5. understand the interaction of water quality and materials applied; 6. understand hydraulic concepts and their relationship to water transport in treatment plants, pipelines and distribution networks; 7. understand the importance and methods for operation and maintenance of water supply systems; 8. understand options for centralised and urban systems versus decentralized and rural systems; 9. understand water supply engineering within a watershed context;
Applying knowledge and understanding	1. design and to rehabilitate raw water abstraction, transport, treatment and distribution processes and systems; 2. use statistical and modelling tools for simulating, prediction of performance and operation of water supply system components; 3. conduct independent research, including formulation of hypotheses, selection and application of research methodologies, and the formulation of conclusions and recommendations;
Making judgements	1. define and evaluate project alternatives on basis of chosen selection criteria;
Communication	1. communicate effectively in oral and written presentations to technical and non-technical audiences.
Lifelong learning skills	2. posses the learning skills to acquire continual knowledge in an independent manner;

1.3 Urban Water Engineering and Management

After successful completion of the programme graduates will be able to:

Knowledge and understanding	1. understand the urban water cycle and its water system components, their characteristics and functioning within greater urban infrastructure systems; 2. understand urban water management problems including ability to: identify water systems’ demand; deal with climatic and hydrologic uncertainties and/or extremes; institutional limitations; and work within a data-constrained environment; 3. understand water infrastructure/asset planning, financing and management, and utility management; 4. familiarise 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. 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 systems; 2. identify, articulate, analyse and solve problems of the urban water cycle and systems, integrating theory and applications; 3. collect, summarise, analyse and interpret technical data/materials in a structured form to gain knowledge on urban water system design and operation and maintenance; 4. work with a range of information technology 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. critically recognize and assess the need for continued-education and research on planning, design, maintenance and management of urban water systems;
Communication	2. reporting and give presentation;
Lifelong learning skills	1. learn independently; 2. demonstrate having improved IT skills; 3. work independently and / or as part of a team; 4. manage time effectively.

1.4 Graduate professional diploma programme

Upon completion of the programme participants will be qualified to:

- perform as a competent professional in the field of sanitation and/or sanitary engineering
- to contribute to the development of innovative approaches to the provision of sustainable sanitation services especially under challenging conditions usually prevailing in developing and countries in transition.

Knowledge and understanding	1. Understand and explain the role of sanitation in the urban water cycle and its relation to public health and environment; 2. Understand the relevant physical, chemical and biological processes and their mutual relationships within various sanitation components;
Applying knowledge and understanding	1. Develop rational approaches towards sustainable wastewater management via pollution prevention, appropriate treatment, and resource recovery and re-use at both centralized and decentralized setting; 2. Apply modern tools for technology selection and to model sanitation components.
Making judgements	1. Define and critically analyze, assess and evaluate various urban drainage and sewerage schemes, and wastewater, sludge (including feacal sludge) and solid waste treatment process technologies; 2. Analyze, synthesize, integrate, interpret, and discuss scientific and practical information in the context of preparing research and engineering projects including preparation of master plans, feasibility studies and preliminary designs;
Communication	
Lifelong learning skills	

2. Environmental Science Programme

2.1 Environmental Science & Technology

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources; 2. describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources; 3. identify the impacts of human activities on the environment, under different levels of environmental stress and in different socio-economic contexts; 4. name and explain concepts, instruments and technologies for pollution prevention and remedial actions in a national and international context;
Applying knowledge and understanding	1. 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. apply general methods (including statistics and modelling) in scientific and technological approaches, concepts and interventions; 3. contribute as a flexible and creative member in interdisciplinary teams in developing solutions for prevention or remediation of environmental problems, by linking scientific knowledge to engineering interventions and to management decisions in different cultural and socio-economic contexts, and using different levels of available knowledge and information;
Making judgements	1. 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. 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;
Communication	1. 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;
Lifelong learning skills	1. demonstrate academic attitude and learning skills (including 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 a largely independent manner.

2.2 Environmental Planning & Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources; 2. describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources; 3. understand the environmental policy cycle and planning process and to analyse and prepare environmental policy strategies, taking into account the impact that society has on water and environmental resources; 4. name and explain principles, concepts and instruments of major national and international water and environmental legislation and common and desired institutional and management arrangements;
Applying knowledge and understanding	1. 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. apply general scientific methods (including statistics and environmental modelling) to processes of water and environmental resources allocation and use at different scales in order to gain an understanding of problems, trends, causes and effects; 3. apply environmental scientific methods (including environmental impact assessment, policy analysis, resource valuation, environmental economics) and models for institutional development with emphasis on policy development, functional decentralisation and good governance; 4. design and facilitate consultation- and decision-making processes between stakeholders, users and their representatives, water managers, politicians and other decision-makers;
Making judgements	1. 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. identify and critically assess the different ecological and socio-economic functions and values of the environmental system and the, often competing, interests of the various stakeholders; 3. 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; 4. design comprehensive environmental resources policies and strategies that aim to enhance the sustainable use of the environment especially focusing on water, and that include a suitable combination of technical, legal, administrative and financial measures.

Communication	5. 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;
Lifelong learning skills	6. demonstrate academic attitude and learning skills (including 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 a largely independent manner;

2.3 Water Quality Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources; 2. describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources; 3. identify the impacts of human activities on aquatic ecosystems; 4. name and explain principles, concepts and instruments of main national and international water and environmental legislation and common and desired institutional and management arrangements;
Applying knowledge and understanding	1. 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. interpret, design and optimise water quality monitoring and assessment schemes in the watershed; 3. apply experimental, statistical and modelling tools for interpreting and designing water quality management programmes; 4. 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;
Making judgements	1. 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. contribute as a flexible and creative member in interdisciplinary teams in developing solutions for water quality management problems in different cultural and socio-economic contexts, and using different levels of available knowledge and information; 3. critically analyse and evaluate alternative water quality management programmes in the watershed under different socio-economic and legal contexts, often in data-poor conditions;
Communication	1. 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;
Lifelong learning skills	1. demonstrate academic attitude and learning skills (including 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 a largely independent manner.

3. Water Management Programme

3.1 Water Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. describe and predict for a given water resources system the main hydrological, hydraulic, chemical and ecological processes and how these processes are dynamically linked with human activities, including land and water use. 2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements over water, including policies, laws and institutions, and by adopting a historical perspective. 3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches. 4. comprehend the broader scientific, engineering, socio-economic and environmental context in which water management and governance issues are manifested and addressed.
Applying knowledge and understanding	1. formulate and apply water management and governance frameworks / tools / methods to water related issues in a given context in a social inclusive and environmental sustainable manner. 2. apply different concepts and methods in a coherent way and through a process of triangulation synthesize results and draw well reason conclusions and recommendations. 3. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.
Making judgements	1. compare and contrast different ideas and approaches to make sound judgement based on available information, and assess the potential for application, integration and further development. 2. apply suitable techniques, tools and procedures for a given context in order to evaluate the consequences of different development and intervention scenarios. 3. reflect critically on ho how different activities impact on the sustainable use of water in a given context. 4. reflect on own professional and educational background relate to this knowledge and skills needed to build a solid career in the water sector, and on this basis identify a coherent personal learning trajectory.
Communication	1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.
Lifelong learning skills	1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues. 2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner. 3. Have the ability to reflect on own performance and advance own career within the water sector.

3.2 Water Resources Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. describe and predict for a given water resources system the main hydrological, hydraulic, chemical and ecological processes and how these processes are dynamically linked with human activities, including land and water use. 2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements over water, including policies, laws and institutions, and by adopting a historical perspective. 3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches. 4. characterize and explain water resource issues using economic concepts and theory for addressing water issues and describe how economic concepts and tools including valuation support integrated water resources management.
Applying knowledge and understanding	1. model processes of the water system (rainfall-runoff, flooding, water allocation, water accounting), validate models, critically interpret model outcomes in order to derive insight in trends, causes and effects, and define and explain model limitations. 2. formulate and critically evaluate governance frameworks related to water resources management and apply tools for policy analysis with the emphasis on social inclusion and sustainability. 3. Apply and develop integrated tools / methods to support water resources assessment / planning / management at different scales and accounting for aspects relating to quality and quantity and upstream / downstream linkages. 4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.
Making judgements	1. analyse a given water resources system in order to quantify the water flows over space and time, accounting for and describing the interdependencies between many (competing) water users. 2. critically evaluate technical and/or institutional water resources interventions (policie actions / agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.
Communication	1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences
Lifelong learning skills	1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues. 2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.

3.3 Water Conflict Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. describe for a given water resources system the interplay between the main biophysical processes and social dynamics, in analyzing, anticipating, preventing and managing conflicts. 2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements over water for collaboration, including policies, laws and institutions, and by adopting a historical perspective. 3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches at sector, intersectoral and transboundary levels. 4. name and critically discuss theories, concepts and tools of conflict management and cooperation building techniques in the context of natural resources and water in particular.
Applying knowledge and understanding	1. design and facilitate inclusive consultation and conflict management processes, such as consensus building, public participation, negotiation and mediation between actors at different levels. 2. formulate and critically evaluate governance frameworks related to water conflict management and apply tools for policy analysis with the emphasis on social inclusion and sustainability. 3. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner. 4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions, recommendations and limitations.
Making judgements	1. appraise the different functions of the water resources system, and the associated competing interests of water using sectors and actors, describe the inter-dependencies between these, and finally assess the possibilities and limitations of cooperation. 2. critically evaluate technical and/or institutional interventions focused on conflict management (projects/ programmes/ policies/ agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.
Communication	1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.
Lifelong learning skills	1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues. 2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.

3.4 Water Quality Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. describe and predict for a given water resources system the main hydrological, hydraulic, chemical and biological processes and how these processes are dynamically linked with aquatic ecosystems as well as with human activities such as land and water use and pollution. 2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements for water quality management, including policies, laws and institutions, and by adopting a historical perspective. 3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of aquatic ecosystems and describe the challenges of such approaches. 4. describe concepts to determine the value of water for various uses and users in (amongst others) economic and ecological terms and explain how these concepts can be used in water resources planning at various spatial and temporal scales.
Applying knowledge and understanding	1. interpret, design and optimize water quality assessment and monitoring programmes by applying experimental, statistical and modelling tools. 2. formulate and critically evaluate governance frameworks related to water quality management and apply tools for policy analysis with the emphasis on social inclusion and sustainability. 3. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner. 4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.
Making judgements	1. define a given water resources system, and compose the water and pollution flows across time and space, including the various water uses, and describe the interdependencies these create between the various water users. 2. critically evaluate technical and/or institutional interventions focused on water quality (projects/ programmes/ policies/ agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.
Communication	1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.
Lifelong learning skills	1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues. 2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner

3.5 Water Services Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. describe for a given water resources system the interplay between the main biophysical processes and social dynamics, in analyzing service delivery modalities. 2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements concerning water supply and sanitation services, including policies, laws and institutions, and by adopting a historical perspective. 3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water services management and describe challenges of providing water supply and sanitation services at different levels (from global to local). 4. summarize the current debates relevant for water supply and sanitation services, using institutional and management theories from different academic disciplines (e.g. economics, public administration, sociology, political science, law).
Applying knowledge and understanding	1. design and apply analytical tools to research issues of water services management and describe, modify and apply management tools (e.g. with the benchmarking, cost benefit analysis, management information systems) with the aim of improving water supply and sanitation provision. 2. formulate and critically evaluate governance frameworks related to water services management and apply tools for policy analysis with the emphasis on social inclusion and sustainability. 3. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner. 4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.
Making judgements	1. analyze and evaluate governance processes and utility management arrangements in the water services sector, integrating technical, legal administrative, social and financial components. 2. critically evaluate technical and/or institutional interventions (e.g. policies actions, agreements) through analysis of implications for water supply and sanitation services, its users and their interrelations at various spatial and temporal scales.
Communication	1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.
Lifelong learning skills	1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues. 2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.

4. Water Science and Engineering Programme

4.1 Hydraulic Engineering and River Basin Development

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. have in-depth understanding of physical processes and natural phenomena in river basin systems, development of river basins by human interference, such as designing river structures and training works, and the management of floods and droughts; 2. master the major hydraulic methodologies and applications for river structures and river modelling techniques with regard to techniques for data collection, processing and analysis; 3. have knowledge of contemporary research (questions) and relevant literature in the field of hydraulic engineering and river basin development; 4. have acquired sufficient skills in using information and communication technology for conducting studies and analyses, in addition to presentation and communication;
Applying knowledge and understanding	1. evaluate and analyse river basin systems and processes at a wide range of scales for the purpose of water resources, including morphological assessments, impact analysis of hydraulic structures and natural hazards assessment and mitigation taking into account relevant aspects of environmental, economical and social planning and management; 2. design and conduct hydraulic research, experiments and tests for both practical and scientific purposes, either independently or within a team-based framework; by intelligent use of engineering and scientific principles, develop and undertake critical evaluations of strategies for the implementation of river engineering works; 3. have the skills to apply and integrate relevant concepts and methodologies in the area of hydraulic, hydrological and geotechnical engineering and research as well as applying computational principles within the context of hydraulic engineering
Making judgements	1. critically judge and evaluate their own work and results, as well as the information of prior research or investigations;
Communication	1. adequately communicate methodologies, results, evaluations, conclusions and recommendations in written, oral and graphical form to a wide variety of audience;
Lifelong learning skills	1. be aware of the importance of hydraulic engineering to society and be able to 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; 2. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and applications in an independent manner.

4.2 Coastal Engineering and Port Development

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. have advanced level of understanding of the hydraulics, coastal processes and nautical and logistic aspects and their interactions with the nearshore and offshore structure; 2. 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; 3. develop an understanding of the application of modern analysis and design techniques to coastal problems and gain the expertise necessary to make effective engineering interventions in the coastal environment; 4. be equipped with various analytical and computational expertise necessary to solve problems in coastal and port engineering;
Applying knowledge and understanding	1. 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 and be able to evaluate and implement the solutions in a multidisciplinary and interdisciplinary environment; 2. apply hydraulic and nautical, logistic and economic theories in the planning and design of coastal and ports layout and port logistics; 3. have the skills to undertake academic research that contributes to the better understanding of coastal and/or port engineering; 4. have developed the talents and skills for problem formulation and solutions synthesizing different fields of knowledge to formulate solutions to relevant technical problems using modern engineering tools
Making judgements	1. place a coastal engineering and/or port project in its environment (social, ecological and physical environment), be able to quantify and understand the interactions between the project and the environment, and is able to communicate the interactions with experts of a different background;
Communication	
Lifelong learning skills	1. have developed the skills to undertake independent creative academic activities and research and the ability to extend them leading to new knowledge that addresses problems of national and international importance; 2. have experienced different aspects of learning which are integrated through different teaching methods and through independent study experiences; 3. possess critical thinking skills, the ability of both independent and team problem-solving and the sense of engineering creativity and design; 4. have acquired sufficient skills in using information and communication technology for conducting research, studies and analyses, in addition to presentation and communication; 5. develop a sense of professionalism and an appreciation for the obligations of a professional engineer; 6. be aware of the professional and ethical issues encountered in engineering practice

4.3 Hydroinformatics– Modelling and Information Systems for Water Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. have in-depth understanding of the information cycle in relation to the management of water based systems, and have a thorough awareness of the flow of information from data acquisition to modelling, to support for decision making; 2. have a critical understanding of the theories and concepts of physical, chemical and biological processes relating to the flow of water in the natural environment, including river basins, coastal waters and urban water systems, as necessary to generate safe and reliable models for water based systems; 3. have an understanding of advanced and appropriate information and communication technologies and their application to manage information relating to water management; 4. have a good knowledge of the relevant literature and the contemporary research questions in the field of Hydroinformatics;
Applying knowledge and understanding	1. master the theory and practice of different modelling paradigms, and, in particular, physically based and data driven modelling, and be able to integrate them in hydroinformatics systems applied to a wide variety of hydraulic, hydrological and environmental situations; 2. to select and apply software tools available on the market, and critically assess their advantages and disadvantages in application to water resources management, hazard risk assessment and forecasting, environmental planning and asset management; 3. provide considered advice to managers and users of advanced Hydroinformatics tools; 4. appreciate and discuss the ethics and nature of the postmodern society and the role of water within it as a "right" and an "asset";
Making judgements	1. make critical use of advanced theories and concepts in Hydroinformatics to research creative solutions for new problems and situations, either independently or within a team; 2. critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others;
Communication	1. develop a range of personal and communication skills, including the use of appropriate information and communication technologies, for oral and written presentation of methodologies, results, evaluations, conclusions and recommendations to a wide variety of audiences;
Lifelong learning skills	1. be aware of the importance of the relationship of Hydroinformatics with related disciplines such as hydraulics, hydrology, ecology and information science, and be able to co-operate within a multidisciplinary and interdisciplinary framework; 2. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner; 3. be aware of the professional and ethical issues encountered in Hydroinformatics practice directed towards issues facing developing countries and countries in transition.

4.4 Hydrology and Water Resources

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. 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, and have a thorough awareness of the natural and human-induced variability in space and time of hydrological systems; 2. 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 of catchment hydrological modelling and aquifer modelling techniques; 3. have a good knowledge of the relevant literature and the contemporary research questions in the field of hydrology;
Applying knowledge and understanding	1. apply and integrate the relevant physical, chemical, applied mathematical, computational and earth-scientific principles and concepts, and to use information and communication technology within a hydrological context; 2. design and conduct hydrological research and experiments for both application and scientific purposes, either independently or within a team-based framework;
Making judgements	1. 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; 2. critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others;
Communication	1. adequately communicate methodologies, results, evaluations, conclusions and recommendations in oral, written and graphical form to a wide variety of audience;
Lifelong learning skills	1. be aware of the importance of hydrology to society, the relationship of hydrology with related disciplines such as ecology, meteorology and climatology, and be able to 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; and 2. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner.

4.5 Land and Water Development

After successful completion of the programme graduates will be able to:

Knowledge and understanding	1. Describe the latest concepts and theories of irrigation and drainage design, modernisation and management, flood protection and land reclamation for sustainable development and food security; 2. Explain 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; 3. Acquire knowledge and understanding of contemporary research issues in the field of land and water development for food security;
Applying knowledge and understanding	1. Apply the latest hydraulic engineering and hydrological methods in planning, design and implementation of irrigation and drainage schemes, independently or in a multidisciplinary team; 2. Apply innovative tools like Remote Sensing and GIS in planning and performance management of land and water development schemes for enhanced food security;
Making judgements	1. Identify options for participatory land and water development, and critically assess their technical, socio-economic and environmental performance; 2. Evaluate aspects of planning, design, modernization, operation & maintenance and financing of irrigation and drainage schemes. 3. Identify, develop and conduct independent research including formulation of hypotheses, selection and application of research methodologies, planning and executing of data gathering and analysis, and formulation of conclusions and recommendations;
Communication	1. Clearly and systematically communicate, argue and defend research proposal and findings orally and written to a wide variety of audience;
Lifelong learning skills	1. Independently acquire knowledge, critically assess data, and acquire critical reading and writing skills whereby distinguishing between minor and major issues. 2. Contribute to the development of innovative approaches for adequate and sustainable land and water development for food security;

4.7 Learning objectives Agricultural Water Management for Enhanced Land and Water Productivity (joint specialisation with AIT)

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. have in-depth understanding and specific knowledge of the latest concepts and theories of irrigation, drainage, flood management, land reclamation and consolidation technologies for increased returns from land and water resources in a sustainable manner; 2. have in-depth understanding and specific knowledge of the cross-sectoral linkages between land and water development and wider aspects of society, economy and the environment 3. acquire knowledge and understanding of contemporary research issues in the fields of land and water development and agricultural water management;
Applying knowledge and understanding	4. use latest hydraulic engineering and hydrological methods to apply in planning, design, implementation and management of irrigation, drainage and flood protection schemes, independently or in a multidisciplinary team; 5. identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their technical, economical, institutional and environmental feasibility; 6. engage in or advise the developers, system managers and water users on the participatory development, management and modernisation, including planning, design, implementation, operation and maintenance, as well as on modernisation of the irrigation, drainage and flood management schemes; 7. formulate and conduct hydraulic and agronomic research, plan development and designs in the field of enhanced land and water productivity, experiments and tests for both practical and scientific purposes, either independently or within a team-based framework;
Making judgements	
Communication	8. formulate research questions, articulate research methodologies, develop study plans, and adequately communicate research results and conclusions in written and oral forms to a wide variety of audience;
Lifelong learning skills	9. develop the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner.

4.8 Learning objectives of the Advanced Water Management for Food Production Program specialization, (joint specialisation with Nebraska)

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	1. understand in-depth the latest concepts and theories of irrigation, drainage, flood protection, land reclamation and consolidation technologies for food production; 2. describe the cross-sectoral linkages comprehending wider aspects of society, economy and the environment; 3. understand and formulate water management methodologies to enhance crop production with limited water supplies; 4. acquire knowledge and understanding of contemporary research issues in the field of land and water development and water for food;
Applying knowledge and understanding	1. use latest hydraulic engineering and hydrological methods to apply in planning, design and implementation of irrigation, drainage and flood protection schemes, independently or in a multidisciplinary team; 2. identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their feasibility; technologically, economically, and environmentally; 3. formulate research questions, articulate research methodologies, develop study plans, and adequately communicate research results and conclusions in written and oral forms to a wide variety of audience.
Making judgements	1. engage in or advise developers, system managers and water users on the participatory development and management, including operation and maintenance of the irrigation, drainage and flood protection schemes; 2. identify and develop available water resources for food production; 3. enhance the of on-farm irrigation systems through better design and management;
Communication	
Lifelong learning skills	

4.10 Flood Risk management

After successful completion of the programme, graduates will have:

Knowledge and understanding	1. a broad and cross-boundary scientific knowledge on flood risk management; 2. a comprehensive knowledge base and understanding of the current theory and practice relating to flooding and flood management; 3. the fundamental knowledge leading to the understanding of socio-economic issue related to flooding; 4. a broad scientific knowledge about conservation, restoration and management measures to overcome challenges imposed on water by humans and by climate change, and; 5. an extended knowledge on a basin-wide approach to flood risk management.
Applying knowledge and understanding	1. analyse the reciprocal relationships between the physical system, the institutional framework and the socio-economic environment, identifying future social and climatic pressures and needs and the consequent trends in system management; 2. 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; 3. 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; 4. review scientific literature and carry out independent research (such as writing a state of the art paper based on research and practice literature); 5. apply sophisticated hydroinformatics and modelling tools and best practices to address the problems of flood risk management;
Making judgements	
Communication	1. communicate his/her knowledge and research results to the scientific and non-scientific communities (such as presenting papers/posters to scientific congresses, general lectures to policy makers and interested non-specialists);
Lifelong learning skills	1. occupy an independent and responsible position as a flood risk professional; 2. acquire independently further knowledge and techniques, and 3. operate in a team.

4.11 Groundwater and Global Change - Impacts and Adaptation

At the end of the programme students are able to:

Knowledge and understanding	1. explain in detail how groundwater systems function; 2. describe the interactions between groundwater systems, climate, surface waters and land use;
Applying knowledge and understanding	1. use modelling tools for climate and groundwater systems; 2. plan groundwater-related adaptation solutions for global change.
Making judgements	1. identify the consequences of global and climate change impacts for groundwater management under uncertainty;
Communication	
Lifelong learning skills	

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 student card and displays it on his 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, UNESCO-IHE 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. Kwame Nkrumah University of Science & Technology (KNUST)

Grading scale of 0 to 100%, where 50% or higher implies a pass.
The minimum grade needed to have a postgraduate degree conferred upon an individual is a CWA of 55%.
CWA (Cumulative Weighted Average) = sum [credits x mark] / sum of all credits

Example:

Module	**Credit**	**Mark obtained**	**Total Module mark**
A	3	60	180
B	2	70	140
C	1	65	65
Total Credit of Student A	**6**		
Cumulative Mark			**385**

CWA= Cumulative Mark/Total Credit = 385/6 = **64.17**

2. 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

3. Universidad del Valle

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)

5. Egerton University

70% and above	A (Excellent)
60-69%	B (Good)
50-59%	C (Average)…
0-49%	F (Fail)

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

6. BOKU

is using the Austrian grading system, which is a five step grading system ranging from (1,very good to 5, not sufficient). Grade 1 to 4 indicate a successful result.
The following grading scale is used:

Austrian grade	ECTS grade	Verbal
1 (sehr gut)	A/B	excellent/very good
2 (gut)	C	good
3 (befriedigend)	D	satisfactory
4 (genügend)	E	pass

6. Gent, Prague

ECTS		Gent University		UNESCO-IHE*		ICTP
A++ (exceptional only 1%)		19 or 20		10		100
A (top 5%)		18		9.2		90-100 A
A (top 10%)		17		8.8		
B (top 20%)		16		8.4		80-89 B
B (top 35%)		15		8		
C (top 50%)		14		7.6		70-79 C
C (top 65%)		13		7.2		
D (top 80%)		12		6.8		60-69 D
E (top 90%)		11		6.4		50-59 E
E (just pass)		10		6		
F (fail)		9		5.4		0-49 F
		8		4.8		
		7		4.2		
		6		3.6		
		5		3		
		4		2.4		
		3		1.8		

		2		1.2		
		1		0.6		
		0		0		

7. TU Dresden:
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.

8. University of Ljubljana

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).

9 TU-Catalonia
Scale from 0-10
MH Honors (is given on exceptional cases)

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

10 University of Lisbon

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

Appendix D MSc modules: names, credits & assessment methods

1. Urban Water and Sanitation programme

SANITARY ENGINEERING		C1349								
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
1	Hydrology, Water supply and water demand management and GIS	M1386	Salinas	5	75		25			
2	Chemistry and public health	M3043	Slokar	5	60		35		5	
3	EPT, Microbiology and Integrated Urban Water	M3030	vd Steen	5	70		30			
4	Urban drainage and sewerage	M3074	Sanchez Torres	5	60		40			
5	Conventional wastewater treatment	M1802	Lopez	5	80		20			
6	Resource oriented wastewater treatment and sanitation	M2384	Ronteltap	5	80		20			
7	Wastewater treatment plants design and engineering	M2373	Lopez	5	50	25	25			
8	Modelling of wastewater treatment processes and plants	M3054	Hooymans	5	60		40			
9	International fieldtrip and fieldwork	M1421	Slokar	5			100			
12	Summer course			1						
13	Groupwork Sint Maarten	M3114	Slokar	5			80	20		
14	MSc research methodology and proposal development	M3040	Garcia	9		100				
15	MSc thesis research and thesis writing	M2927	various	36		100				
	Electives modules:									
10	Industrial effluents treatment and residuals management	M3102	Garcia	5	60		40			
10	Water treatment processes and plants	M2371	Sharma	5		60	40			
10	Urban water systems	M3006	Voijnovic	5	40		60			
11	Solid waste management	M1331	Siebel	5	60		35	5		
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50			
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30			
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20		
11	Urban water governance	M1568	Acevedo Guerre	5			100			
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40			
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15			
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10		
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100			
11	Water Sensitive Cities	M3048	Pathirana	5						
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40			
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40			
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75			

WATER SUPPLY ENGINEERING		C1352								
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
1	Hydrology, Water supply and water demand management and GIS	M1386	Salinas	5	75		25			
2	Chemistry and public health	M3043	Slokar	5	60		35		5	
3	EPT, Microbiology and Integrated Urban Water	M3030	vd Steen	5	70		30			
4	Surface water treatment I	M2550	Kennedy	5	60		20		20	
5	Surface water treatment II	M1577	Ferrero	5	70		10		20	
6	Groundwater resources and treatment	M3033	Petrusevski	5	70		15		15	
7	Water transport and distribution	M2553	Trifunovic	5	60		40			
8	Advanced water treatment and reuse	M2335	Salinas	5	70		20		10	
9	International fieldtrip and fieldwork	M1421	Slokar	5			100			
12	Summer course									
13	Groupwork Sint Maarten	M3114	Slokar	5			80	20		
14	MSc research methodology and proposal development	M3040	Garcia	9		100				
15	MSc thesis research and thesis writing	M2927	various	36			100			
	Electives modules:									
10	Industrial effluents treatment and residuals management	M3102	Garcia	5	60		40			
10	Water treatment processes and plants	M2371	Sharma	5		60	40			
10	Urban water systems	M3006	Voijnovic	5	40		60			
11	Solid waste management	M1331	Siebel	5	60		35	5		
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50			
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30			
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20		
11	Urban water governance	M1568	Acevedo Guerre	5			100			
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40			
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15			
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10		
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100			
11	Water Sensitive Cities	M3048	Pathirana	5						
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40			
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40			
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75			

URBAN WATER ENGINEERING AND MANAGEMENT

Location	Module number	Module Name	Code	Module coordinator	AIT credits / ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
AIT		Watershed hydrology			3 (7.5)	x		x			
		Drinking water treatment			3 (7.5)	x					
		Wastewater treatment			3 (7.5)	x		x			
		Integrated water resources management			3 (7.5)	x		x			
U-IHE	4	Urban drainage and sewerage	M3074	Sanchez Torres	E	5	60		40		
	5	Asset management	M3047	Pathirana	2 (5.0)		50	50			
	6	Managing water organisations	M3103	Schwartz	2 (5.0)			100			
	7	Water transport and distribution	M2553	Trifunovic	2 (5.0)	60		40			
	8	Urban flood management and disaster risk mitigation	M1710	Vojinovic	2 (5.0)	40		60			
	9	International fieldtrip and fieldwork	M1421	Slokar	2 (5.0)			100			
		Electives:									
	10	Industrial effluents treatment and residuals management	M3102	Garcia	2 (5.0)	60		40			
	10	Water treatment processes and plants	M2371	Sharma	2 (5.0)		60	40			
	10	Urban water systems	M3006	Voijnovic	2 (5.0)	40		60			
		Summer course			0.4 (1)						
		Total coursework			26 (65)						
		MSc research proposal development for UWEM/EtSUD/AWMELW	M3040	Garcia	0			x	x		
AIT		MSc thesis work			22 (55)			x	x		
		Grand total (coursework + thesis)			48 (120)						

Joint MSc programme in Urban Water and Sanitation with KNUST			C1030 /C1039								
Location	Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation	Lab Report (%)	Home work (%)
KNUST	KN1	Module (KN) 1 Introduction to Environmental Sanitation			5	70		30			
	KN2	Module (KN) 2 Mathematical and research methods			4	70		30			
	KN3	Module (KN) 3 Environmental science and process technology			6	70		30			
	KN4	Module (KN) 4 Environmental quality			3	70		30			
	KN5	Module (KN) 5 water supply			2	70		30			
U-IHE	6	Resource oriented wastewater treatment and sanitation	M2384	Ronteltap	5	80		20			
	7	Wastewater treatment plants design and engineering	M2373	Lopez	5	50	25	25			
	8	Modelling of wastewater treatment processes and plants	M3054	Hooymans	5	60		40			
	OR										
	6	Groundwater resources and treatment	M3033	Petrusevski	5	70		15		15	
	7	Water transport and distribution	M2553	Trifunovic	5	60		40			
	8	Advanced water treatment and reuse	M2335	Salinas	5	70		20		10	
	9	International fieldtrip and fieldwork	M1421	Slokar	5			100			
	12	Summer course			1						
	13	Groupwork Sint Maarten	M3114	Slokar	5			80	20		
		Electives modules:									
	10	Industrial effluents treatment and residuals management	M3102	Garcia	5	60		40			
	10	Water treatment processes and plants	M2371	Sharma	5		60	40			
	10	Urban water systems	M3006	Voijnovic	5	40		60			
	11	MSc proposal preparation	M3040	Garcia	5						
U-IHE / KNUST	15	MSc thesis research and thesis writing	M2384	various	36		100				

Joint MSc programme in Urban Water and Sanitation with specialisation Sanitary Engineering with Universidad del Valle, Colombia			C1033								
Location	Module number	Module Name	Code	Module coordinator	UVC /ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
Univalle	C1	C1 Chemistry of Environmental Pollution			3 /5.13	50		20		30	
	C2	C2 Environmental Pollution Microbiology			3 /5.13	x		x	x	x	
	C3	C3 Fundamentals of Environmental Processes			3 /5.13	60		20		20	20
	C4	C4 Environmental and Development			3 /5.13	35		30	35		
	C5	C5 Engineering Research Introduction			2/3.42			100		20	
U-IHE	4	Urban drainage and sewerage	M3074	Sanchez Torres	5	60		40			
	5	Conventional wastewater treatment	M1802	Lopez	5	80		20			
	6	Resource oriented wastewater treatment and sanitation	M2384	Ronteltap	5	80		20			
	7	Wastewater treatment plants design and engineering	M2373	Lopez	5	50	25	25			
	8	Modelling of wastewater treatment processes and plants	M3054	Hooymans	5	60		40			
	9	International fieldtrip and fieldwork	M1421	Slokar	5			100			
	12	Summer course			1						
	13	Groupwork Sint Maarten	M3114	Slokar	5			80	20		
		Electives modules:									
	10	Industrial effluents treatment and residuals management	M3102	Garcia	5	60		40			
	10	Water treatment processes and plants	M2371	Sharma	5		60	40			
	10	Urban water systems	M3006	Voijnovic	5	40		60			
	11	MSc proposal preparation	M3040	Garcia	5						
Univalle	C9	Engineering research I (4 UVC)			4/6.84						
	C10	Engineering Research II (8 UVC)			8/13.68						
		MSc thesis (14 UVC)			14/23.94						

Joint MSc programme in Urban Water and Sanitation with specialisation Water Supply Engineering with Universidad del Valle, Colombia

Location	Module number	Module Name	Code	Module coordinator	UVC /ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
Univalle	C1	C1 Chemistry of Environmental Pollution			3 /5.13	50		20		30	
	C2	C2 Environmental Pollution Microbiology			3 /5.13	x		x	x	x	
	C3	C3 Fundamentals of Environmental Processes			3 /5.13	60		20		20	20
	C4	C4 Environmental and Development			3 /5.13	35		30	35		
	C5	C5 Engineering Research Introduction			2/3.42			100		20	
U-IHE	4	Surface water treatment I	M2550	Kennedy	5	60		20		20	
	5	Surface water treatment II	M1577	Ferrero	5	70		10		20	
	6	Groundwater resources and treatment	M3033	Petrusevski	5	70		15		15	
	7	Water transport and distribution	M2553	Trifunovic	5	60		40			
	8	Advanced water treatment and reuse	M2335	Salinas	5	70		20		10	
	9	International fieldtrip and fieldwork	M1421	Slokar	5			100			
	12	Summer course									
	13	Groupwork Sint Maarten	M3114	Slokar	5			80	20		
		Electives modules:									
	10	Industrial effluents treatment and residuals management	M3102	Garcia	5	60		40			
	10	Water treatment processes and plants	M2371	Sharma	5		60	40			
	10	Urban water systems	M3006	Voijnovic	5	40		60			
	11	MSc proposal preparation	M3040	Garcia	5						
Univalle	C9	Engineering research I (4 UVC)			4/6.84						
	C10	Engineering Research II (8 UVC)			8/13.68						
		MSc thesis (14 UVC)			14/23.94						

2. Environmental Science programme

	ENVIRONMENTAL SCIENCE AND TECHNOLOGY	C1140									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to environmental science 1 +2	M3026	de Ruyter	5	80+20		20+35				
3	Introduction to environmental science 3	M3038	de Ruyter				100				
4	Integrated project environmental science	M3031	vd Steen	5			70	30			
5	Industrial Resource Management & Cleaner Production	M1953	Raj	5	60		35	5			
6	Environmental systems analysis	M3034	Irvine	5	30		60	10			
7	Environmental engineering	M3081	Raj	5	75		25				
8	Environmental monitoring and modelling	M2658	Irvine	5	70		15		15		
9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	5			100				
12	Summer courses			1			100				
13	Groupwork ES	M2240	van Bruggen	5			100				
14	MSc research methodology and proposal development	M1288	van Bruggen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
10	Aquatic ecosystems: processes and applications	M2122	Gettel	5			90	10			
10	Environmental assessment for water related policies and develo	M3080	Mendoza	5	50		50				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

ENVIRONMENTAL POLICY MAKING		C1127									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to environmental science 1 +2	M3026	de Ruyter	5	80+20		20+35				
3	Introduction to environmental science 3	M3038	de Ruyter				100				
4	Integrated project environmental science	M3031	vd Steen	5			70	30			
5	Water and environmental law	M1003	Jaspers	5	70		30				
6	Environmental systems analysis	M3034	Irvine	5	30		60	10			
7	Water and environmental policy making	M3082	Douven	5	50		50				
8	Environmental planning and implementation	M3021	Evers	5	50		50				
9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	5			100				
12	Summer courses			1			100				
13	Groupwork ES	M2240	van Bruggen	5			100				
14	MSc research methodology and proposal development	M1288	van Bruggen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
10	Aquatic ecosystems: processes and applications	M2122	Gettel	5			90	10			
10	Environmental assessment for water related policies and develo	M3080	Mendoza	5	50		50				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

WATER QUALITY MANAGEMENT		C1166									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to environmental science 1 +2	M3026	de Ruyter	5	80+20		20+35				
3	Introduction to environmental science 3	M3038	de Ruyter				100				
4	Integrated project environmental science	M3031	vd Steen	5			70	30			
5	Water and environmental law	M1003	Jaspers	5	70		30				
6	Water quality assessment	M2835	de Ruyter	5	60		30		10		
7	Constructed wetlands for wastewater treatment	M2216	van Bruggen	5	60		40				
8	Environmental planning and implementation	M3021	Evers	5	50		50				
9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	5			100				
12	Summer courses			1			100				
13	Groupwork ES	M2240	van Bruggen	5			100				
14	MSc research methodology and proposal development	M1288	van Bruggen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
10	Aquatic ecosystems: processes and applications	M2122	Gettel	5			90	10			
10	Environmental assessment for water related policies and develo	M3080	Mendoza	5	50		50				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

ENVIRONMENTAL SCIENCE AND TECHNOLOGY WITH UNIVALLE			C1019									
Location	Module number	Module Name	Code	Module coordinator	UVC /ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
Univalle	C1	C1 Chemistry of Environmental Pollution			3 /5.13	50		20		30		
	C2	C2 Environmental Pollution Microbiology			3 /5.13	x		x	x	x		
	C3	C3 Fundamentals of Environmental Processes			3 /5.13	60		20		20	20	
	C4	C4 Environmental and Development			3 /5.13	35		30	35			
	C5	C5 Engineering Research Introduction			2 /3.42			100		20		
U-IHE	4	Integrated project environmental science	M3031	vd Steen	5			70	30			
	5	Industrial Resource Management & Cleaner Production	M1953	Raj	5	60		35	5			
	6	Environmental systems analysis	M3034	Irvine	5	30		60	10			
	7	Environmental engineering	M3081	Raj	5	75		25				
	8	Environmental monitoring and modelling	M2658	Irvine	5	70		15		15		
	9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	5			100				
	12	Summer courses			1			100				
	13	Groupwork ES	M2240	van Bruggen	5			100				
Univalle		MSc thesis (14 UVC)		various	14 / 23.94							
		Total ECTS			113.5							
U-IHE		Elective modules:										
	10	Aquatic ecosystems: processes and applications	M2122	Gettel	5			90	10			
	10	Environmental assessment for water related policies and develo	M3080	Mendoza	5	50		50				
	11	Solid waste management	M1331	Siebel	5	60		35	5			
	11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
	11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
	11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
	11	Urban water governance	M1568	Acevedo Guerre	5			100				
	11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
	11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
	11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
	11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
	11	Water Sensitive Cities	M3048	Pathirana	5							
	11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
	11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
	11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

ENVIRONMENTAL SCIENCE WITH AIT			C1029									
Location	Module number	Module Name	Code	Module coordinator	AIT creditis / ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
AIT		Environmental chemistry and laboratory			3 (7.5)	x		x				
		Environmental quality management			3 (7.5)	x		x				
		Any two course out of:										
		- Air pollution and management			6 (15.0)	x		x				
		- Solid waste management										
		- Environmental impact assessment										
		- Industrial waste abatement and management										
U-IHE	4	Integrated project environmental science	M3031	vd Steen	2 (5.0)			70	30			
	5	Industrial Resource Management & Cleaner Production	M1953	Raj	2 (5.0)	60		35	5			
	6	Environmental systems analysis	M3034	Irvine	2 (5.0)	30		60	10			
	7	Constructed wetlands for wastewater treatment	M2216	van Bruggen	2 (5.0)	60		40				
	8	Environmental monitoring and modelling	M2658	Irvine	2 (5.0)	70		15		15		
	9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	2 (5.0)			100				
		Elective modules:										
	10	Aquatic ecosystems: processes and applications	M2122	Gettel	2 (5.0)			90	10			
	10	Environmental assessment for water related policies and develo	M3080	Mendoza	2 (5.0)	50		50				
	11	MSc research proposal development for UWEM/EtSUD/AWMELW	M3039	Raj	0			x	x			
		Total coursework			26 (65)							
AIT												
		Elective			2 (5.0)	x		x				
		MSc thesis work			22 (55)			x	x			
		Grand total (coursework + thesis)			50 (125)							

ENVIRONMENTAL TECHNOLOGY ERASMUS MUNDUS			C1024									
1 General Courses												
Location	**Module number**	**Module name**	**Code**	**Module coordinator**	**74 ECTS**	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
U-IHE	1	Introduction to environmental science 1 +2	M3026	de Ruyter	5	80+20		20+35				
	3	Introduction to environmental science 3	M3038	de Ruyter				100				
	4	Integrated project environmental science	M3031	vd Steen	5			70	30			
		Seminars Environmental Technology and Engineering I			2							
Prague		Environmental Microbiology			4							
		Environmental Engineering			4							
		Wastewater Treatment			5							
		Sludge Management			3							
		Atmosphere Protection Technology			2							
		Waste Management and Treatment			4							
		Elective Project			5							
		Laboratory Training in Environmental Technology			3							
Ghent		Scientific Skills			4							
		Clean Technology			3							
		Environmental Fate and Management of Heavy Metals and Metalloids			5							
		Basics of Control Engineering and Process Engineering			4							
		Microbial Re-use Technology			3							
		Seminars Environmental Technology and Engineering II			3							
2 Elective Courses					**16 ECTS**							
Prague		Basics of Czech			2							
Ghent		Advanced Waste Gas Treatment			3							
		Applied Isotopes			5							
		Applied Statistics			5							
		Ecological Risk Assessment			7							
		Environmental Constructions			5							
		Environmental Ecology			7							
		Environmental Noise			3							
		Geostatistics			5							
		Life Cycle Assessment			3							
		Membrane Processes in Environmental Technology			3							
		Modeling and Control of Waste Water Treatment Plants			3							
		Quality of Groundwater Resources			5							
		Soil Degradation			3							
		Soil Water Management			3							
		Urban and Indoor Air Pollution			5							
		Internship			6							
		Environmental Legislation			3							
U-IHE		Basic Dutch for Foreigners	M1380	vd Vossenberg	2	50	50					
		Cleaner Production and the Water Cycle			5							
		Constructed Wetlands for Wastewater Treatment	M2216	van Bruggen	5	60		40				
		Ecological Sanitation			5							
		Modelling Sanitation Systems			5							
3 Master Dissertation					**30**							

LIMNOLOGY AND WETLAND MANAGEMENT			C1155									
Location	Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab report (%)	Home work (%)	Integrated in modules (%)
BOKU	LWM1	Basics in Limnology			9							
	LWM2	Ecology of Aquatic Organisms			6							
	LWM3	Basics in Applied Limnology			6							
	LWM4	Aquatic Ecosystem Management			4							
	LWM5	Scientific Methods			3							
EGERTON	ES05bL	Lake Ecology			5.6	60		10	20	10		
	ES06L	Stream & River Ecology			5.6	60			20	20		
	ES07L	Wetlands for Water Quality			5.6	60		10	20			10
	ES08L	Fisheries & Aquaculture			5.6	60			20			20
UNESCO-IHE	9	Data Analysis and Modeling for Aquatic Ecosystems	M1212	van Dam	5.6	40		40	20			
	10	Aquatic ecosystems: processes and applications	M2122	Gettel	5			90	10			
	11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
	12	Summer courses			1			100				
	13	Groupwork ES	M2240	van Bruggen	5			100				
	14	MSc research methodology and proposal development	M1288	van Bruggen	9			100				
	15	MSc research	M2927	various	36							
		TOTAL			120							

3. Water Science and Engineering programme

RIVER BASIN DEVELOPMENT		C1477									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	5	80		20				
3	River basin hydraulics, geotechnics and remote sensing	M2307	Paron	5	75		25				
4	River morphodynamics	M2730	Crosato	5	80		20				
5	Data collection and analysis and design	M3090	Werner	5	70		30				
6	River Basin Development and EIA	M1703	Masih	5	50		50				
7	River structures	M1171	Cattapan	5	100						
9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
12	Summer courses			1			100				
13	Groupwork WSE	M1284	Veerbeek	5				100			
14	MSc preparatory course and thesis research proposal	M1679	Foppen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
8	Dams and hydropower	M3009	Marence	5		50		50			
8	Planning and delivery of flood resilience	M2135	Gersonius	5		50		50			
10	Applied Groundwater Modelling	M2841	Zhou	5			100				
10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner								
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	5		60	40				
10	Innovative Water Systems for Agriculture	M3092	Karimi	5	40		60				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerrero	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

COASTAL ENGINEERING AND PORT DEVELOPEMENT		C1427									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	5	80		20				
3	Introduction to coastal science and engineering	M1026	Semedo	5	90		10				
4	Port planning and infrastructure design	M1433	Dastgheib	5			100				
5	Coastal systems	M1553	Ranasinghe	5	70		30				
6	Coastal and port structures	M2033	Dastgheib	5			100				
7	Environmental aspects of coasts and ports	M2831	vd Wegen	5	60		40				
9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
12	Summer courses			1			100				
13	Groupwork WSE	M1284	Veerbeek	5				100			
14	MSc research proposal development for WSE	M1679	Foppen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
8	Management of coasts and ports (International Port Seminar)	M3078	van Schuylenburg	5				100			
8	Management of coasts and ports (ICZM)	M3079	vd Wegen	5		100					
8	Dams and hydropower	M3009	Marence	5	90		10				
10	Applied Groundwater Modelling	M2841	Zhou	5			100				
10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner								
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	5		60	40				
10	Innovative Water Systems for Agriculture	M3092	Karimi	5	40		60				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerrero	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

LAND AND WATER DEVELOPMENT		C1505									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	5	80		20				
3	Principles and practices of land and water development	M3024	Karimi	5	30		80				
4	Design aspects of irrigation and drainage	M3087	Hayde	5	30		70				
5	Tertiary unit design and hydraulics	M2255	Hayde	5	40		60				
6	Socio-economic and environmental aspects of land and water de	M3023	Duker	5	30		70				
7	Conveyance and irrigation structures	M3025	Suryadi	5	35		65				
8	Management of irrigation and drainage systems	M3022	Duker	5	60		40				
9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
12	Summer courses			1			100				
13	Groupwork WSE	M1284	Veerbeek	5				100			
14	MSc research proposal development for WSE	M1679	Foppen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
10	Applied Groundwater Modelling	M2841	Zhou	5			100				
10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner								
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	5		60	40				
10	Innovative Water Systems for Agriculture	M3092	Karimi	5	40		60				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerrero	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

LAND AND WATER DEVELOPMENT WITH NEBRASKA

	Module number	Module Name	Code	Module coordinator	UNL credits/ ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
UNESCO-IHE	1	Introduction to Water Science and Engineering	M2131	Foppen	5	55		45				
	2	Hydrology and hydraulics	M2208	Maskey	5	80		20				
	3	Principles and practices of land and water development	M3024	Karimi	5	30		80				
	4	Design aspects of irrigation and drainage	M3087	Hayde	5	30		70				
	5	Tertiary unit design and hydraulics	M2255	Hayde	5	40		60				
	6	Socio-economic and environmental aspects of land and water de	M3023	Duker	5	30		70				
	7	Conveyance and irrigation structures	M3025	Suryadi	5	35		65				
	8	Management of irrigation and drainage systems	M3022	Duker	5	60		40				
	9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
University of Nebraska, Lincoln, USA		Field Course: Measurement Techniques in Hydrology and Irrigation			3 (5)							
		Research Methodology & Thesis Research Proposal			2 (14)							
		Plant-Water Relations			3 (5)							
		Groundwater Geology			3 (5)							
		Advanced Irrigation and Drainage Systems Engineering			3 (5)							
		Advanced Irrigation Management			3 (5)							
		Water Law, Planning and Policy			3 (5)							
		Masters Research Project			4 (28)			100				

LAND AND WATER DEVELOPMENT WITH AIT C1054

Location	Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
AIT		Watershed Hydrology			7.5	30+40		30				
		Hydrodynamics			7.5	40+50		10				
		Irrigation and Drainage Engineering			7.5	30+40		30				
		Integrated Water Resources Management			7.5	20+30		50				
U-IHE	4	Design aspects of irrigation and drainage	M3087	Hayde	5	30		70				
	5	Tertiary unit design and hydraulics	M2255	Hayde	5	40		60				
	6	Socio-economic and environmental aspects of land and water de	M3023	Duker	5	30		70				
	7	Conveyance and irrigation structures	M3025	Suryadi	5	35		65				
	8	Management of irrigation and drainage systems	M3022	Duker	5	60		40				
	9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
	11	MSc research proposal development for UWEM/EtSUD/AWMELW	M3039	Raj	0			x	x			
AIT		MSc research work			22							
		Elective modules:										
	10	Applied Groundwater Modelling	M2841	Zhou	5			100				
	10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
	10	Drought Management and Reservoir Operations	M3036	Werner								
	10	Geotechnical Engineering and Dredging	M2214	vd Wegen	5		60	40				
	10	Innovative Water Systems for Agriculture	M3092	Karimi	5	40		60				

HYDROINFORMATICS		C1490									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	5	80		20				
3	Information technology and software engineering	M2191	Alfonso Segura	5	50		50				
4	Modelling theory and Computational Hydraulics	M1507	Popescu	5	55	25	20				
5	Modelling and information systems development	M2128	van Andel	5			100				
6	Computational Intelligence and Operational water management	M2847	Solomatine	5	55		45				
7	River basin modelling	M2665	Jonoski	5	100						
9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
12	Summer courses			1			100				
13	Groupwork WSE	M1284	Veerbeek	5				100			
14	MSc research proposal development for WSE	M1679	Foppen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
8	River Flood Analysis and Modelling	M2709	Popescu	5	50		50				
8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	5	60		40				
10	Applied Groundwater Modelling	M2841	Zhou	5			100				
10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner								
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	5		60	40				
10	Innovative Water Systems for Agriculture	M3092	Karimi	5	40		60				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerrero	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

HYDROLOGY AND WATER RESOURCES		C1501									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	5	80		20				
3	Hydrogeology	M2166	Zhou	5	70		30				
4	Surface hydrology	M2367	Venneker	5	70		30				
5	Water quality	M2497	McClain	5	70		30				
6	Tracer hydrology and flow systems analysis	M1903	Foppen	5	100						
8	Integrated hydrological and river modelling	M1309	Maskey	5			85	15			
9	Fieldtrip and fieldwork WSE	M3101	Duker	5						100	
12	Summer courses			1			100				
13	Groupwork WSE	M1284	Veerbeek	5				100			
14	MSc research proposal development for WSE	M1679	Foppen	9			100				
15	MSc research	M2927	various	36			100				
	Elective modules:										
7	Hydrological data collection and processing	M1554	Venneker	5	60				40		
7	Groundwater data collection and interpretation	M2227	Stigter	5	40		60				
10	Applied Groundwater Modelling	M2841	Zhou	5			100				
10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner								
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	5		60	40				
10	Innovative Water Systems for Agriculture	M3092	Karimi	5	40		60				
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerrero	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

FLOOD RISK MANAGEMENT			C1440									
Location	Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
TU-Dresden		Introduction to Flood Risk Management			10	50		30 +20				
		Climatology and Hydrology			5	100						
		Geodesy			5	100						
		Two courses out of the following four:										
		Hydraulic Engineering			5	100						
		Hydromechanics			5							
		Ecology			5	75			25			
		Hydrochemistry			5							
		Courses without credits:										
		GIS and Remote Sensing			0							
		Statistics			0							
		Fieldtrip			0							
				Total ECTS	**30**							
U-IHE	6	Computational Intelligence and Operational water management	M2847	Solomatine	5	55		45				
	7	River basin modelling	M2665	Jonoski	5	100						
		One course out of the following two:										
	8a	River Flood Analysis and Modelling	M2709	Popescu	5	50		50				
	8b	Urban flood management and disaster risk mitigation	M1710	Vojnovic	5	40		60				
	9	International Fieldtrip (12 days)			5						100	
	10	Flood Risk Management	M3083	Bhattacharya	5	30		70				
	11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
				Total ECTS	**30**							
UPC		Global warming effects, Flood and Drought			3		40	60				
		Coastal flooding: impacts, conflicts and risks			3	100						
		Fluvial morphodynamics			5							
		Debris flow and flash floods: risk, vulnerability, hazard and resilience concepts			5	40		55				5
		The application of radar-based rainfall observations and forecast in Early Warning			4	100						
				Total ECTS	**30**							
UL		Spatial planning for flood protection and resilience			5	20		80				
		Socio-economic and institutional framework of floods			5							
TUD/IHE /UPC/UL		MSc thesis work		**Total ECTS**	**30**							

GROUNDWATCH			C1441									
Location	Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
IST Lisbon		Hydrogeology			4,5							
		Hydrology, Environment and Water Resources			6							
		Ocean and Atmospheric Physics			4,5							
		Integrated River Basin Management			4,5							
		Groundwater Pollution and Protection			6							
		Global Environmental Policies			4,5							
U-IHE	6	Tracer hydrology and flow systems analysis	M1903	Foppen	5	100						
	7	Groundwater data collection and interpretation	M2227	Stigter	5	40		60				
	8	Groundwater adaptation to global change impacts	M3096	Stigter	5			100				
	9	Fieldtrip and Fieldwork	M2440	Duker	5						100	
	10	Applied Groundwater Modelling	M2841	Zhou	5			100				
	11	IWRM as a Tool for Adaptation to Climate Change	M2155	de Ruyter	5	70			30			
TU-Dresden		Climate Systems and Climate Modelling			5							
		Soil Water			5							
		Study Project IWRM			10							
		Ecology (optional)			5							
		Advanced Watershed Management (optional)			5							
		Integrated Land Use Management in the Landscape (optional)			5							
		Drinking Water Supply (optional)			5							
		Water Quality adn Water Treatment (optinal)			5							
IST/IHE/TUD		MSc thesis work			30							

4. Water Management programme

WATER RESOURCES MANAGEMENT		C1396									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3084	Evers	5	45		55				
2	The water resources system	M3042	Susnik	5	70		30				
3	Water governance	M3032	Kemerink	5		40	60				
4	Water economics	M3028	Yong	5	70		30				
5	Water and environmental law	M1003	Jaspers	5	70		30				
6	Water resources assessment	M1617	Yasir	5	65		35				
7	Water systems modelling	M2054	Graas	5	60			40			
8	Water resources planning	M2535	Cauwenberg	5	60		40				
9	International fieldwork	M3045	Tutusaus Luque	5			100				
12	Summer course			1			100				
13	IWRM Groupwork	M2252	Susnik	5			100				
14	MSc preparatory course and thesis research proposal for WM	M2169	Kooy	9		100					
15	MSc thesis research and thesis writing	M2927	various	36		100					
	Elective modules:										
10	Partnerships for Water Supply and Sanitation	M2711	Schwartz	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M2122	Gettel	5			90	10			
10	Institutional Analysis	M3007	Smit	5			80	20			
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

WATER CONFLICT MANAGEMENT		C1370									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3084	Evers	5	45		55				
2	The water resources system	M3042	Susnik	5	70		30				
3	Water governance	M3032	Kemerink	5		40	60				
4	Water economics	M3028	Yong	5	70		30				
5	Water and environmental law	M1003	Jaspers	5	70		30				
6	Water conflict management 1	M3069	Shubber	5	50		50				
7	Water conflict management 2	M3070	Shubber	5	60		40				
8	Water resources planning	M2535	Cauwenberg	5	60		40				
9	International fieldwork	M3045	Tutusaus Luque	5			100				
12	Summer course			1			100				
13	IWRM Groupwork	M2252	Susnik	5			100				
14	MSc preparatory course and thesis research proposal for WM	M2169	Kooy	9		100					
15	MSc thesis research and thesis writing	M2927	various	36		100					
	Elective modules:										
10	Partnerships for Water Supply and Sanitation	M2711	Schwartz	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M2122	Gettel	5			90	10			
10	Institutional Analysis	M3007	Smit	5			80	20			
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

WATER MANAGEMENT		C1362									
Code	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3084	Evers	5	45		55				
2	The water resources system	M3042	Susnik	5	70		30				
3	Water governance	M3032	Kemerink	5		40	60				
4	Water economics	M3028	Yong	5	70		30				
5	Water and environmental law	M1003	Jaspers	5	70		30				
9	International fieldwork	M3045	Tutusaus Luque	5			100				
12	Summer course			1			100				
13	IWRM Groupwork	M2252	Susnik	5			100				
14	MSc preparatory course and thesis research proposal for WM	M2169	Kooy	9		100					
15	MSc thesis research and thesis writing	M2927	various	36		100					
	Elective modules:										
6	Water quality assessment	M2835	de Ruyter	5	60		30		10		
6	Water resources assessment	M1617	Yasir	5	65		35				
6	Water conflict management 1	M3069	Shubber	5	50		50				
6	Managing water organisations	M3103	Schwartz	5			100				
7	Environmental Engineering	M3081	Raj	5	75		25				
7	Water systems modelling	M2054	Graas	5	60			40			
7	Water conflict management 2	M3070	Shubber	5	60		40				
7	Environmental management and water services	M3041	Bichai	5		50	50				
8	Environmental planning and implementation	M3021	Evers	5	50		50				
8	Water resources planning	M2535	Cauwenberg	5	60		40				
8	Financial management in the water sector	M3044	Tutusaus Luque	5	50		50				
10	Partnerships for Water Supply and Sanitation	M2711	Schwartz	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M2122	Gettel	5			90	10			
10	Institutional Analysis	M3007	Smit	5			80	20			
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

WATER SERVICES MANAGEMENT		C1409									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3084	Evers	5	45		55				
2	The water resources system	M3042	Susnik	5	70		30				
3	Water governance	M3032	Kemerink	5		40	60				
4	Water economics	M3028	Yong	5	70		30				
5	Water and environmental law	M1003	Jaspers	5	70		30				
6	Managing water organisations	M3103	Schwartz	5			100				
7	Environmental management and water services	M3041	Bichai	5		50	50				
8	Financial management in the water sector	M3044	Tutusaus Luque	5	50		50				
9	International fieldwork	M3045	Tutusaus Luque	5			100				
12	Summer course			1			100				
13	IWRM Groupwork	M2252	Susnik	5			100				
14	MSc preparatory course and thesis research proposal for WM	M2169	Kooy	9		100					
15	MSc thesis research and thesis writing	M2927	various	36		100					
	Elective modules:										
10	Partnerships for Water Supply and Sanitation	M2711	Schwartz	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M2122	Gettel	5			90	10			
10	Institutional Analysis	M3007	Smit	5			80	20			
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

WATER QUALITY MANAGEMENT		C1383									
Module number	Module Name	Code	Module coordinator	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3084	Evers	5	45		55				
2	The water resources system	M3042	Susnik	5	70		30				
3	Water governance	M3032	Kemerink	5		40	60				
4	Water economics	M3028	Yong	5	70		30				
5	Water and environmental law	M1003	Jaspers	5	70		30				
6	Water quality assessment	M2835	de Ruyter	5	60		30		10		
7	Environmental Engineering	M3081	Raj	5	75		25				
8	Environmental planning and implementation	M3021	Evers	5	50		50				
9	International fieldwork	M3045	Tutusaus Luque	5			100				
12	Summer course			1			100				
13	IWRM Groupwork	M2252	Susnik	5			100				
14	MSc preparatory course and thesis research proposal for WM	M2169	Kooy	9		100					
15	MSc thesis research and thesis writing	M2927	various	36		100					
	Elective modules:										
10	Partnerships for Water Supply and Sanitation	M2711	Schwartz	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M2122	Gettel	5			90	10			
10	Institutional Analysis	M3007	Smit	5			80	20			
11	Solid waste management	M1331	Siebel	5	60		35	5			
11	Strategic Planning for River Basins and Deltas	M3086	Yong	5	50		50				
11	IWRM as a tool for adaptation to climate change	M2155	de Ruyter	5	70		30				
11	Wetlands for livelihoods and conservation	M3089	Hes	5			80	20			
11	Urban water governance	M1568	Acevedo Guerre	5			100				
11	Advanced water transport and distribution	M2602	Trifunovic	5	60		40				
11	Faecal Sludge Management	M2873	Ronteltap	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	5			100				
11	Water Sensitive Cities	M3048	Pathirana	5							
11	Modelling river systems and lakes	M3075	Cattapan	5	60		40				
11	Flood Protection in Lowland Areas	M3104	Roelvink	5	60		40				
11	Remote sensing, GIS and modelling for agricultural water use	M3027	Karimi	5	25		75				

Appendix E MSc thesis marking guidelines

Criterion 1	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
	Excellent	**Very Good**	**Good**	**Sufficient**	**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.	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. .	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 unrealisitc.	Generally lacks some coherence; may be poorly referenced, but includes at least some points relevant to the research. Aims and objectives no more than adequate.	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

Criterion 2		9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
		Excellent	**Very Good**	**Good**	**Sufficient**	**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 maps, diagrams etc.	Appropriate actions and methods identified and detailed. Where appropriate, setting of research well described with relevant maps etc	Methodology generally sound but with some lapses in detail of methods, and/or proposed analysis. 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. Maps may be absent or poorly produced.	Methodology vague and poorly detailed. No obvious understanding of methodology relevant to research theme. Maps etc 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 obvious flaws in analysis, but the general essence of the key findings conveyed.	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 lease some use of key literature. There will likely to be some repetition with the results section.	Largely a repetition of the results section, with minimal context to wider understanding and relevant literature.	Fails to identify key findings and/or their wider significance . Little logical framework and lacking any individual ideas or intepretation.

Criterion 3	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
	Excellent	**Very Good**	**Good**	**Sufficient**	**Fail**
Organisation, style, presentation and communication	Writing elegant and succinct. Uses precise language and correct terminology throughout. Figs and tables well laid out to a publishable quality with accurate and succinct legends.	A clear and well-written report that is technically proficient.	A generally well-written report that is understandable. Uses appropriate terminology. Occasional spelling or grammatical errors. Presentation generally neat	Language generally clear and uses correct terminology, but with some misunderstandings and lapses in grammar or spelling. Presentation and use of tables and figures may be sloppy.	Sentences and/or paragraphs poorly constructed. Language inexact or ambiguous. Contains numerous grammatical and spelling mistakes.

Criterion 4	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
	Excellent	**Very Good**	**Good**	**Sufficient**	**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 2015-17)
draft d.d. 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 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.

UNESCO-IHE - Academic Calendar 2016/2018

YEAR 1	2016												2017																				fieldtrip			2017								Groupw ork			2017							
	October			November				December					January				February				March				April					May				June				July					August				September				October			
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	37	38	39	40	41	42
Mon		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	11	18	25	02	09	16
Tue		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	12	19	26	03	10	17
Wed		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	13	20	27	04	11	18
Thu		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	14	21	28	05	12	19
Fri		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	15	22	29	06	13	20
Sat		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	09	16	23	30	07	14	21
Sun		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	10	17	24	01	08	15	22
			(2x5 ECTS)							(2x5 ECTS)								(2x5 ECTS)							(2x5 ECTS)								(1x5 ECTS)			(2x5 ECTS)							1	(1x5 ECTS)					(4+5 ECTS)					
			Module 1			Module 2				Module 3					Module 4				Module 5			Module 6				Module 7			Module 8				Module 9			Module 10			Module 11				M12	Module 13					Module 14					

YEAR 2	2017											2018																	
	October		November				December					January				February				March				April					M..
Week		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
Mon		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
Tue		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
Wed		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
Thu		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
Fri		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
Sat		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
Sun		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
		(36 ECTS)																											
		Module 15																											

Legend

- 🟦 = Lecture period
- 🟨 = Examination days
- 🟪 = MSC thesis w riting
- ⬜ = Holiday/free time
- 🟩 = Opening acad. year
- 🟥 = Diploma aw arding
- 🟫 = Summer course

Christmas:	Dec 25/26 2016
Good Friday:	April 14 2017
Easter:	April 16/17 2017
Kingsday:	April 27 2017
Liberationday:	May 5 2017
Ascencion:	May 25 2017
Pentecost:	Juni 4/5 2017
Christmas:	Dec 25/26 2017
Good Friday:	March 30 2018
Easter:	April 1/2 2018
Kingsday:	27 April 2018

Water Science and Engineering

Certificate course

2016/2017

Data Acquisition, Preprocessing and Modelling using the PCRaster Python Framework

M1386

Hydrology, Water Supply and Water Demand Management and GIS

Term	201617T01
Coordinator	S.G. Salinas Rodríguez
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 identify and discuss the basic elements of hydrology, and apply hydrological principles in water and wastewater engineering.

2 Forecast water demand in a city, based on population forecasts, per capita use and Water Demand Management measures.

Assessments

%	Type	Name
25	Assignment	GIS
45	Written examination (closed book)	Hydrology/Hydraulics
30	Written examination (closed book)	Water Supply and Water Demand Management

Topics

1 Hydrology and Hydraulics

Hydrological cycle, precipitation, evaporation, run-off, river systems, unsaturated zone and groundwater systems; rock and water, porosity, permeability, aquifers and aquitards, groundwater balances, groundwater availability, use and method of groundwater

2 Water Supply and Water Demand Management

Different types of water demand, factors affecting water demand, demand forecasting, urban water demand management approaches, measures and case studies.

3 Geographic Information Systems (GIS)

A practical introduction to the use of geographic information systems, remote sensing technologies and GIS-based modelling for the analysis and solution of different water and environmental problems. State of the art open source software will be used for

Topics

4 Hydrology and Hydraulics (2)

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Hydrology and Hydraulics	12	0	8	0	0	0	20	44	S.G. Salinas Rodríguez
2	Water Supply and Water Demand Management	8	0	0	0	0	0	8	24	S.K. Sharma
3	Geographic Information Systems (GIS)	8	8	0	0	0	0	8	32	J. van der Kwast
4	Hydrology and Hydraulics (2)	0	0	0	0	0	0	0	0	J.W. Wenninger, T.Y. Stigte
	Total	28	8	8	0	0	0	36	100	

Education Material

Lecture notes	Lecture notes GIS
Lecture notes	Lecture notes Hydrology
Lecture notes	Lecture notes Water Supply and Water Demand Management

Scientific Software

M3127

Introduction to Environmental Science 1

Term	201617T01
Coordinator	E.D. de Ruijter van Steveninck
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1	Make a critical analysis of the global and national agendas and policies for "Water and Environment" in the contex of sustainable development
2	Identify and describe the major global, regional and local environmental problems
3	Identify and describe the basic natural, chemical, hydrological and socio-economic processes in relation to the environment
4	Explain basic environmental concepts, such as ecological footprint, feedback mechanisms, ecosystem dynamics, carrying capacity and nutrient cycling
5	Apply basic principles of data analysis, statistics, environmental modelling and GIS

Assessments

%	Type	Name
35	Written examination (closed book)	Chemistry
20	Written examination (closed book)	Ecology
20	Assignment	GIS
25	Written examination (closed book)	Hydrology

Topics

1 **Water, environment and sustainable development**

Week 1 will provide an introduction to the global agendas and policies for water and environment. Participants will be introduced to key documents in these fields (World Water Vision, Vision21, Earth Summit on Sustainable Development, WWF-3). The concept of IWRM will be explained and illustrated by examples.

2 **Introduction Environmental Science**

Introduction to the module objectives and procedures. The river basin as the context to study environmental science.

Topics

3 Hydrology

Precipitation and collection of meteorological data, evaporation, soil moisture, geo-hydrology and the hydrodynamics of ecosystems.

4 Chemistry

Phosphorus, nitrogen, redox systems and acidity. Ecotoxicology. The lectures will be supported by laboratory sessions.

6 Ecology

Food webs, trophic levels, flow of energy, cycling of nutrients, biological communities and species interactions, population dynamics.

8 GIS

Introduction to GIS, vector data, projections, raster data,file types, raster analysis, map design. Introduction to remote sensing.

Exercises on: 1) digitizing vector data from a scanned map; 2) importing tabular data and interpolation; 3) map algebra; and 4) file conversion and geodatabase.

In Module 3 GIS has to be applied in a case study.

11 Examinations

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water, environment and sustainable development	0	0	20	0	0	0	20	20	
2	Introduction Environmental Science	0	0	4	0	0	0	4	4	E.D. de Ruijter van Steveninck, E.M.A. Hes
3	Hydrology	8	0	6	0	0	0	14	30	J.W. Wenninger, T.Y. Stigte
4	Chemistry	10	0	12	0	0	0	22	42	C.A.M. van Gestel, G.M. Gettel, K.A. Irvine, Y.M. Slokar
6	Ecology	8	0	0	0	0	0	8	24	E.D. de Ruijter van Steveninck
8	GIS	4	0	12	0	0	0	16	24	J. van der Kwast
11	Examinations	0	0	6	0	0	0	6	6	
	Total	30	0	60	0	0	0	90	150	

Education Material

Book	Cunningham & Cunningham, Environmental Science, a global concern. 13th ed.

Scientific Software

QGis
R_statistics
stella

M2131

Introduction to Water Science and Engineering

Term	201617T01
Coordinator	J.W.A. Foppen
Credit points	5.000000000
Specialization	Core Program

Target Group

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

Prerequisites

Entry requirements of the WSE-programme

Learning Objectives

1 1 Tell the relevant issues of the global agenda for water and sustainable development; understand the field of water science and engineering, identify its different specialisations and understand the structure of the programm at UNESCO-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

Assessments

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

Topics

2 **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 har

3 **Review of Statistics and Frequency Analysis**

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

4 **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 interactin

Topics

5 Fieldwork Excursion Delaworks

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**
2	Review of Mathematics	8	0	4	0	0	0	12	28	I.I. Popescu
3	Review of Statistics and Frequency Analysis	6	4	0	0	0	0	6	22	PHAJM van Gelder
4	The Earth System (geology, geomorphology, the anthropocene)	18	14	14	0	0	0	32	82	AC Seijmonsbergen, C.M.S. de Fraiture, P. Paron
5	Fieldwork Excursion Delaworks	0	0	0	0	0	0	0	0	
	Total	32	18	18	0	0	0	50	132	

Education Material

Handout	1 Various material, handouts, and references: Lecturing material available as on-line resource
Handout	2 Price, R. & Popescu, I.: Review of Mathematics Handouts: Lecturing material available as on-lin resource
Handout	3 LN00072, Van Gelder, P.: Review of Statistics and Frequency Analysis Handouts: Lecturing material available as on-line resource
Handout	5 (a) 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	6 De Heer, Geurtsen, Bijnsdorp, 2005. Handout Visit to the Deltaworks.

Scientific Software

M3084

Principles of Integrated Water Resources Management

Term	201617T01
Coordinator	J.G. Evers
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals, engineers and (mid-level) decision makers interested in a basic and broad understanding of main issues in the water management context.

Prerequisites

Preferably a relevant water science or management related BSc degree; some experience in the water sector; good command of the English language (reading, writing, speaking).

Learning Objectives

1 Summarize the latest insights, context and concepts in integrated water management that are under debate in international and regional forums.

2 Explain the main arguments for an integrated approach in the field of water management.

3 Describe the major natural functions and human uses of river systems.

4 Understand the concepts of Geographical Information Systems and apply them in practical examples relevant to water management.

5 Explain what science is and what scientific research entails including distinguishing the main methodological approaches (Research Path)

Assessments

%	Type	Name
20	Assignment	GIS
35	Assignment	WM Research Methodologies (Annotated Bibliography Assignment; What is science)
45	Written examination (closed book)	

Topics

1 Introduction to the Module

General introduction to the module, learning objectives, learning activities, and assessment

Topics

2 Principles of IWRM

Context, developments, perspectives, issues and debates in Integrated Water Resources Management. Water Resources: green water vs. blue water; catchment yield. Water Demand: demand projections; demand management; elasticity of water demand; the value of water. Water allocation. Water governance.

2.1 Water Resources

Water resources; green water vs. blue water; catchment yield

2.2 Water Demand

Water Demand: demand projections; demand management; elasticity of water demand; the value of water

2.3 Water Allocation

Balancing demand and supply; Issues in water allocation; Water allocation in international river basins

2.4 Water Governance

Water institutions, water allocations

2.5 Emerging Issues

Water-energy-food nexus, upstream-downstream; virtual water

3 GIS and Remote Sensing

Basics of GIS and Remote Sensing. Vector-based geographic data processing with Arc-View GIS. GIS analysis and visualization. Grid data analysis and overlays including DEM and hydrological applications. Supervised and unsupervised classification.

3.1 Introduction to GIS

Explain the basic concepts of GIS (raster, vector, projections, geospatial analysis). Vector-based geographic data processing with QGIS. GIS analysis and visualization.

3.2 GIS for thematic mapping

GIS for thematic mapping

3.3 Basic geo-processing and analysis

Basic geoprocessing and analysis

3.4 DEM processing and catchment delineation

DEM processing and catchment delineation. Find open source software and open access data.

4 Research and Academic Skills Development

What is Science?; Different Approaches to Scientific Methodology; Referencing; Plagiarism; Critical Reading.

4.1 What is Science?

What is Science?

4.2 Different Approaches to Scientific Methodology

Different Approaches to Scientific Methodology

4.3 Critical Reading

Critical Reading

4.4 Referencing and Plagiarism

Referencing and plagiarism

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 Module	0	0	2	0	0	0	2	2	J.G. Evers
2	Principles of IWRM	0	0	0	0	0	0	0	0	
2.1	Water Resources	4	0	0	0	0	0	4	12	P. van der Zaag
2.2	Water Demand	4	0	0	0	0	0	4	12	P. van der Zaag
2.3	Water Allocation	4	0	0	0	0	0	4	12	P. van der Zaag
2.4	Water Governance	4	0	0	0	0	0	4	12	M.Z. Zwarteveen, P. van der Zaag
2.5	Emerging Issues	4	0	0	0	0	0	4	12	P. van der Zaag
3	GIS 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. van der Kwast, J.W. Wenninger
3.2	GIS for thematic mapping	0	2	2	0	0	0	2	4	J. van der Kwast, J.W. Wenninger
3.3	Basic geo-processing and analysis	0	3	2	0	0	0	2	5	J. van der Kwast, J.W. Wenninger
3.4	DEM processing and catchment delineation	0	3	2	0	0	0	2	5	J. van der Kwast, J.W. Wenninger
4	Research and Academic Skills Development	0	0	0	0	0	0	0	0	
4.1	What is Science?	4	0	0	0	0	0	4	12	K.A. Irvine, M.Z. Zwarteveen U.W.C. Wehn
4.2	Different Approaches to Scientific Methodology	4	0	0	0	0	0	4	12	K.A. Irvine, M.Z. Zwarteveen U.W.C. Wehn
4.3	Critical Reading	0	0	4	0	0	0	4	4	U.W.C. Wehn
4.4	Referencing and Plagiarism	0	0	4	0	0	0	4	4	L.P. Darvis
	Total	30	8	16	0	0	0	46	114	

Education Material

Lecture notes	Introduction to GIS and RS, Reader on GIS.
Handout	Other handouts and relevant articles.
Lecture notes	Water Resources Management

Scientific Software

QGis

M2630

Short Course on Where there is Little Data: How to Estimate Design Variables in Poorly Gauged Basins

Term	201617T01
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

M3043

Chemistry and Public Health

Term	201617T02
Coordinator	Y.M. Slokar
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Describe bonds between elements and identify chemical reactions.

2 Calculate stoichiometric relationships in reactions and balance them.

3 Describe reactions in water treatment (flocculation, adsorption, disinfection, softening, etc.).

4 Describe waterborne infectious diseases and the pathogens.

5 List legislative requirements for safe water, and explain Water Safety Plan and QMRA concepts for waterborne infections.

6 Reproduce pathogen reductions by treatment processes.

Assessments

%	Type	Name
5	Lab. Report	Chemistry
60	Written examination (closed book)	Chemistry
35	Assignment	Public health

Topics

1 Chemistry

Atoms, ions, molecules; Periodic table of elements; Chemical bonds; Physical properties of matter; Basic principles of chemical reactions; Reaction rate; Equilibrium; Acid-base reactions; Precipitation vs. solubility; Redox reactions; Adsorption phenomenon and mechanisms; Ion exchange; Reactions in water treatment (flocculation, disinfection, iron removal, removal of aggressivity, softening); Introduction to organic chemistry.

2 Public health

Waterborne infectious diseases; Global situation and regulations concerning water quality (WHO, UN, etc.); Current and innovative water treatment processes - focus on pathogen reduction; Water Safety Plans and risk assessment; Detection methodologies for microbial indicators and pathogens (e.g. ISO).

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Chemistry	12	0	10	4	0	0	26	54	Y.M. Slokar
2	Public health	8	6	6	0	0	0	14	36	G. Ferrero
	Total	20	6	16	4	0	0	40	90	

Education Material

Lecture notes	Chemistry: self-study material, lecture notes, laboratory notes.
Lecture notes	Public health: lecture notes.

Scientific Software

M2208

Hydrology and Hydraulics

Term	201617T02
Coordinator	S. Maskey
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants; and participants of Joint International Master Programmes IMHI, IMCEPD and IMHWR (following the programme in partner institutes).

Prerequisites

Entry requirements for WSE

Learning Objectives

1 Describe the main concepts of steady/unsteady and uniform/non-uniform flow.

2 Understand and 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 Understand, describe and apply the concepts of hydrology needed for their specialisation.

5 Understand the concepts of Geographical Information Systems and apply them in practical examples relevant to their specialization.

6 Understand the main techniques of remote sensing and know when their use is appropriate or inappropriate.

Assessments

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

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	W.G.M. Bastiaanssen
3.3	GIS exercises	0	0	0	8	0	0	8	16	F.X. Suryadi, J.L. Alfonso Segura, J.S. Craven
	Total	28	0	6	26	0	0	60	142	

Education Material

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

Scientific Software

ArcGIS

M3128

Introduction to Environmental Science 2

Term	201617T02
Coordinator	E.D. de Ruijter van Steveninck
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

6 Apply the principles of the scientific method to design, develop and communicate a research project

Assessments

%	Type	Name
30	Written examination (closed book)	Economics
15	Assignment	Integration topics: Evidence-based policy making
10	Assignment	Integration topics: Information research & retrieval
10	Assignment	Integration topics: Reading & reviewing literature
35	Written examination (closed book)	Microbiology

Topics

5 Microbiology

The basic aspects of natural processes in relation to the environment will be discussed. In microbiology the (micro-)biological actors in the cyclic processes of the most important elements (C, N, P, S) will be discussed. The lectures in microbiology are supported by laboratory sessions in the module Introduction to Environmental Science 3.

7 Economics with special focus on use and scarcity of natural resources

The subject of use and scarcity of natural resources starts with reviewing resource and scarcity concepts and mechanisms leading towards and away from scarcity. In a second part, the cases of specific resources are treated: food, wood, fish, biodiversity, water and energy.

9 Environmental modelling, data analysis and statistics

You will apply the basic principles with practical examples and case studies.

Topics

10 Integration topics

Developing critical thinking, academic writing and communication/presentation skills..

11 Examinations

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
5	Microbiology	10	0	0	0	0	0	10	30	J.L.C.M. van de Vossenberg
7	Economics with special focus on use and scarcity of natural resources	8	0	8	0	0	0	16	32	Y. Jiang
9	Environmental modelling, data analysis and statistics	8	0	14	0	0	0	22	38	A.A. van Dam, E.M.A. Hes
10	Integration topics	6	0	12	0	0	0	18	30	A.A. van Dam, G.M. Gettel, K.A. Irvine, L.P. Darvis
11	Examinations	0	0	6	0	0	0	6	6	
	Total	32	0	40	0	0	0	72	136	

Education Material

Book	Cunningham & Cunningham, Environmental Science, a global concern. 13th ed.

Scientific Software

QGis
R_statistics
stella

M3024

Principles and Practices of Land and Water Development

Term	201617T02
Coordinator	P. Karimi
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 Explain the importance of irrigation and drainage for global food production and economics.
2 Analyse the relevance, concept, elements and needs of irrigation and drainage.
3 Make a preliminary layout and design of gravity irrigation and drainage networks.
4 Explian commonalities and differences between traditional and improved agronomic practices w
5 Plan an improved irrigation agronomy and field water management

Assessments

%	Type	Name
0,2	Assignment	Irrigation Agronomy
0,6	Assignment	Irrigation and Drainage Main System Design
0,2	Written examination (open book)	Land and Water Development

Topics

2 Land and Water Development

Availability of land and water resources on a global and regional scale to meet the present and future food requirements. Need for land and water development in rural and urban areas. Principles of land and water development. Economic and social incentives and history. Physical planning and environmental impact aspects. Various aspects of water management.

Topics

3 Introduction Irrigation and Drainage Systems

Basic functions, elements and needs of and for irrigation and drainage systems. Elements of the irrigation system, 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. Regulation structures and emergency measures.

4 Irrigation Agronomy

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.

4 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.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
2	Land and Water Development	6	0	0	0	0	0	6	18	C.M.S. de Fraiture
3	Introduction Irrigation and Drainage Systems	6	0	0	0	0	0	6	18	L.G. Hayde
4	Irrigation Agronomy	8	0	6	0	0	0	14	30	DE Eisenhauer
4	Irrigation and Drainage Main System Design	18	0	20	0	0	0	38	74	P. Karimi
	Total	38	0	26	0	0	0	64	140	

Education Material

Scientific Software

M3042

The Water Resources System

Term	201617T02
Coordinator	J. Susnik
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals, engineers and (mid-level) decision makers interested in understanding the bio-physical system as a sound basis for water management.

Prerequisites

A relevant water science or water management related BSc degree; some experience in the water sector; good command of the English language. Good working knowledge of MS Excel is essential, as is basic mathematics. Knowledge of scientific units and unit conversion is essential. Basic knowledge of integrated water resources management is essential.

Learning Objectives

1 Describe the key bio-chemo-physical processes that determine water quantity and quality within a general water resources system

2 Apply basic knowledge of the hydrological cycle, the water balance, precipitation, evapotranspiration, surface water discharge and groundwater movement to make a water balance and analyse rainfall and surface water and groundwater flows of water resources

3 Apply knowledge of basic chemistry and biology to analyse and explain eutrophication, stratification and the distribution of nutrients and ecological communities along water resources systems, and to relate these processes to water quality

4 Combine understanding and knowledge of water quantity (see objective 2) and water quality (see objective 3) to analyse a range of problems and potential solutions in water resources management

5 Measure basic water quality parameters and evaluate records with rainfall and flow data

6 Gain enhanced appreciation of the entire water resources system, recognising that quantity and quality issues affect each other in order to successfully undertake remaining Modules towards the UNESCO-IHE MSc degree.

Assessments

%	Type	Name
10	Assignment	Evaporation
10	Assignment	Rating Curve Analysis
10	Assignment	Water Quality Analysis
70	Written examination (closed book)	Written Exam

Topics

1 Introduction to the Water Resources System

Basic concepts for understanding a water resources system are introduced. Emphasis is placed on the idea of the system - this is, all elements in a water resources system should be considered as a whole. A case study is used to elaborate on the concepts and to introduce particular water quality and quantity problems.

1.1 Introduction to module

1.2 Introduction to Water Resources System

2 Water Quantity

Surface water hydrology: Hydrological cycle and water balance. Precipitation and evaporation. Principles of hydrology of surface and groundwater systems, hydrology of lakes and reservoirs including introduction to reservoir water balance and operations. Analysis of hydro-climatic data (e.g. precipitation, river flows), discharge rating curve and reservoir operation. Groundwater hydrology: Hydrogeology, groundwater zones, groundwater balance, hydraulic head, pressure head, evelation head, groundwater recharge and discharge, groundwater pollution.

2.1 Concepts of hydrology, hydrological cycle, water balance

2.2 Precipitation

2.3 Evaporation and Transpiration

2.4 Surface water resources

2.5 Groundwater resources

2.6 Reservoir water balance and operation

3 Water Quality

pH, BOD, nutrients, heavy metals, anaerobic waters, eutrophication, bio-accumulation

3.1 pH, BOD, anaerobic waters and stratification

3.2 Nutrients and Euthrophication

3.3 Heavy metals and bio-accumulation

4 Ecology (Case studies Water quality and quantity)

In a case study on the Nile river and lakes/reservoirs, knowledge about water quality and quantity is used to analyse real life problems in the Nile basin.

4.1 Fresh water ecology

4.2 Case study

5 Exam

6 Research methodology classes

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 Water Resources System	0	0	0	0	0	0	0	0	
1.1	Introduction to module	1	0	0	0	0	0	1	3	J. Susnik
1.2	Introduction to Water Resources System	3	0	0	0	0	0	3	9	J. Susnik
2	Water Quantity	0	0	0	0	0	0	0	0	
2.1	Concepts of hydrology, hydrological cycle, water balance	2	0	2	0	0	0	4	8	J. Susnik, Y.A. Mohamed
2.2	Precipitation	2	0	4	0	0	0	6	10	J. Susnik, Y.A. Mohamed
2.3	Evaporation and Transpiration	2	0	4	0	0	0	6	10	J. Susnik, Y.A. Mohamed
2.4	Surface water resources	2	0	0	0	0	2	4	12	J. Susnik, Y.A. Mohamed
2.5	Groundwater resources	4	0	4	0	0	0	8	16	T.Y. Stigter
2.6	Reservoir water balance and operation	2	0	0	0	0	0	2	6	Y.A. Mohamed
3	Water Quality	0	0	0	0	0	0	0	0	
3.1	pH, BOD, anaerobic waters and stratification	2	0	4	0	0	0	6	10	P Kelderman
3.2	Nutrients and Euthrophication	2	0	4	0	0	0	6	10	P Kelderman
3.3	Heavy metals and bio-accumulation	2	0	0	0	0	0	2	6	P Kelderman
4	Ecology (Case studies Water quality and quantity)	0	0	0	0	0	0	0	0	
4.1	Fresh water ecology	2	0	0	0	0	0	2	6	K.A. Irvine
4.2	Case study	2	4	0	0	0	0	2	10	K.A. Irvine
5	Exam	0	0	3	0	0	0	3	3	
6	Research methodology classes	2	2	0	0	0	0	2	8	
	Total	30	6	25	0	0	2	57	127	

Education Material

Lecture notes	J.C. Nonner. 2006. Introduction to Hydrogeology.UNESCO-IHE Lecture Notes Series. Taylor and Francis, Leiden.
Lecture notes	P.J.M. de Laat, Y.A. Mohamed. M.L. Mul, and J.W. Wenninger. 2010. Hydrology: An introductory course. UNESCO-IHE Lecture Notes.
Lecture notes	Pre-Lecture material on Basics of Chemistry, Kelderman, UNESCO-IHE lecture notes.
Lecture notes	Water Chemistry and Biology, Kelderman. UNESCO-IHE Lecture Notes.
Lecture notes	Y. Mohamed, P.J.M. de Laat, and L. Kewzi. Workshop Hydrology. 2010. UNESCO-IHE Lecture Notes.

Scientific Software

ArcGIS

M3030

EPT, Microbiology and Integrated Urban Water Management

Term	201617T03
Coordinator	N.P. van der Steen
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

Learning Objectives

1 Apply mass balance analysis to natural and engineered water systems, especially for the analysis of microbial growth and substrate conversion in CFST and plug flow reactors.

2 Apply microbiological principles in water and wastewater engineering.

3 Develop strategies for Integrated Urban Water Management, and to evaluate consequences for the wider social, economic and environmental context. The specific learning objectives for IUWM are:

Assessments

%	Type	Name
35	Written examination (closed book)	EPT
30	Assignment	IUWM
35	Written examination (closed book)	Microbiology

Topics

1 Environmental Process Technology (EPT)

2 Microbiology

3 Integrated Urban Water Management (IUWM)

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Environmental Process Technology (EPT)	18	0	4	0	0	0	22	58	N.P. van der Steen
2	Microbiology	12	0	0	16	0	0	28	68	J.J.A. van Bruggen, J.L.C.M van de Vossenberg
3	Integrated Urban Water Management (IUWM)	21	20	9	0	0	0	30	92	D. Brdanovic, J.G. Evers, N.P. van der Steen, W.J. Sturrock
	Total	51	20	13	16	0	0	80	218	

Education Material

Scientific Software

M2166

Hydrogeology

Term	201617T03
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

M2191

Information Technology and Software Engineering

Term	201617T03
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 Explain the main principles of computer organisation and operation.
2 Explain and apply the main working concepts of computer networks and Internet
3 Select and apply software tools to increase productivity
4 Describe and apply the main principles of software engineering and computer programming
5 Apply the process of algoritmic thinking to solve computational problems
6 Develop computer code for general and water-related problems
7 Describe the MATLAB environment, its working philosophy and use it to perform basic operations and plots

Assessments

%	Type	Name
50	Written examination (closed book)	Information Technology, Software Engineering and Database Systems
50	Assignment	Software Engineering

Topics

1 Information and communication technology

2 Introduction to MATLAB

3 Software Engineering

4 Introduction to database systems

Topics

5 Visit to Deltares

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	Introduction to MATLAB	0	0	0	8	0	0	8	16	J.L. Alfonso Segura
3	Software Engineering	6	0	26	8	0	0	40	60	D. Solomatine, G.A. Corzo Perez, J.L. Alfonso Segura
4	Introduction to database systems	6	0	6	0	0	0	12	24	D. Solomatine, S.J. van And
5	Visit to Deltares	0	0	0	0	8	0	8	8	
	Total	16	0	36	24	8	0	84	140	

Education Material

Lecture notes	Schotanus, Lecture Notes on GIS and Remote Sensing
Lecture notes	Solomatine, Lecture Notes on Information Technology and Computer Science: An Introduction
Lecture notes	Solomatine, Lecture Notes on Object Oriented Programming: A Practical Introduction
Lecture notes	Solomatine, Lecture Notes on Software Development with Borland Delphi
Lecture notes	Solomatine, Lecture Notes on Software Engineering: An Introduction
Lecture notes	Solomatine, Lecture Notes on Uncertainty Analysis in Modelling.
Lecture notes	Yun Qing y L. Alfonso, Lecture Notes on Introduction to MATLAB

Scientific Software

ArcGIS

Matlab

M3124

Introduction to Coastal Science and Engineering

Term	201617T03
Coordinator	A.A. Milho Semedo
Credit points	5.000000000
Specialization	Coastal Engineering and Port Development

Target Group

Prerequisites

Basic knowledge of hydraulics

Learning Objectives

1 Understand the basics of coastal engineering.

2 Analyse the behaviour of waves in oceanic and coastal waters

3 Describe tides and tidal currents and be familiar with methods for tidal computations.

4 Understand the principle of soil mechanics.

Assessments

%	Type	Name
5	Written examination (closed book)	Introduction to Coastal Engineering
25	Written examination (closed book)	Soil Mechanics
30	Written examination (closed book)	Tides and Tidal Currents
40	Written examination (closed book)	Waves

Topics

1 Introduction to Coastal Engineering

Introduction of the Module, Coastal Environments, Sediment balances in coastal environments

2 Waves

Observation techniques: in-situ techniques (buoys and poles) and remote sensing (imaging and altimeter radar). Description of ocean waves: significant wave height and period, 1D and 2D spectrum, spectral analysis. Statistics: short-term (Gaussian distribu

3 Tides and Tidal Currents

Introduction, tide generating force, main constituents of the tide, type of tide , equations for tidal waves in one dimension, harmonic waves, resonance, short basin, tidal wave on a river, tidal windows for navigation, examples and applications. Astronom

Topics

4 Soil Mechanics

Elements of soil mechanics; soil particles, grain size distribution, soil classification, Atterberg limits, soil: a system with 3 phases. Stress in soil; water pressure and effective stress in soil, shear stress and shear strength in soil, Columb strength

5 Introduction to Matlab

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	2	0	0	0	0	0	2	6	J.A. Roelvink
2	Waves	14	0	22	0	0	0	36	64	A.A. Milho Semedo
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	Soil Mechanics	6	0	6	0	0	0	12	24	JH van Dalen
5	Introduction to Matlab	0	0	4	0	0	0	4	4	J.L. Alfonso Segura
	Total	32	0	44	0	0	0	76	140	

Education Material

Scientific Software

Matlab

M3038

Introduction to Environmental Science 3

Term	201617T03
Coordinator	E.D. de Ruijter van Steveninck
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 See under Introduction to Environmental Science 1-2

Assessments

%	Type	Name
30	Assignment	Case study water quality and eutrophication (30%)
35	Assignment	Data analysis & modelling: modelling (35%)
35	Assignment	Data analysis & modelling: statistics and presentation (35%)

Topics

1 Lab Microbiology

2 Case study water quality and eutrophication

3 Data Analysis and Modelling

4 Integration Topics

5 Individual written assignment

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Lab Microbiology	0	0	16	0	0	0	16	16	J.J.A. van Bruggen
2	Case study water quality and eutrophication	5	0	24	0	0	0	29	39	A.A. van Dam, E.D. de Ruijter van Steveninck, G.M Gettel, J. van der Kwast
3	Data Analysis and Modelling	16	0	13	0	0	0	29	61	A.A. van Dam, E.M.A. Hes
4	Integration Topics	6	0	4	0	0	0	10	22	A.A. van Dam, E.D. de Ruijter van Steveninck, G.M Gettel, J.G. Evers, N.P. van der Steen, W.A.H. Thissen
5	Individual written assignment	0	0	2	0	0	0	2	2	
	Total	27	0	59	0	0	0	86	140	

Education Material

Lecture notes	Lecture notes

Scientific Software

R_statistics

stella

M3024

Principles and Practices of Land and Water Development

Term	201617T03
Coordinator	P. Karimi
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 Explain the importance of irrigation and drainage for global food production and economics.
2 Analyse the relevance, concept, elements and needs of irrigation and drainage.
3 Make a preliminary layout and design of gravity irrigation and drainage networks.
4 Explian commonalities and differences between traditional and improved agronomic practices w
5 Plan an improved irrigation agronomy and field water management

Assessments

%	Type	Name
0,2	Assignment	Irrigation Agronomy
0,6	Assignment	Irrigation and Drainage Main System Design
0,2	Written examination (open book)	Land and Water Development

Topics

2 Land and Water Development

Availability of land and water resources on a global and regional scale to meet the present and future food requirements. Need for land and water development in rural and urban areas. Principles of land and water development. Economic and social incentives and history. Physical planning and environmental impact aspects. Various aspects of water management.

Topics

3 Introduction Irrigation and Drainage Systems

Basic functions, elements and needs of and for irrigation and drainage systems. Elements of the irrigation system, 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. Regulation structures and emergency measures.

4 Irrigation Agronomy

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.

4 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.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
2	Land and Water Development	6	0	0	0	0	0	6	18	C.M.S. de Fraiture
3	Introduction Irrigation and Drainage Systems	6	0	0	0	0	0	6	18	L.G. Hayde
4	Irrigation Agronomy	8	0	6	0	0	0	14	30	DE Eisenhauer
4	Irrigation and Drainage Main System Design	18	0	20	0	0	0	38	74	P. Karimi
	Total	38	0	26	0	0	0	64	140	

Education Material

Scientific Software

M3129

River Basin Hydraulics, Geotechnics and Remote Sensing

Term	201617T03
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 understand hydraulic concepts useful in river basin structure design and management

2 gain solid knowledge of optical remotely sensed data collection and analysis for water resources and river basin development

3 manage geotechnical (soil and rock) concepts relevant to river basin development

Assessments

%	Type	Name
25	Written examination (open book)	Applied Hydraulics
25	Assignment	Remote Sensing
25	Written examination (closed book)	Rock Mechanics
25	Written examination (closed book)	Soil Mechanics

Topics

1 Applied Hydraulics

Advanced concepts in: non-uniform flow; unsteady flow; pressure flow; fluid forces on structures

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.

Topics

3 Rock mechanics

Geotechnical characterization of rock mass; rock mass classification; rock mass parameter estimation; typical problems in rock mechanics (slope stability, tunnel excavation,...)

4 Soil mechanics

Elements of soil mechanics; soil particles, grain size distribution, soil classification, Atterberg limits, soil: a system with 3 phases. Stress in soil; water pressure and effective stress in soil, shear stress and shear strength in soil, Columb strength law. Laboratory tests for soil mechanics; direct shear test and 3-axial test. Mohre circle to determine failure in soil. Earth retaining structures; Rankineâ€™s theory of active and passive earth pressure, Columb method for retaining structures, stability conditions for retaining structures. Slope stability; the ordinary method of slices and simplified Bishop method.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Applied Hydraulics	11	0	1	0	0	0	12	34	AE Mynett
2	Remote Sensing for Water Resources	6	0	9	10	0	0	25	47	J. van der Kwast, P. Paron
3	Rock mechanics	7	0	0	3	0	0	10	27	M. Marence
4	Soil mechanics	8	0	4	0	0	0	12	28	JH van Dalen
	Total	32	0	14	13	0	0	59	136	

Education Material

Handout	Handouts, reading list will be provided by lecturers

Scientific Software

Multispec

Photoscan

ROCLAB

M3032

Water Governance

Term	201617T03
Coordinator	J.S. Kemerink - Seyoum
Credit points	5.000000000
Specialization	Core Program

Target Group

Students enrolled in the Water Management Master Programme, who ideally are young mid-career professionals working at middle and upper level in an organization in the water sector or employed in policy making institutions in the water sector or are working for organizations engaged in management of water resources and water services.

Prerequisites

Good English command to read and discuss academic articles; willingness to engage in social science theory and new conceptual frameworks; willingness to engage in cross-disciplinary discussions and applications.

Learning Objectives

1 Identify and analyse actors and decision making processes related to water governance
2 Distinguish and explain main discourses and theories on water governance
3 Identify context, purpose, perspective and arguments of scientific papers on water governance
4 Compare and contrast different scientific papers, case studies and theories on dynamic and political nature of water governance

Assessments

%	Type	Name
40	Assignment	Group assignment: documentary on contemporary governance issue
20	Assignment	Individual assignment: literature study on contemporary governance issue
40	Oral examination	Oral examination on water governance literature

Topics

1 Introduction to water governance

1.2 Social-Nature

1.5 Shifts in Governance

1.6 Research methodology

2.1 Politics: an introduction

2.3 Everyday politics

Topics

2.5 Politics of policy

2.6 Global politics

3 Tutorials

4 Group assignment

5 Exam

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 governance	10	0	2	0	0	0	12	32	J.S. Kemerink - Seyoum, M.Z. Zwarteveen, T. Acevedo Guerrero
1.2	Social-Nature	4	0	0	0	0	0	4	12	J.S. Kemerink - Seyoum, T. Acevedo Guerrero
1.5	Shifts in Governance	4	0	0	0	0	0	4	12	J.S. Kemerink - Seyoum, K.H. Schwartz
1.6	Research methodology	2	10	0	0	0	0	2	16	J.G. Evers
2.1	Politics: an introduction	4	0	0	0	0	0	4	12	J.S. Kemerink - Seyoum, T. Acevedo Guerrero
2.3	Everyday politics	4	0	0	0	0	0	4	12	M.Z. Zwarteveen
2.5	Politics of policy	6	0	2	0	0	0	8	20	
2.6	Global politics	4	0	6	0	0	0	10	18	M.Z. Zwarteveen, T. Acevedo Guerrero
3	Tutorials	0	0	8	0	0	0	8	8	E. Fantini, J.G. Evers, J.S. Kemerink - Seyoum, K.H. Schwartz, M.E. Kooy, T. Acevedo Guerrero
4	Group assignment	0	20	0	0	0	0	0	20	J.S. Kemerink - Seyoum, T. Acevedo Guerrero
5	Exam	0	10	0	0	0	0	0	10	
	Total	38	40	18	0	0	0	56	172	

Education Material

Scientific journal	Bakker, K. (2002) ‘From State to Market? Water Mercantilización in Spain’, Environment and Planning A, 34: 767-790.
Scientific journal	Bridge, G. and Perreault, T. (2009) Environmental Goverance. Chapter 28 in Castree, N., Demerit D., Liverman, D. and Rhoads B. (eds.) A Companion to Environmental Geography. Oxford, UK: Blackwell Publishing Inc.: 475-498.
Scientific journal	Castro J.E. (2007) 'Water Governance in the twentieth-first century.' Ambiente & Sociedade 10(2): 97-118.
Scientific journal	Cleaver, F. (1999) ‘Paradoxes of Participation: Questioning Participatory Approaches to Development’ Journal of International Development 11(4): 597-612.
Lecture notes	Powerpoints presentations of lectures
Scientific journal	Rap, E. (2006) ‘The Success of a Policy Model: Irrigation Management Transfer in Mexico.’ Journa of Development Studies 42 (8): 1301- 1324
Scientific journal	Swyngedouw, E. (2005) Governance Innovation and the Citizen: The Janus Face of Governance-beyond-the-State, Urban Stud 2005 42: 1991

Scientific Software

M3087

Design Aspects of Irrigation and Drainage

Term	201617T04
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 system design and soil characteristics

Learning Objectives

1 Analyse and evaluate the various types of flow and to apply the hydraulic principles for uniform and non-uniform open channel, and flow in specific hydraulic structures in irrigation and drainage engineering issues

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

4 Make a preliminary layout and design of a gravity irrigation and drainage network at tertiary level.

Assessments

%	Type	Name
25	Assignment	Applied Hydraulics of Irrigation Systems I
25	Assignment	Irrigation Methods
20	Assignment	Irrigation and Drainage - Tertiary Unit Design
30	Written examination (open book)	Soil Water Plant Relations

Topics

1 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 of the design of irrigation and drainage canals under (semi) steady flow conditions.

Topics

2 Soil-Water-Plant Relations

Physical and chemical properties of soils: texture; structure; density; colour; temperature; specific surface of particles; structure of clays; cation exchange capacity; exchange equations; modification and Stalinisation. 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; estimating the actual evapotranspiration in relation to soil moisture conditions, estimating 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 Tertiary Unit Design I.

Computation of design parameters for rice and dry fruit crops under basin and furrow irrigation systems: irrigation interval, delivery time, irrigation depth, distribution uniformity and efficiency, basin size and number, length and number of furrows. Computations are done manually as well as using Basdev and Furdev programmes.
Preliminary tertiary unit layout for furrow and basin irrigation systems: identification of natural drains; alignment of secondary, tertiary and quaternary irrigation and drainage canals, furrow and basin fields; determination of the number and location of water distribution and drainage structures.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Applied Hydraulics of Irrigation Systems I	8	0	4	0	0	0	12	28	L.G. Hayde
2	Soil-Water-Plant Relations	10	0	8	0	0	0	18	38	M.W. Wubneh
3	Irrigation Methods	10	0	4	0	0	0	14	34	RH Cuenca
4	Tertiary Unit Design I.	10	0	10	0	0	0	20	40	F.X. Suryadi
	Total	38	0	26	0	0	0	64	140	

Education Material

Lecture notes	Depeweg, H.W.Th., 1998. Field Irrigation and Drainage - Surface Irrigation Methods, LN0213/98/1
Lecture notes	Depeweg, H.W.Th., 2001. Off-Farm Irrigation and Drainage - Design and Operation of Tertiary Units, LN0185/01/1
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., 2016. Basic Principles of Irrigation and Drainage, LN0439/16/1
Lecture notes	Hayde,L.G., 2011. Applied Hydraulics - Synopsis, LN 0378/11/1
Lecture notes	de Laat, P.J.M., 2011. Soil-Water-Plant Relations, LN006/11/1

Scientific Software

Basdev
Furdev
candes
flop

M3031

Integrated Project Environmental Science

Term	201617T04
Coordinator	N.P. van der Steen
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

ES Modules 1-3 or ETSUD programme AIT or programme Univalle Cali

Learning Objectives

1 Describe the environmental policy process and the role and sources of data and information that play a role in formulating policy

2 Gather information on an environmental problem from various sources and critically assess its quality and role in the debate about the problem

3 Formulate a scientific research question, compare and contrast scientific information relevant to the research question from a variety of sources and present the findings in a concise report

4 Make an oral presentation of scientific information

5 Analyze, evaluate and present scientific data

6 Perform a basic multi-criteria analysis in the context of decision making for an environmental problem

Assessments

%	Type	Name
30	Presentation	Consisting of technical report, policy brief and poster presented by group
70	Assignment	Consisting of three assignments submitted by each individual participant

Topics

1 Introductory and closing session

2 Policy

3 Documentary

4 Research questions

5 Data Analysis

6 Multi-criteria analysis

Topics

7 Group sessions

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introductory and closing session	8	0	0	0	0	0	8	24	N.P. van der Steen
2	Policy	4	0	0	0	0	8	12	36	A. Mendoza - Sammet, J.G. Evers
3	Documentary	0	0	4	0	0	4	8	16	N.P. van der Steen
4	Research questions	4	0	0	0	0	4	8	24	A.A. van Dam, G.M. Gettel
5	Data Analysis	0	0	0	0	0	4	4	12	A.A. van Dam
6	Multi-criteria analysis	2	0	2	0	0	4	8	20	E.M.A. Hes
7	Group sessions	0	0	8	0	0	0	8	8	M Bijlsma, N.P. van der Stee
	Total	18	0	14	0	0	24	56	140	

Education Material

Scientific Software

M1507

Modelling Theory and Computational Hydraulics

Term	201617T04
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

M1433

Port Planning and Infrastructure Design

Term	201617T04
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
70	Assignment	Marine Structures
30	Assignment	Port Planning

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

Topics

2.4 Design of Wet Areas

2.5 Planning of Land Areas

2.6 Container Terminals

2.7 Queuing theory and traffic simulation

3 Marine Structures

4 Excursion Port of Rotterdam and Maeslantkering

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	8	0	0	0	0	0	8	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	M. van Schuylenburg
2.4	Design of Wet Areas	4	0	0	0	0	0	4	12	A. Dastgheib
2.5	Planning of Land Areas	2	0	0	0	0	0	2	6	A. Dastgheib
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
3	Marine Structures	14	12	8	0	0	0	22	62	LAM Groenewegen
4	Excursion Port of Rotterdam and Maeslantkering	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, M. van Schuylenburg
	Total	36	20	16	0	8	0	60	152	

Education Material

Scientific Software

M2730

River Morphodynamics

Term	201617T04
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	
3	1-D modeling of Rivers with Mobile Bed	0	0	12	0	0	0	12	12	
	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

M2367

Surface Hydrology

Term	201617T04
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.

2.1 Soil water and evaporation I

2.2 Soil water and evaporation II

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.

4 Examination

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	0	0	0	0	0	12	36	R.G.W. Venneker
2.1	Soil water and evaporation I	7	0	4	0	0	0	11	25	R.G.W. Venneker
2.2	Soil water and evaporation II	7	0	4	0	0	0	11	25	J.W. Wenninger
3	Conceptual catchment modelling	6	0	6	0	0	0	12	24	J.W. Wenninger
4	Examination	0	0	0	0	0	0	0	0	
	Total	32	0	14	0	0	0	46	110	

Education Material

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

Scientific Software

M2550

Surface Water Treatment I

Term	201617T04
Coordinator	M.D. Kennedy
Credit points	5.000000000
Specialization	

Target Group

Mid-career professionals dealing with technical aspects of water and wastewater treatment plants, working for municipalities, water supply agencies or consulting firms.

Prerequisites

BSc degree in Engineering or similar technical background meeting the MSc Programme entry requirements.

Learning Objectives

1 Describe the theoretical principles of the unit processes: coagulation, filtration, sedimentation and dissolved air flotation in conventional surface water treatment

2 Link theoretical principles with practical aspects

3 Determine design parameters from experimental studies

4 Design a sedimentation tank

Assessments

%	Type	Name
20	Assignment	
20	Lab. Report	
60	Written examination (closed book)	

Topics

1 Coagulation

Theory of coagulation and flocculation processes: colloidal stability and mechanisms of destabilization, rapid and slow mixing, coagulation in practice and natural coagulants.

2 Sedimentation

Hydrodynamic principles of sedimentation and flotation, Stokes Law, principles of discrete settling, flocculent settling and hindered settling. Horizontal and vertical continuous flow basins, settling tanks, shape of inlets and outlets. Design of a rectan

3 Dissolved air flotation

Key design parameters, Henry's law, nucleus theory, Stokes law, rate of rise theory, hydraulic loading rate, solids loading

Topics

4 **Filtration**

General introduction to various types of filtration systems, Mechanical filtration, Slow sand filtration, Rapid sand filtration (pilot experiments, removal mechanisms, hydraulics, filter elements, rate control, backwashing, multi-layer filtration, applica

5 **Design asects of surface water treatment**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Coagulation	6	0	2	4	0	0	12	28	JP Buiteman, M.D. Kennedy
2	Sedimentation	10	4	6	3	0	0	19	46	S.K. Sharma
3	Dissolved air flotation	2	0	2	0	0	0	4	8	
4	Filtration	12	0	6	4	0	0	22	50	JP Buiteman, S.K. Sharma
5	Design asects of surface water treatment	0	0	0	0	8	0	8	8	M.D. Kennedy, S.K. Sharma
	Total	30	4	16	11	8	0	65	140	

Education Material

Scientific Software

M3074

Urban Drainage and Sewerage

Term	201617T04
Coordinator	Z. Vojinovic
Credit points	5.000000000
Specialization	Core Program

Target Group

The same as the specializations' (SE, UWEM) target groups.

Prerequisites

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

Learning Objectives

1 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.

2 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

3 Explain the standard practice in designing urban drainage systems. Prepare drainage system designs by integrating information on hydrological, hydraulic, economic and practical engineering concerns, and evaluating different design options.

Assessments

%	Type	Name
20	Assignment	Computer workshops and Individual assignment
20	Assignment	Design Exercises
60	Written examination (closed book)	Intro. to urban drainage and sewerage, Rainfall characteristics and wet weather flows quantitative, Sewerage layout and design and design exercise and pumping stations, Hydraulics for ur

Topics

1 Introduction to Module

2 Introduction to urban drainage and sewerage and Types of drainage and sewer system

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

3 Urban hydrological and hydraulic processes

4 Sewerage layout and design and design exercise and pumping stations

5 Sewer processes

Topics

6 Data acquisition for urban drainage and sewerage studies

7 Model-based design and simulation

8 Hydraulics of urban drainage and sewerage

9 Dry and wet weather flows quantitative characterization and exercise

10 Conventional sewer design exercise

11 Pumping stations and CSOs

12 Current Practice and Multifunctional Design

Sustainable urban drainage measures (SUDS), BMPs, LIDS, Multi functional design, Multiple Benefits, tools for technology selection

13 Field trip

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	1	0	0	0	0	0	1	3	A. Sanchez Torres
2	Introduction to urban drainage and sewerage and Types of drainage and sewer system	2	0	0	0	0	0	2	6	A. Sanchez Torres
3	Urban hydrological and hydraulic processes	6	0	0	0	0	0	6	18	P.D.A. Pathirana
4	Sewerage layout and design and design exercise and pumping stations	4	0	0	0	0	0	4	12	A. Sanchez Torres
5	Sewer processes	8	0	4	0	0	0	12	28	
6	Data acquisition for urban drainage and sewerage studies	2	0	0	0	0	0	2	6	Z. Vojinovic
7	Model-based design and simulation	2	0	4	0	0	0	6	10	A. Sanchez Torres, Z. Vojinovic
8	Hydraulics of urban drainage and sewerage	6	0	0	0	0	0	6	18	A. Sanchez Torres
9	Dry and wet weather flows quantitative characterization and exercise	4	0	0	0	0	0	4	12	D. Brdanovic
10	Conventional sewer design exercise	0	0	0	0	0	6	6	18	
11	Pumping stations and CSOs	2	0	0	0	0	0	2	6	A. Sanchez Torres
12	Current Practice and Multifunctional Design	2	0	0	0	0	0	2	6	A. Sanchez Torres, Z. Vojinovic
13	Field trip	0	0	0	0	3	0	3	3	A. Sanchez Torres
	Total	39	0	8	0	3	6	56	146	

Education Material

Scientific Software

Mike Urban

M3028

Water Economics

Term	201617T04
Coordinator	Y. Jiang
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

Learning Objectives

1	Describe the principles of economics and the relevance of economics to water management
2	Discuss and compare different economic perspectives/approaches with respect to water management
3	Characterize and explain water resource issues using economic concepts and theory
4	Describe the economic efficiency perspective for addressing water scarcity and allocation
5	Conduct simple cost-benefit analysis and policy analysis of water-related decision-making
6	List and review economic instruments for water management
7	Describe economic methods and techniques for estimating the value of water in different uses

Assessments

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

Topics

1 Introduction to water economics

1.1 Introduction to module

1.2 Water issues and management agenda

1.3 Principles of economics, economist role and the relevance of economics to water management

2 Understanding water demand and supply

2.1 Economic concepts of demand and supply

2.2 Empirics of water demand and supply

3 Characterizing water and use issues in socio-economic context

3.1 Typology of goods in economics

Topics

3.2 Socio-economic conception of water

4 Economic approaches to water management

4.1 Resource scarcity

4.2 Tradable water rights, markets

4.3 Water pricing

4.4 Application of economic instruments

4.5 Policy analysis of water demand and supply

4.6 Benefit-cost analysis

5 The economic value of water

6 The role of economics in water management: synthesis and reflection

7 Ravilla role play

8 Group assignment

9 Exam

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 economics	0	0	0	0	0	0	0	0	
1.1	Introduction to module	0	0	1	0	0	0	1	1	Y. Jiang
1.2	Water issues and management agenda	0	2	2	0	0	0	2	4	Y. Jiang
1.3	Principles of economics, economist role and the relevance of economics to water management	2	0	2	0	0	0	4	8	Y. Jiang
2	Understanding water demand and supply	0	0	0	0	0	0	0	0	
2.1	Economic concepts of demand and supply	2	0	4	0	0	0	6	10	Y. Jiang
2.2	Empirics of water demand and supply	2	0	2	0	0	0	4	8	Y. Jiang
3	Characterizing water and use issues in socio-economic context	0	0	0	0	0	0	0	0	
3.1	Typology of goods in economics	2	0	2	0	0	0	4	8	Y. Jiang
3.2	Socio-economic conception of water	0	3	2	0	0	0	2	5	Y. Jiang
4	Economic approaches to water management	0	0	0	0	0	0	0	0	
4.1	Resource scarcity	1	0	3	0	0	0	4	6	Y. Jiang
4.2	Tradable water rights, markets	2	0	2	0	0	0	4	8	
4.3	Water pricing	2	2	2	0	0	0	4	10	Y. Jiang
4.4	Application of economic instruments	0	2	4	0	0	0	4	6	Y. Jiang
4.5	Policy analysis of water demand and supply	0	0	4	0	0	0	4	4	Y. Jiang
4.6	Benefit-cost analysis	2	0	4	0	0	0	6	10	Y. Jiang
5	The economic value of water	4	0	0	0	0	0	4	12	Y. Jiang
6	The role of economics in water management: synthesis and reflection	0	4	4	0	0	0	4	8	Y. Jiang
7	Ravilla role play	0	0	21	0	0	0	21	21	I. Masih, S. Graas
8	Group assignment	0	12	0	0	0	0	0	12	Y. Jiang
9	Exam	0	3	0	0	0	0	0	3	
	Total	19	28	59	0	0	0	78	144	

Education Material

Lecture notes	Lecture notes by Prof. M.P. van Dijk and Dr. Y. Jiang

Scientific Software

M3047

Asset Management

Term	201617T05
Coordinator	P.D.A. Pathirana
Credit points	5.000000000
Specialization	

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.

4 Define databases and describe what a relational database is. Design a simple relational database (on paper!). Lis the important features of a relational database and appraise the use of data driven models in Asset Management. Describe sample approaches

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
2 Asset Inventory
3 Data/Databases
4 Relational databases in Asset Management
5 Making sense of data - data mining in AM
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
3	Data/Databases	1	0	0	0	0	0	1	3	S.D. Seyoum
4	Relational databases in Asset Management	2	0	2	0	0	0	4	8	P.D.A. Pathirana
5	Making sense of data - data mining in AM	2	0	4	0	0	0	6	10	P.D.A. Pathirana, S.D. Seyoum
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	
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	R.M. Ashley
	Total	38	0	28	0	8	0	74	150	

Education Material

Scientific Software

M1553

Coastal Systems

Term	201617T05
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 understand the basics for numerical aspects, be aware of the limitations and characteristics of hydronamic numerical models, know the principle of finite differences and finite element-based methods.

Assessments

%	Type	Name
30	Assignment	Numerical Methods
70	Written examination (open book)	Written exam Coastal Hydrodynamics and Morphology

Topics

1 Coastal Hydrodynamics and Morphology

Coastal Hydrodynamics, Sediment transport by currents plus waves. Sediment balance equation. Sedimentation of navigation channels. Current-induced scour around breakwaters. Entrance channel stability; formation of channels in deltas and tidal inlets Trans

2 Coastal Hydrodynamics and Morphology

3 Coastal Hydrodynamics and Morphology

4 Barrier island coasts

5 Rip currents

6 Modelling and Numerical Aspects

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	4	0	4	0	0	0	8	16	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	8	0	2	0	0	0	10	26	R.W.M.R.J.B. Ranasinghe
4	Barrier island coasts	4	0	0	0	0	0	4	12	
5	Rip currents	4	0	0	0	0	0	4	12	
6	Modelling and Numerical Aspects	2	20	8	0	0	0	10	34	I.I. Popescu
	Total	30	20	30	0	0	0	60	140	

Education Material

Lecture notes Os, A.G. van, Salt intrusion and density currents - Lecture notes ln 0286/98/

Scientific Software

Matlab

M1802

Conventional Wastewater Treatment

Term	201617T05
Coordinator	C.M. Lopez Vazquez
Credit points	5.000000000
Specialization	

Target Group

MSc participants enroled in the Municipal Water Infrastructure program from the Sanitary Engineering Specialization (MWI-SE). Wastewater professionals with background and/or proven qualifications in sanitary engineering, environmental sciences, microbiology, civil engineers, chemical engineering, biochemical engineering, environmental engineering and/or environmental biotechnology.

Prerequisites

Preceding modules of the MWI-SE program and/or, in the case of short-course participants, required background on sanitary and wastewater engineering (see target group) in full compliance with UNESCO-IHE admission regulations.

Learning Objectives

1 critically determine and analyse quality and quantity characteristics of wastewater originating from urban environments as a basis for the design, control and operation of sewage treatment facilities.

2 discuss the physical, chemical, and biological processes applied for sewage purification and the complex interactions among them occurring in wastewater treatment systems.

3 apply the knowledge on biological treatment processes and engineering on the process design and critical assessment of wastewater treatment systems and configurations for the removal of organic matter (as COD) and nutrients (nitrogen and phosphorus)

4 discuss the principles, fundamentals and applicability of recently developed wastewater treatment processes suc as innovative nitrogen removal processes and membrane bioreactors.

Assessments

%	Type	Name
20	Assignment	
80	Written examination (closed book)	

Topics

1 Wastewater characterization and sampling

Description and analysis of the different factors that affect the quantity and quality of wastewater generated in urban environments. Discussion of relevant components and activities commonly used to assess and determine the wastewater quality and strengt

2 Primary treatment

Topics

- **3 Biological processes for the removal of organic matter, nitrogen and phosphorus**
- **4 Organic matter removal**
- **5 Nitrification**
- **6 Denitrification**
- **7 Enhanced biological phosporus removal**
- **8 Final settling**
- **9 Innovative nitrogen removal**
- **10 Membrane bioreactors**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Wastewater characterization and sampling	4	0	0	0	0	0	4	12	D. Brdanovic
2	Primary treatment	4	0	0	0	0	0	4	12	D. Brdanovic
3	Biological processes for the removal of organic matter, nitrogen and phosphorus	0	0	0	0	0	0	0	0	C.M. Lopez Vazquez, L. Welles
4	Organic matter removal	4	0	1	1	0	2	8	21	C.M. Lopez Vazquez, L. Welles
5	Nitrification	4	0	1	1	1	2	9	22	C.M. Lopez Vazquez, L. Welles
6	Denitrification	4	0	1	1	0	2	8	21	C.M. Lopez Vazquez, L. Welles
7	Enhanced biological phosporus removal	4	0	1	1	1	2	9	22	C.M. Lopez Vazquez, L. Welles
8	Final settling	4	0	1	0	0	0	5	13	C.M. Lopez Vazquez
9	Innovative nitrogen removal	4	0	0	0	0	0	4	12	C.M. Lopez Vazquez
10	Membrane bioreactors	4	0	1	0	0	0	5	13	H.A. Garcia Hernandez
	Total	36	0	6	4	2	8	56	148	

Education Material

Scientific Software

M3090

Data Collection and Analysis and Design

Term	201617T05
Coordinator	M.G.F. Werner
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

Engineers, geoscientists, and other professionals with an interest for 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 for water resources and floods, water quality, and sediments. Quality control of data and optimisation of data collection networks, management of data in the ri

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	M.G.F. Werner
2	Deterministic & Probabilistic Design	12	0	14	0	0	0	26	50	
	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

M1953

Industrial Resource Management and Cleaner Production

Term	201617T05
Coordinator	E.R. Raj
Credit points	5.000000000
Specialization	

Target Group

The module on Industrial Resource Management and Cleaner Production (IRM&CP) is directed at engineers and scientists working in the urban or industrial water field and wanting to have a better grasp at the efficient dealing with industrial resources, in particular water. The module is of great interest to practicing engineers and scientists in the fields of urban, municipal and industrial sanitation, water-related chemistry and biology, water resources, chemical engineering, process design and implementation.

Prerequisites

Participants should possess a BSc degree in an area relate environmental engineering and science, microbiology, chemical engineering, chemistry, public health, etc. Professional experience in the water field helps to fully grasp the significance of the back-ground thinking relayed in the module and of the practical benefits of some of the concepts presented.
A good command of the English language is required.

Learning Objectives

1 suggest options for preventing pollution within urban and industrial water management settings;
2 assess the environmental impact of products and processes;
3 suggest treatment/disposal methods for industrial wastewater from which the value has been taken out;
4 understand the importance of environmental management systems in the industrial context;
5 indicate how the sustainable use of resources can be beneficial for reducing environmental burden(s);
6 analyze the different system tools that support industrial ecology and make basic calculations related to life cycle analysis.

Assessments

%	Type	Name
60	Written examination (open book)	Examination is on-line using MOODLE
35	Assignment	Group work (case-study), final presentation and final report submission
5	Presentation	Part of the 5% from presentation includes contribution in class, presence, intiative

Topics

1 **Introduction to the field of Cleaner Production (CP)**

What is Cleaner Production (CP)? How did it develop, in what context? How can Cleaner Production be applied to industrial, domestic, institutional management? How does Cleaner Productin relate to Water Management?

2 **Life Cycle Analysis (LCA), Eco Design**

What is Life Cycle Analysis (LCA)? What does it aim at? How does it work in practice and what is the practical significance of LCA?

3 **Environmental Management Systems**

What is Environmental Management, what are Environmental Management Systems (EMS)? What are the major components? How does ESM relate to environmental issues? What is the industrial perspective of ESM? Does is EMS applied to industrial systems?

4 **Corporate social responsibility (CSR)**

What is a company?, What is the role of business in society ? What is the difference between CSR active and CSR proactive business models ?

5 **Water Footprint (WF)**

What is water stress, How is water footprint related to climate change, How can global water scarcity be measured, What are the temporal and spatial domensions of water scarcity and How do we estimate the water footprint of a product?

6 **Material Flow Analysis (MFA)**

- To be able to describe conversion and mass transfer in selected industrial processes (paper manufacturing, leather production, horiclture, meat production, dairy industry, waste water treatment, electricity production)
- To indicate apropriate waste prevention strategies for each industry
- To know adeaquat data sources and data collection strategies to conduct a regional MFA
- To suggest policy measures for resource efficiency at different policy levels

7 **Eco-industrial parks and Industrial ecology (EIP and IE)**

What are the key concepts of industrial ecology, What are the consequences of not-effectively managing the resources, How the sustainable use of resources can be beneficial for reducing environmental burden(s), What are the different system tools that support industrial ecology and the creation of a sustainable eco-industrial park?

8 **Simulation game - fun factory**

- Learning to apply mass balancing in process industries
- Understanding the different reasons of waste production during a production process
- Getting a feeling for waste prevention measures and where to implement them

9 **Industrial Water Management - Processes and case studies**

- Understanding the impact of industry on water resources
- Implementing cleaner production practices and concepts in process industries

10 **Group work**

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	4	0	0	0	10	22	D Huisingh, M.A. Siebel
2	Life Cycle Analysis (LCA), Eco Design	3	0	2	0	0	0	5	11	LF Dijk
3	Environmental Management Systems	4	0	0	0	0	0	4	12	M. Grashof
4	Corporate social responsibility (CSR)	2	0	2	0	0	0	4	8	E. van Galen
5	Water Footprint (WF)	4	0	0	0	0	0	4	12	AK Chapagain
6	Material Flow Analysis (MFA)	6	0	4	0	0	0	10	22	VS Rotter
7	Eco-industrial parks and Industrial ecology (EIP and IE)	4	0	0	0	0	0	4	12	E.R. Raj
8	Simulation game - fun factory	0	0	5	0	0	0	5	5	M.A. Siebel, VS Rotter
9	Industrial Water Management - Processes and case studies	4	0	0	0	0	0	4	12	C.M. Lopez Vazquez, H.A. Garcia Hernandez
10	Group work	1	6	15	0	0	0	16	24	E.R. Raj, M.A. Siebel
	Total	34	6	32	0	0	0	66	140	

Education Material

Lecture notes	Lecture notes in electronic form

Scientific Software

M2128

Modelling and Information Systems Development

Term	201617T05
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 test 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 the graphical user interface using MATLAB

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

3 River modelling

Application of 1D river modelling using Mike11 and Sobek modelling systems. Model development, calibration and validation

Topics

4 Modelling system development

Developing modelling and graphical user interface components of a water-based system using standard numerical and graphics toolboxes (in the 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. var Andel
4	Modelling system development	2	0	6	14	0	0	22	40	G.A. Corzo Perez, J.L. Alfonso Segura
	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
Lecture notes	Solomatine: Lecture notes on Database, information and knowledge systems
Lecture notes	Solomatine: Lecture notes on Uncertainty analysis in modelling

Scientific Software

Matlab

Mike 11

sobek-RUR

M1577

Surface Water Treatment II

Term	201617T05
Coordinator	G. Ferrero
Credit points	5.000000000
Specialization	

Target Group

Students of the MWI master programme. Professionals in water treatment, consulting agencies, ministries and equipment suppliers.

Prerequisites

Participants should meet the general UNESCO-IHE admission criteria, and possess a BSc degree in chemical, environmental, or civil engineering.

Learning Objectives

1. Explain the principles of disinfection, drinking water quality, natural treatment systems, adsorption and activated carbon filtration processes
2. Integrate theoretical principles of disinfection with practical aspects of evaluation of disinfection systems
3. Prepare conceptual design of appropriate processes depending on the nature of impurities to be removed and the intended use of the treated water

Assessments

%	Type	Name
10	Assignment	
20	Lab. Report	
70	Written examination (closed book)	

Topics

1 Drinking water quality

2 Surface water collection and storage

3 Disinfection

Basic principles of disinfection; chemical disinfection; disinfection by products; ozone disinfection; UV disinfection.

4 Adsorption

Theoretical background of adsorptive processes.

5 Activated carbon

Granular and powdered activated carbon, modelling and design.

Topics

6 **Natural treatment systems**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Drinking water quality	4	8	0	0	0	0	4	20	G. Ferrero
2	Surface water collection and storage	4	0	2	0	0	0	6	14	M.D. Kennedy
3	Disinfection	12	0	4	8	4	4	32	72	G. Ferrero
4	Adsorption	4	0	2	0	0	0	6	14	S.K. Sharma
5	Activated carbon	4	0	2	2	0	0	8	18	S.K. Sharma
6	Natural treatment systems	4	0	0	0	0	0	4	12	S.K. Sharma
	Total	32	8	10	10	4	4	60	150	

Education Material

Scientific Software

M3088

Tertiary Unit Design and Hydraulics

Term	201617T05
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 (LWDFS)

Prerequisites

Irrigation agronomy, applied hydraulics, plant water relationships

Learning Objectives

1. Analyse, evaluate and apply the hydraulic principles for pipe flow in irrigation and drainage engineering.
2. Present, process and interpret results of hydraulic laboratory measurements in a technical report
3. Assess the need and implications of drainage 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
40	Written examination (closed book)	Applied Hydraulics of Irrigation Systems II
0	Lab. Report	Hydraulic Laboratory 2
35	Assignment	Irrigation and Drainage,Tertiary Unit Design II
25	Assignment	Salinity Control and Main Drainage System

Topics

1 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.

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.

Topics

3 Salinity Control and Main Drainage System

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.

4 Irrigation and Drainage - Tertiary Unit Design II

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.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Applied Hydraulics of Irrigation Systems II.	14	0	8	0	0	0	22	50	L.G. Hayde
2	Hydraulics Laboratory 2	0	0	0	8	0	0	8	16	L.G. Hayde
3	Salinity Control and Main Drainage System	10	0	4	0	0	0	14	34	F.X. Suryadi, PHJ Hollander
4	Irrigation and Drainage - Tertiary Unit Design II	12	0	6	0	0	0	18	42	F.X. Suryadi
	Total	36	0	18	8	0	0	62	142	

Education Material

Lecture notes	Depeweg, H.W.Th., 1998. Field Irrigation and Drainage - Surface Irrigation Methods, LN0213/98/1
Lecture notes	Depeweg, H.W.Th., 2001. Off-Farm Irrigation and Drainage - Design and Operation of Tertiary Units, LN0185/01/1
Lecture notes	Ritzema, H., 2009. Main Drainage Systems, LN0340/09/1

Scientific Software

Basdev
Furdev
candes

M2497

Water Quality

Term	201617T05
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.

3 Determine the various transport mechanisms taking place in (sub)surface hydrology.

Assessments

%	Type	Name
50	Written examination (open book)	Hydrochemistry
20	Written examination (open book)	Organic matter and nutrient biogeochemistry
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

1.4 Transport of Microorganisms in Aquifers

2 Water Quality Monitoring

2.1 Water quality standards

2.2 Designing a monitoring program

2.3 Physico-chemical and bio-Monitoring

Topics

2.5 Case study - monitoring program design

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	3	0	0	0	0	0	3	9	
1.2	Carbon Cycling	2	0	2	0	0	0	4	8	
1.3	Nutrient Cycling	2	0	2	0	0	0	4	8	
1.4	Transport of Microorganisms in Aquifers	3	0	0	0	0	0	3	9	
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	2	0	0	0	0	0	2	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	32	0	24	0	0	0	56	120	

Education Material

Lecture notes	Lecture Notes

Scientific Software
QUAL2K

M1003

Water and Environmental Law

Term	201617T05
Coordinator	F.G.W. Jaspers
Credit points	5.000000000
Specialization	Core Program

Target Group

Students of the Masters of Science Programmes of Water Management and Environmental Science and Technology . Practitioners with a relevant Bachelor's degree in a water related discipline

Prerequisites

Preferably a relevant water science and engineering related bachelor's degree or equivalent; affinity with water management; good command of English.

Learning Objectives

1 Critically investigate and grasp different dimensions of water and environmental law (including principles, rights, instruments, organizations) from local to global level.

2 Obtain proficiency in the review of contrasting legal arguments.

3 Practise treaty writing and contract writing skills.

4 Integrate legal knowledge within their existing water and environmental knowledge that try to address key issues water sharing under the equity articles of the UN Watercourses Convention.

Assessments

%	Type	Name
30	Assignment	Water and environmental law
70	Written examination (closed book)	

Topics

1 International Water Law

1.1 Introduction International Water Law

1.2 International Water Law

1.3 International Environmental Law

1.4 Case studies

1.5 Other international law

1.6 Trans-boundary water and environmental law and related basin organizations

Topics

2 National Water Law

2.1 Introduction to legal concepts

2.2 Legal principles (including spatial planning law) in national water and climate change

2.3 Legal instruments for water quality management

2.4 Centralization, decentralization and subsidiarity: risks and advantages of each

2.5 Customary and statutory water and environmental rights, including rights of indigenous peoples

2.6 National river basin organizations; organizations for implementing climate change

2.7 National jurisprudence on water and environment

2.8 National dispute resolution issues

2.1 Intro National Water Law
2.2 Legal Instruments
2.3 River Basin Organizations (Intro)
2.4 Water Rights
2.5 Case: Customary Water Rights
2.6 Water Quality Management Regulations

3 Contract Management

3.1 Contract law

3.2 Case study contract management on water related issues

3.3 Case study contract management for the Clean Development Mechanism or Reducing Emissions from Deforestation and Forestation Degradation

3.4 Group work contract law

Topics

3.1 Contract Law

3.2 Contract Management Workshop

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	International Water Law	0	0	0	0	0	0	0	0	
1.1	Introduction International Water Law	2	0	0	0	0	0	2	6	J. Gupta
1.2	International Water Law	4	0	2	0	0	0	6	14	J. Gupta
1.3	International Environmental Law	4	0	2	0	0	0	6	14	J. Gupta
1.4	Case studies	0	0	4	0	0	0	4	4	J. Gupta
1.5	Other international law	2	0	0	0	0	0	2	6	Z.S. Shubber
1.6	Trans-boundary water and environmental law and related basin organizations	2	0	0	0	0	0	2	6	Z.S. Shubber
2	National Water Law	0	0	0	0	0	0	0	0	
2.1	Intro National Water Law	2	0	0	0	0	0	2	6	F.G.W. Jaspers
2.2	Legal Instruments	2	0	0	0	0	0	2	6	F.G.W. Jaspers
2.3	River Basin Organizations (Intro)	4	0	2	0	0	0	6	14	F.G.W. Jaspers
2.4	Water Rights	4	0	2	0	0	0	6	14	F.G.W. Jaspers
2.5	Case: Customary Water Rights	0	0	4	0	0	0	4	4	P. van der Zaag
2.6	Water Quality Management Regulations	4	0	4	0	0	0	8	16	
3	Contract Management	0	0	0	0	0	0	0	0	
3.1	Contract Law	2	0	2	0	0	0	4	8	F.G.W. Jaspers
3.2	Contract Management Workshop	0	0	4	0	0	0	4	4	F.G.W. Jaspers
	Total	32	0	26	0	0	0	58	122	

Education Material

Lecture notes	F.G.W. Jaspers - Chapters in Water and Environmental Resources Law, UNESCO-IHE Lecture Notes.

Scientific Software

M2874

Anaerobic Wastewater Treatment

Term	201617T06
Coordinator	M. Ronteltap
Credit points	0.000000000
Specialization	

Target Group

Young and mid-career professionals with a relevant wo bachelor (academic bachelor)

Prerequisites

BSc degree or equivalent qualification in a relevant field from a recognised university Several years of relevant working experience

Learning Objectives

1 have a proper understanding of Anaerobic wastewater treatment (AnWT) and technologies making use of anaerobic treatment
2 know how to calculate on COD balances
3 be able to design a basic UASB reactor
4 know how anaerobic reactor effluent can be treated
5 be introduced to innovations in anaerobic wastewater treatment such as anaerobic MBRs

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

M2033

Coastal and Port Structures

Term	201617T06
Coordinator	A. Dastgheib
Credit points	5.000000000
Specialization	

Target Group

This course is useful for engineers involved in the design of coastal structures specially breakwaters and/or the supervision of coastal structure projects. Knowledge about 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 Have an overview of structures and vessels used in the offshore industry, their behaviour under conditions of winds, waves, currents, environmental loading.

3 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.

Assessments

%	Type	Name
100	Assignment	Design of Breakwaters

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

Topics

4 Offshore Engineering

Review of structures and vessels used in the offshore industry, characteristic effects of wave, wind and current environment on the behaviour of floating offshore vessels: motions, mooring loads, workability, response of the structure to environmental loading: motions, mooring loads, both in the frequency and time domains, review of techniques to assess the behaviour in the design stage and during operations.

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	JW van der Meer
2	Design of Breakwaters	0	8	0	0	0	16	16	56	A. Dastgheib, JW van der Meer
4	Offshore Engineering	0	0	6	0	0	0	6	6	AB Aalbers
	Total	26	8	6	0	0	16	48	140	

Education Material

Lecture notes	Breakwater Design; J.W. van der Meer, H. Ligteringen; ln0026/14
Lecture notes	Exercise Breakwater Design J.W. van der Meer, A. Dastgheib; ln0027/14

Scientific Software

Breakwat

M2847

Computational Intelligence and Operational Water Management

Term	201617T06
Coordinator	D. Solomatine
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in WSE programmme, Specialisation in hydroinformatics, Participants in Erasmus Mundus Flood Risk Management Programme, Participants in short course "Computational Intelligence and Operational Water Management"

Prerequisites

Learning Objectives

1 Understand and be able to formulate and solve an optimisation problem in relation to water systems (model calibration, reservoirs, urban pipe networks)

2 Understand and explain how real-time control systems work

3 Identify the potential of control to solve hydrological problems

4 Sketch a general plan for a regional real-time control system

5 Appreciate and apply the main techniques of data-driven modelling (machine learning): neural networks, model trees, instance-based learning, and select proper methods and tools for building data-driven models

6 Correctly classify a modelling problem as a physically-based, data-driven, or hybrid

Assessments

%	Type	Name
20	Assignment	Data driven modelling and computational intelligence
30	Written examination (open book)	Data driven modelling and computational intelligence
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)

Topics

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 **Data driven modelling and computational intelligence**

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. Applications in flow/flood forecasting.

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	4	2	0	0	10	20	D. Solomatine
2	Operational water management	12	0	20	0	0	0	32	56	A.H. Lobbrecht, J.L. Alfonso Segura, S.J. van Andel
3	Data driven modelling and computational intelligence	14	0	22	0	0	0	36	64	B. Bhattacharya, D. Solomatine
	Total	30	0	46	2	0	0	78	140	

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

Aquarius

Lingo

Matlab

Weka

M3034

Environmental Systems Analysis

Term	201617T06
Coordinator	K.A. Irvine
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in the Environmental Science MSc-programme at UNESCO-IHE

Prerequisites

Modules 1-4 of Environmental Science programme.

Learning Objectives

1 List and describe environmental systems analysis (ESA) concepts and methods, and in particular the Ecosystem Services framework
2 Perform a problem analysis and stakeholder analysis for a given environmental system
3 Perform an analysis of ecosystem functions and services and their drivers of change for a given environmental system
4 Construct a simple dynamic simulation model of an environmental system
5 Discuss critically the strengths, weaknesses, missing information, advantages and disadvantages of the analyses
6 Communicate effectively the methods, results and conclusions of a case study (presentation and written report)

Assessments

%	Type	Name
60	Assignment	Individual report on the case study
10	Presentation	Stella model developed during the group work
30	Written examination (closed book)	

Topics

1 Introduction ESA

2 Ecosystem characteristics

3 Ecosystem functions and services

4 Drivers of change in ecosystems

5 Biodiversity

6 Systems modelling for policy analysis

Topics

7 Stakeholder analysis

8 DPSIR analysis

9 Problem analysis & conceptual models

10 Group work (case study)

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction ESA	2	0	0	0	0	0	2	6	A.A. van Dam, K.A. Irvine
2	Ecosystem characteristics	2	0	0	0	0	0	2	6	K.A. Irvine
3	Ecosystem functions and services	6	0	0	0	0	0	6	18	A.A. van Dam, K.A. Irvine
4	Drivers of change in ecosystems	2	0	0	0	0	0	2	6	K.A. Irvine
5	Biodiversity	6	0	0	0	0	0	6	18	de Rooij, J.H. Janse
6	Systems modelling for policy analysis	2	0	0	0	0	0	2	6	
7	Stakeholder analysis	2	2	0	0	0	0	2	8	A. Mendoza - Sammet
8	DPSIR analysis	2	2	0	0	0	0	2	8	A. Mendoza - Sammet
9	Problem analysis & conceptual models	0	4	0	0	0	0	0	4	A.A. van Dam, E.M.A. Hes
10	Group work (case study)	6	0	42	0	0	0	48	60	A. Mendoza - Sammet, E.M.A. Hes, K.A. Irvine
	Total	30	8	42	0	0	0	72	140	

Education Material

Scientific Software

stella

M3033

Groundwater Resources and Treatment

Term	201617T06
Coordinator	B. Petrusevski
Credit points	5.000000000
Specialization	

Target Group

The module specifically targets professionals in water treatment companies, consulting agencies, ministries and equipment suppliers.

Prerequisites

Participants should meet the general UNESCO-IHE admission criteria, and possess a BSc degree in Chemical, Environmental, Civil or Sanitary Engineering.

Learning Objectives

1 Assess if given (ground)water is aggressive against materials used in water a supply system and propose appropriate neutralisation technique.

2 Assess overall quality of a given groundwater.

3 Establish appropriate treatment approach for groundwater containing commonly occurring impurities and pollutan including iron, manganese, ammonia, fluoride, and hydrogen sulphate.

4 Understand advanced groundwater treatment approaches applied in The Netherlands

Assessments

%	Type	Name
15	Assignment	
15	Lab. Report	
70	Written examination (closed book)	

Topics

1 Introduction to the module

2 Aeration

3 Water Quality & Treatment

removal of taste and odour, aggressive characteristics of water, neutralisation of aggressive nature of water, aeration.

3.1 Aggressive properties of (ground)water

3.2 Neutralisation of (ground)water aggressivity

Topics

3.3 Taste & Odour of (ground)water

4 Groundwater quality

5 Patogens transport in soil

6 Conventional groundwater treatment

Quality of groundwater, Conventional and advanced concepts in the removal of iron, manganese, ammonia, arsenic, fluoride and hydrogen sulphide.

6.1 Iron removal

6.2 Manganese removal

6.3 Ammonia removal

7 Arsenic removal

Sources of arsenic in groundwater, arsenic chemistry, arsenic and health, arsenic removal methods, research on arsenic removal at IHE Delft, analysis of arsenic (colorimetric and AAS-GF).

8 Fluoride removal

Sources of fluoride in groundwater, fluoride removal methods, research on fluoride removal at IHE Delft

9 Computer exercise groundwater treatment

Computer programmes will be used to (i) establish and optimise design of conventional groundwater treatment plants and (ii) examine the applicability of adsorptive iron removal.

10 Hydrogen sulphide removal

11 GW treatment in Belgium

12 Introduction to IGRAC

13 Advanced groundwater treatment in The Netherlands

14 Fieldtrip - design exercise

Field visit to a groundwater treatment plant in The Netherlands incl. small design exercises.

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 module	1	0	1	0	0	0	2	4	B. Petrusevski
2	Aeration	4	0	2	0	0	0	6	14	Y.M. Slokar
3	Water Quality & Treatment	4	0	6	0	0	0	10	18	B. Petrusevski
3.1	Aggressive properties of (ground)water	0	0	0	0	0	0	0	0	B. Petrusevski
3.2	Neutralisation of (ground)water aggressivity	0	0	0	0	0	0	0	0	B. Petrusevski
3.3	Taste & Odour of (ground)water	1	0	1	0	0	0	2	4	B. Petrusevski
4	Groundwater quality	2	0	2	0	0	0	4	8	B. Petrusevski
5	Patogens transport in soil	1	0	1	0	0	0	2	4	J.W.A. Foppen
6	Conventional groundwater treatment	7	0	3	4	0	0	14	32	B. Petrusevski, Y.M. Slokar
6.1	Iron removal	0	0	0	0	0	0	0	0	
6.2	Manganese removal	0	0	0	0	0	0	0	0	
6.3	Ammonia removal	0	0	0	0	0	0	0	0	
7	Arsenic removal	2	0	3	4	0	0	9	17	B. Petrusevski, Y.M. Slokar
8	Fluoride removal	2	0	1	0	0	0	3	7	B. Petrusevski
9	Computer exercise groundwater treatment	0	2	6	0	0	4	10	20	
10	Hydrogen sulphide removal	2	0	0	0	0	0	2	6	B. Petrusevski
11	GW treatment in Belgium	2	0	2	0	0	0	4	8	
12	Introduction to IGRAC	0	0	1	0	0	0	1	1	
13	Advanced groundwater treatment in The Netherlands	3	0	0	0	1	0	4	10	
14	Fieldtrip - design exercise	0	0	4	0	4	0	8	8	B. Petrusevski
	Total	31	2	33	8	5	4	81	161	

Education Material

Lecture notes	B. Petrusevski, Groundwater Treatment: Removal of Arsenic & Fluoride (LN 0485.16.1)
Lecture notes	B. Petrusevski, J.C. Schippers, Aggressive Characteristics & Neutralisation Techniques (LN0482.16.1)
Lecture notes	B. Petrusevski, J.C. Schippers, Module Introduction, Taste & Odour, Quality of Groundwater (LN 0490.16.1)
Lecture notes	B. Petrusevski, S.K. Sharma and J.C. Schippers, Groundwater Treatment: Removal of Iron, Manganese & Ammonia (LN 0484.16.1)
Lecture notes	J. W. Foppen, Pathogen Transfer in Groundwater
Lecture notes	K. Huysman, From ground water to drinking / process water at Pidpa
Lecture notes	S. K. Sharma, Hydrogen Sulphide Removal

Scientific Software

M3103

Managing Water Organisations

Term	201617T06
Coordinator	K.H. Schwartz
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and mid-career professionals with an interest in strategic and operational management of water supply and sanitation organisations (including regulators).

Prerequisites

Preferably experience in the water sector. A bachelors degree or equivalent. Basic PC-computer knowledge. Good command of English language.

Learning Objectives

1 Relate academic debates concerning water supply and sanitation provisioning to the management of water organisations

2 Explain the position and strategy of a water organisation in relation to its institutional environment.

3 Diagnose challenges for a water organisation in relation to its context and develop strategic plans accordingly, including the management of change

5 The first block focuses on understanding the water services sector in which a water organisation develops. During this block the regulatory and policy context of water organisations is elaborated upon.

6 During the second block, the module focuses on specific elements of organisational management. This includes strategic management, change management, human resources management and customer management.

Assessments

%	Type	Name
70	Assignment	Essay
20	Assignment	Research assignment
10	Assignment	Simulation game

Topics

1 Sector overview

2 Performance

3 Policy Analysis

4 Regulatory Models

Topics

5 Public Sector Reform

6 Strategic Management

7 Water Utilty Simulation Game

8 Benchmarking

9 Benchmarking Game

10 Change Management

13 Water Utility Research Assignment

15 Introduction Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Sector overview	3	0	0	0	0	0	3	9	K.H. Schwartz
2	Performance	1	0	2	0	0	0	3	5	K.H. Schwartz
3	Policy Analysis	3	0	0	0	0	0	3	9	K.H. Schwartz
4	Regulatory Models	0	0	0	0	0	0	0	0	
5	Public Sector Reform	3	0	0	0	0	0	3	9	K.H. Schwartz
6	Strategic Management	3	0	0	0	0	0	3	9	K.H. Schwartz
7	Water Utilty Simulation Game	1	7	0	0	0	0	1	10	A. Cabrera Flamini, K.H. Schwartz, M. Tutusaus Luqu
8	Benchmarking	1	0	0	0	0	0	1	3	M. Tutusaus Luque
9	Benchmarking Game	0	0	4	0	0	0	4	4	M. Tutusaus Luque
10	Change Management	3	0	0	0	0	0	3	9	
13	Water Utility Research Assignment	1	23	0	0	0	0	1	26	K.H. Schwartz, M. Tutusaus Luque
15	Introduction Exam	1	0	0	0	0	0	1	3	M. Tutusaus Luque
	Total	20	30	6	0	0	0	26	96	

Education Material

Scientific Software

M2384

Resource Oriented Wastewater Treatment and Sanitation

Term	201617T06
Coordinator	M. Ronteltap
Credit points	5.000000000
Specialization	

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

7 Constructed Wetlands

8 Algae Conference

Students are invited to the Algae Conference here at UNESCO-IHE for one day

This international conference brings together scientists, algaeneers and practitioners to exchange the latest knowledge on the application of algae for wastewater treatment and resource recovery.

Wastewater engineers using algae can benefit from knowledge coming from the use of algae to produce biofuels, food supplements or green pharmaceuticals. Likewise, wastewater as a cheap source of nutrients and inorganic carbon is promising for the production of algae-based commodities. For example, algae based treatment systems in developing world tropical countries, may reduce wastewater treatment costs via the recovery of its inherent resources.

The conference offers an overview and discussion of the latest scientific developments and practical applications in these fields.

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	15	4	5	4	0	0	24	62	J.B. van Lier, J.L.C.M. van de Vossenberg, N.P. van de Steen
2	Waste Stabilisation Ponds	3	0	0	0	0	2	5	15	N.P. van der Steen
3	Urine Treatment	6	0	0	3	0	0	9	24	M. Ronteltap
4	Field trip	0	0	0	0	8	0	8	8	M. Ronteltap
5	Effluent reuse in agriculture	4	0	0	0	0	0	4	12	A.E.C. Duker, J.B. van Lier
6	Algae photobioreactors	4	0	0	0	0	0	4	12	N.P. van der Steen
7	Constructed Wetlands	4	0	0	0	0	2	6	18	DPL Rousseau, J.J.A. van Bruggen
8	Algae Conference	0	0	6	0	0	0	6	6	N.P. van der Steen
9	Introduction into resource orientation in wastewater treatment and sanitation	8	0	0	0	0	0	8	24	M. Ronteltap
	Total	44	4	11	7	8	4	74	181	

Education Material

Lecture notes	Lecture notes.

Scientific Software

M1703

River Basin Development and Environmental Impact Assessment

Term	201617T06
Coordinator	I. Masih
Credit points	5.000000000
Specialization	Hydraulic Engineering and River Basin Development

Target Group

Students of Hydraulic Engineering and River Basin Development

Prerequisites

Working knowledge in topics such as Hydrology, Hydraulics, Sediment and Morphology, Water Quality, Ecology and River Dynamics.

Learning Objectives

1 Explain and apply the concepts of river basin development including integrated water resources management (IWRM) and principles and advances in integrated planning

2 Explain the principles of environmental impact assessment (EIA) and apply EIA for a River Basin Development Plan and clearly communicate the outcomes and recommendations

3 Describe the basics of economics in river basin development and the importance of good governance for the implementation of river basin development plans and the operational management of river basins.

4 Apply state of the art modelling tools to simulate the distribuion of water to stakeholders within a river basin, and evaluate the impact of future scenarios and develop strategies to manage expected consquences

5 Formulate a plan for the development of a river basin following the basic steps in a river basin planning process and design alternative strategies and assess their consequent social, economic and environmental impacts

Assessments

%	Type	Name
15	Assignment	EIA
35	Assignment	River Basin Development Exercise (Nile)
50	Written examination (closed book)	River Basin Development and EIA

Topics

1 Module Introduction and Basin Development Trajectory

2 Water Resources Development

3 Environmental Impact Assessment for WRM Projects

Topics

4 River Basin Development Exercise

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Module Introduction and Basin Development Trajectory	4	0	0	0	0	0	4	12	I. Masih
2	Water Resources Development	20	4	0	0	0	0	20	64	E. van Beek
3	Environmental Impact Assessment for WRM Projects	10	0	8	0	0	0	18	38	
4	River Basin Development Exercise	2	0	20	0	0	0	22	26	
	Total	36	4	28	0	0	0	64	140	

Education Material

Lecture notes	Beevers, L. and H. Clouting, Environmental Assessment (EIA/SEA). UNESCO-IHE Lecture notes
Handout	Various Handouts

Scientific Software

Ribasim

M2292

Short Course on Hydropower Water Conduit Design

Term	201617T06
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 th 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

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	2	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	I.I. Popescu
4	Civil structure	10	0	0	0	0	0	10	30	M. Marence
	Total	24	0	0	0	0	0	24	72	

Education Material

Scientific Software

M3023

Socio-economic and Environmental Aspects of Land and Water Development

Term	201617T06
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	Land and Water Development for Food Security

Target Group

All Land and Water Development participants.

Prerequisites

Main and tertiary irrigation system design, agronomy, soil plant water relationship.

Learning Objectives

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

2 Understand the rationale for and mechanisms of water pricing

3 Describe the economic feasibility of land and water development projects and have a first understanding of financial reporting

4 Determine the requirements for water table and salinity control in irrigated area and design a subsurface drainage system

5 Explain the opportunities and implications of wastewater use for irrigation

6 Identify major potential health benefits and disease risks of agricultural water management

Assessments

%	Type	Name
30	Written examination (open book)	Economics and Sociology
20	Assignment	Environmental Impact Assessment
20	Assignment	Irrigation & Health and Wastewater Irrigation
30	Assignment	Sub-surface Drainage

Topics

1 Economic & financial aspects of land and water development

Capital, interest and time. Costs and benefits. B/C ratios and the internal rate of return. Unit prices. Evaluation of alternatives. An introduction to financial reporting; balance sheets, profit and loss account, cash flow statements.

Topics

2 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.

3 Environmental Impact Assessment of irrigation and drainage

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 enviro

4 Sub-surface drainage

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.

5 Wastewater irrigation

Opportunities and challenges of wastewater irrigation, pathogenicrisks and heavy metal contamination in crop production and consumption, risk-mitigating measures, instituational aspects of wastewater use in agriculture.

6 Irrigation and health

Impacts of agricultural water management on human health and well-being. Linkages between design of irrigation, drainage and storage infrastructure, operation, actual water use and maintenance; and implications for ecology, water quality, behaviour, livelihoods, health and disease. Engineering options for enhancing health benefits and reducing disease risks.Health impact assessment.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Economic & financial aspects of land and water development	6	0	2	0	0	0	8	20	C.M.S. de Fraiture
2	Sociological aspects of land and water development	6	0	6	0	0	0	12	24	J.G. Evers
3	Environmental Impact Assessment of irrigation and drainage	8	6	6	0	0	0	14	36	WJR Buydens
4	Sub-surface drainage	6	8	4	0	0	0	10	30	HP Ritzema
5	Wastewater irrigation	4	6	4	0	0	0	8	22	A.E.C. Duker
6	Irrigation and health	4	0	2	0	0	0	6	14	E.D.C. Boelee
	Total	34	20	24	0	0	0	58	146	

Education Material

Scientific Software

M1903

Tracer Hydrology and Flow Systems Analysis

Term	201617T06
Coordinator	J.W.A. Foppen
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

M3069

Water Conflict Management I

Term	201617T06
Coordinator	Z.S. Shubber
Credit points	5.000000000
Specialization	Core Program

Target Group

Current and future water managers, decision-makers and others involved in water management wanting to broaden their scope in water management. Professionals involved in dispute resolution wanting to broaden the scope of their activities to include water.
Students need to have a first degree in a relevant subject (economics, social sciences, law, engineering, biology etc.) and preferably several years of relevant working experience.

Prerequisites

Knowledge and appreciation of the principles of integrated water resources management, the water resources system and water governance.

Fluency in English is an absolute requirement.

Learning Objectives

1 Explain, discuss and analyze the basic concepts of conflict management and conflicts related to water.

2 Critically analyse cases of water sharing and use among different actors at different levels and from different sectors, from a conflict and cooperation perspective.

3 Identify, explain and analyse the elements of a conflict transformation process applied to the management of a water conflict, and prepare, organise and engage in them as a party and as the process leader.

4 Identify, explain and analyse the elements of a mediation process applied to the management of a water conflict, and prepare, organise and engage in them as a party and as a mediator.

Assessments

%	Type	Name
0,4	Assignment	Annotated Bibliography
0,1	Assignment	Skills Assessment
0,5	Written examination (closed book)	Written Exam

Topics

1 Theoritical background

The module will start with an introduction to basic theoretical concepts and frameworks that apply to conflict. The spectrum of dispute resolution mechanisms will be presented as well as key skills for successful conflict resolution. Additionally, concepts, theories and tools will be drawn from water governance, water resources planning and institutional analysis in relation to water conflicts.

2 Case studies

Case studies of disputes around water, at different levels and between different sectors, are presented and discussed. They illustrate concepts set out in the theoretical background.

3 Key theories and concepts on water conflict and cooperation

This component considers the key theories and concepts that help explain and analyse conflict and cooperation over water. It particularly focuses on institutions and agency of water politics, especially in international transboundary river basins. In addition, discussion will cover scalar implications of water conflict and cooperation.

4 Design and implement conflict resolution processes

The lectures provide an opportunity to learn about current and leading-edge ways to work effectively in contentious water situations. It offers a place to practice new skills that are applicable from the individual level to the societal level and across a range of real-life situations.

5 Mediation

Environmental and water conflicts often involve more than two parties and are multi-layered in content. It is therefore crucial to suit the process to the conflict at hand. Mediation is among the processes well suited for two or more parties that are involved in a water-related conflict as a means to resolve the conflict. Participants will consider the advantages of mediation and learn and practice the components of the process.

7 Annotated bibliography

The students will develop an annotated bibliography on a topic related to cases of water sharing or disputes relating to water, from a list provided, and submit it at the end of the module. The annotated bibliography will be a stepping stone for the Essay assignment of the WCM II module.

8 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Theoritical background	2	0	4	0	0	0	6	10	Z.S. Shubber
2	Case studies	0	0	4	0	0	0	4	4	
3	Key theories and concepts on water conflict and cooperation	2	0	4	0	0	0	6	10	
4	Design and implement conflict resolution processes	4	0	22	0	0	0	26	34	
5	Mediation	2	0	12	0	0	0	14	18	
7	Annotated bibliography	0	12	0	0	0	0	0	12	Z.S. Shubber
8	Exam	0	3	0	0	0	0	0	3	
	Total	10	15	46	0	0	0	56	91	

Education Material

Handout	Negotiation and Mediation, Theory and Skill. The Israel Centre for Negotiation and Mediation (2016), Haifa
Book	Sharing Waters, Sharing Benefits; UNESCO

Scientific Software

M2835

Water Quality Assessment

Term	201617T06
Coordinator	E.D. de Ruijter van Steveninck
Credit points	5.000000000
Specialization	

Target Group

Young and mid-career professionals (scientists, consultants, decision makers) with a background in Water management or Environmental science.

Prerequisites

Preferably a bachelor's degree in chemistry, chemical engineering, biology, environmental science, hydrology, geography or equivalent. Basic knowledge in computer operations (MS-Windows; Office). Good command of English.

Learning Objectives

1	Describe different water pollutant groups, their risks and fates, and ways of modelling these fates
2	Describe and apply the different tools, criteria and assessment methods for succesful monitoring of surface waters in river basins
3	Describe and apply groundwater quality monitoring concepts
4	Design sustainable water quality monitoring programmes for river basins

Assessments

%	Type	Name
15	Assignment	Groupwork: presentation on case study, design of a sustainable water quality monitoring programme in a specific river basin in a developing country
60	Written examination (closed book)	Topics: surface water quality monitoring, data handling; ground water monitoring
10	Lab. Report	Lab Report Written individual report on field/labwork
15	Assignment	Written individual report on exercise, GIS water quality model of the Scheldt river basin

Topics

1 Water Quality Monitoring

Water quality variables.

Natural water quality and pollution variables.

The monitoring cycle. Items of the monitoring programme: why, what, where, how, how often. Physico-chemical and biological water quality monitoring.

Basic concepts and applications of Aquatic Ecotoxicology in Water quality monitoring.

Monitoring in the EU Water Framework Directive.

Workshop: Recent trends in Water Quality monitoring: use of mobile phones; GIS; low cost instruments such as sensors; case studies and examples.

Exercise: optimization of water quality monitoring programmes. Group work: design of a river basin monitoring network.

Practical field&lab work: sampling, preservation, field analyses; Quality control in the laboratory.

2 Data analysis and presentation

Use of statistics in water quality monitoring. Statistical tests: z-test; t-test, confidence intervals, etc. Hypothesis setting.

Non-parametric statistics. Applications: minimum sampling frequency; significant differences between data sets, correlation between variables,etc.

Introduction to more advanced techniques such as ANOVA and FACTOR analysis.

Presentation of data.

Hands-on computer exercises.

Topics

3 Water Quality Modelling

Introduction to Modelling: types of models and model components.

BOD-DO modelling in a river.

Spatial-Dynamic Modelling of nitrate in the Scheldt Catchment, using a GIS based nutrient model. Modelling point and non-point sources.

In-class exercise.

4 Groundwater quality monitoring

Basics of hydrogeology. Pollutants reactions and transport in groundwater. Design of a groundwater monitoring network;

surveys; design and installation; locations; monitoring frequency; optimization.

5 Design of water quality monitoring network

(Liable to change): half-whole day visit(s) to water quality monitoring and modelling Institutions.

6 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water Quality Monitoring	10	0	11	8	0	4	33	69	G.F. Kruis, G.M. Gettel, J.L. Alfonso Segura
2	Data analysis and presentation	6	0	6	0	0	0	12	24	A.A. van Dam
3	Water Quality Modelling	0	0	2	8	0	0	10	18	J. van der Kwast
4	Groundwater quality monitoring	6	0	2	0	0	0	8	20	J.W.A. Foppen
5	Design of water quality monitoring network	0	0	0	0	6	0	6	6	
6	Exam	0	3	0	0	0	0	0	3	
	Total	22	3	21	16	6	4	69	140	

Education Material

Handout	C.A.M. van Gestel (2014) - Handout Aquatic Ecotoxicology
Handout	Compiled power point slides on all above topics; exercise materials; additional materials: relevant info, field trips materials, etc.
Handout	G.F. Kruis and P. Kelderman (2012) - Handout Fieldwork water quality monitoring and Laboratory QA/QC. Febr. 2012.
Handout	J. van der Kwast (2014)- Handout Introduction to Modelling/Nitrate modelling in the Scheldt basin
Handout	J.W.A. Foppen (2014) - Handout groundwater quality monitoring.
Lecture notes	P. Kelderman (2011) - Water quality and monitoring. UIHE lecture notes LN5/11/1.
Handout	P. Kelderman (2014) - Handout Data handling and presentation
Handout	P. Kelderman (2014) - Handout Design of a Water Quality Monitoring Network in a River Basin

Scientific Software

M1617

Water Resources Assessment

Term	201617T06
Coordinator	Y.A. Mohamed
Credit points	5.000000000
Specialization	

Target Group

Young and mid-career professionals, managers, engineers and technicians interested in water resources management in general, and in particular the assessment of quantity and quality of water resources. Processing and validation of both ground and remote sensing data is a key part of the module.

Prerequisites

Successful completion of WM1, WM2 or equivalent is strongly recommended. Affinity with quantitative approaches is required. Good command of English.

Learning Objectives

1 Describe different types of water resources data, generated from ground and RS measurements.

2 Apply diverse methods of data processing and data validation for water resources assessment.

3 Quantify the different components of the water resources spectrum (rainfall, river flow, groundwater), and assess availability and access at different scales.

4 Describe and apply different methods of water quality monitoring and assessment.

5 Analyse and quantify multiple uses of water for: agriculture, hydropower, domestic, environment and other uses

6 Apply water accounting techniques as a quick method for assessing water resources, water use, and water productivity in a river basin context.

Assessments

%	Type	Name
35	Assignment	
65	Written examination (closed book)	Writen Exam

Topics

1 Introduction to WRA

Topics

2 Water Resources Assessment

Water Resources data: Different types of water resources data, monitoring, validation, archiving, and dissemination.
Surface water resources assessment: time series analysis of WR data, including: flow duration curves, statistical distribution and trend analysis, extreme value analysis (floods and droughts).
Groundwater resources assessment: Defining sustainable yield, occurrence of groundwater and investigation methods, methods of groundwater abstraction.
Water quality monitoring and assessment: requirements for WQ assessment; WQ parameters; WQ monitoring program; Pollution; WQ assessment.
Estimation of water resources data in un-gauged basins and regionalization.

This includes field visits to the "Water Management Centre", The Netherlands, Lelystad, and to Deltares, Delft.

2.1 Water resources data (case study)

2.2 Surface water resources assessment

2.3 Groundwater resources assessment

2.4 Water quality assessment

2.5 WRA in un-gauged basins

3 Water use activities

Agricultural water demand, crop water requirement, net irrigation requirement, yield analysis, domestic water use, hydropower water demand, environmental water requirement.

4 Water accounting

Introduction to remote sensing data for water resources management; Satellite image processing; Catchment water balance in GIS environment; Water productivity and water valuation; Water accounting.

4.1 GIS/RS applications in WRA

4.2 Processing of spatial data (Land use, precipitation, evapotranspiration, runoff)

4.3 Computation of catchment water balance

4.4 Water accounting at different scales

5 Field visit "Water Management Center"

6 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to WRA	2	0	0	0	0	0	2	6	Y.A. Mohamed
2	Water Resources Assessment	0	0	0	0	0	0	0	0	
2.1	Water resources data (case study)	2	0	2	0	0	0	4	8	J. Susnik
2.2	Surface water resources assessment	4	0	4	0	0	0	8	16	Y.A. Mohamed
2.3	Groundwater resources assessment	4	0	4	0	0	0	8	16	T.Y. Stigter
2.4	Water quality assessment	6	0	0	0	0	0	6	18	A.L. Zuijdgeest
2.5	WRA in un-gauged basins	2	0	2	0	0	0	4	8	J. Susnik
3	Water use activities	4	0	2	0	0	0	6	14	S. Graas
4	Water accounting	0	0	0	0	0	0	0	0	H.H.G. Savenije, W.G.M. Bastiaanssen, Y.A. Mohame
4.1	GIS/RS applications in WRA	2	0	2	0	0	0	4	8	W.G.M. Bastiaanssen
4.2	Processing of spatial data (Land use, precipitation, evapotranspiration, runoff)	2	0	4	0	0	0	6	10	Y.A. Mohamed
4.3	Computation of catchment water balance	2	0	4	0	0	0	6	10	H.H.G. Savenije, Y.A. Mohamed
4.4	Water accounting at different scales	2	0	4	0	0	0	6	10	Y.A. Mohamed
5	Field visit "Water Management Center"	0	0	0	0	6	0	6	6	
6	Exam	0	0	0	0	3	0	3	3	
	Total	32	0	28	0	9	0	69	133	

Education Material

Book	Water Resources Assessment Hand Book for review of national capabilities, 1997 (WMO, UNESCO)
Lecture notes	Water accounting at river basin scale, Mohamed, 2013. UNESCO-IHE lecture notes.

Scientific Software

ArcGIS
Cropwat
QGis

M2216

Constructed Wetlands for Wastewater Treatment

Term	201617T07
Coordinator	J.J.A. van Bruggen
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 assess the value of wetlands and explain the use of natural and constructed wetlands for the treatment of wastewater;
2 describe the concept of wastewater treatment by wetlands;
3 design and operate a wetland treatment system.

Assessments

%	Type	Name
40	Assignment	
60	Written examination (closed book)	

Topics

1 Introduction into the module

Explanation of the contents of the module, the objectives, logistics etc.

2 Introduction Natural Wetlands

Definition, characteristics, types, relevance, human well being

3 Basics Wastewater Treatment

Wastewater: composition, prinicples.

Natural wetlands or constructed wetlands, limitations

Topics

4 **Wetlands and Climate**

Climate change, Greenhouse effect, Solar energy, evaporation, condensation, airconditioning, case studies, solutions, waterparadigm

5 **Natural wetlands for water treatment**

the basic principles, the advantages and disadvantages, the risks. Examples in a temperate climate and examples in the tropics.

6 **Types of Constructed Wetlands and Application**

Different types. Advantages and disadvantages. Constructed wetlands in The Netherlands, the tropics and the rest of the world.

Application for different types of wastewater.

7 **Integrated production systems**

theory, examples, advantages, disadvantages, economics, nutrient flows. Modelling of integrated production systems. Field visits.

8 **Design Constructed Wetlands**

Design of constructed wetlands

9 **Operation and Maintenance**

Operation and Maintenance Constructed Wetlands

10 **Economics**

Economics of constructed wetlands

11 **Case study**

Case study constructed wetland on Texel

12 **Fieldtrip 1**

Fieldtrip to constructed wetland at ZIN in Vught, and the forested wetland in Hapert

13 **Assignment**

Explanation of the assignment

14 **Presentations**

Final presentations on own design of a constructed wetland

15 **Exam**

Exam about the content of the module

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction into the module	1	0	0	0	0	0	1	3	J.J.A. van Bruggen
2	Introduction Natural Wetlands	6	3	0	0	0	0	6	21	E.M.A. Hes
3	Basics Wastewater Treatment	2	0	0	0	0	0	2	6	J.J.A. van Bruggen
4	Wetlands and Climate	2	0	0	0	0	0	2	6	J. Pokorny
5	Natural wetlands for water treatment	4	0	0	0	0	0	4	12	
6	Types of Constructed Wetlands and Application	4	0	0	0	0	0	4	12	J.J.A. van Bruggen
7	Integrated production systems	4	0	0	0	0	0	4	12	A.A. van Dam
8	Design Constructed Wetlands	8	0	0	0	0	0	8	24	DPL Rousseau
9	Operation and Maintenance	2	0	0	0	0	0	2	6	DPL Rousseau
10	Economics	2	0	0	0	0	0	2	6	DPL Rousseau
11	Case study	0	0	4	0	0	0	4	4	S Toet
12	Fieldtrip 1	0	0	0	0	8	0	8	8	J.J.A. van Bruggen
13	Assignment	1	10	0	0	0	0	1	13	J.J.A. van Bruggen
14	Presentations	0	0	4	0	0	0	4	4	J.J.A. van Bruggen
15	Exam	0	3	0	0	0	0	0	3	
	Total	36	16	8	0	8	0	52	140	

Education Material

Lecture notes	Lecture notes and case studies

Scientific Software

M3025

Conveyance and Irrigation Structures

Term	201617T07
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 Understand the factors that influence the functioning of a surface drainage system and design a surface drainage system;

5 Select the appropriate type of structure for irrigation and drainage networks, to establish the boundary conditions and to prepare a preliminary hydraulic design;

6 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.

7 Understand the sediment tarnsport mechanism and how to control sediment transport in canal systems

Assessments

%	Type	Name
15	Assignment	Flow Control Structures
35	Assignment	Irrigation Structures
15	Assignment	Sediment Transport in Irrigation Canals
35	Written examination (open book)	Unsteady Flow

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 structures

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 canal systems

- 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	10	0	0	0	0	10	40	F.X. Suryadi
2	Irrigation structures	12	12	0	0	0	0	12	48	L.G. Hayde
3	Flow control structures	8	8	0	0	0	0	8	32	F.X. Suryadi
4	Sediment transport in canal systems	6	4	0	0	0	0	6	22	N Mendez Vasquez
	Total	36	34	0	0	0	0	36	142	

Education Material

Scientific Software

Duflow

M2831

Environmental Aspects of Coasts and Ports

Term	201617T07
Coordinator	M. van der Wegen
Credit points	5.000000000
Specialization	Coastal Engineering and Port Development

Target Group

Coastal engineers interested in environmental aspects in coasts and ports

Prerequisites

Basic knowledge of waves, hydraulics, coastal morphology, breakwaters, marine structures and port planning and lay out

Learning Objectives

1 Understand and be able to quantify the interactions between the environment and hydraulic engineering projects on coasts and in harbours, get acquainted with sustainable development and management of coasts and ports an the relevant technical, legal and

2 Familiarise with the different coastal protection schemes and the governing factors for their selection and impacts. Understand the different methods for the management of the coastline and how to apply them in practice.

3 Be able to apply the engineering principles in solving a combined coastal/port problem.

4 Have a better insight in the natural characteristics and physical processes of coastal ecosystems.

5 Assess possible impacts of human activities and climate change on coastal systems and think of innovative alternatives for coastal engineering and management, for example via "building with nature".

Assessments

%	Type	Name
40	Assignment	Coast and Port Project
15	Written examination (closed book)	Coastal Ecosystems and Management
15	Written examination (closed book)	Coastline Management
15	Written examination (closed book)	Environmental Issues in Port dvelopment and Port operation
15	Written examination (closed book)	Salt Intrusion, Density Currents and siltation

Topics

1 Coastal Ecosystems and Management

2 Environmental Issues in Port development and Port operation

3 Coastline Management

4 Coast and Port project

Topics

5 Salt Intrusion, Density Currents and siltation

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Coastal Ecosystems and Management	6	0	0	0	0	0	6	18	F van der Meulen
2	Environmental Issues in Port development and Port operation	8	0	0	0	0	0	8	24	T Vellinga
3	Coastline Management	6	0	0	0	0	0	6	18	R.W.M.R.J.B. Ranasinghe
4	Coast and Port project	6	32	12	0	0	0	18	62	A. Dastgheib, J.A. Roelvink
5	Salt Intrusion, Density Currents and siltation	6	0	0	0	0	0	6	18	M. van der Wegen
	Total	32	32	12	0	0	0	44	140	

Education Material

Lecture notes	Van Os, Density currents and salt intrusion, LN0286.98.1
Handout	Van der Meulen, Frank, Coastal Ecosystems and Management An Introduction. LN0355.12.1. Handouts to be provided during the course.

Scientific Software

Matlab

Xbeach

M3081

Environmental Engineering

Term	201617T07
Coordinator	E.R. Raj
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target groups (MSc and short course participants) having background in Environmental Sciences, Chemical or Civil Engineering

Prerequisites

Basic knowledge in mathematics, including calculus, linear algebra and differential equations - Strong fundamentals in chemistry and biology - Fundamental understanding of different physical, chemical and biological processes of environmental significance - Confidence to solve problems involving chemical kinetics and design of bioprocesses - Ability to work in a group and contribute to specific assignments

Learning Objectives

1 Describe different biological processes and their engineering applications for wastewater treatment;

2 Categorize different air pollutants and distinguish the different physico-chemical and biological air pollution control techniques for particulate and gaseous contaminants;

3 Apply basic thermodynamic principles to determine reaction rates of environmental processes under a given set o operating conditions

4 Describe the different water treatment methods and with the help of simple examples, evaluate the performance o water treatment plants;

5 Solve problems pertaining to the design and operation of different environmental systems

Assessments

%	Type	Name
25	Written examination (closed book)	Environmental process technology
50	Written examination (closed book)	Wastewater treatment and air pollution control
25	Assignment	Water treatment

Topics

1 Water treatment

Water is playing an essential role in relation with the environment and in this module it is shown, how man can actively intervene in its pollution. Man is using several simple and advanced techniques to produce reliable drinking water from groundwater and surface water. The participant will be able to learn the following aspects: (i) Water treatment methods, and (ii) water treatment processes and plants.

2 Wastewater treatment

To limit environmental pollution, wastewater has to be treated. An overview of basic processes available for the treatment of domestic and industrial wastewater, with special emphasis on natural processes and systems that can be applied, is taught under the topic wastewater treatment. The following topics will be covered; (i) Anaerobic reactors, (ii) Waste stabilization ponds, (iii) Activated sludge process, (iv) UASB reactor, (v) Photo-bioreactors, and (vi) Design and problem solving tutorials.

3 Environmental process technology

For a better understanding of water and wastewater treatment the principles of mass balances, reaction kinetics and reactor design are discussed in environmental process technology (EPT). During this lecture, the following topics will be covered; (i) Mass balance analysis, (ii) Ideal batch reactors, (iii) Plug flow reactor, (iv) Stirred tank reactor, (v) Tracer responses in reactors, (vi) Continuous flow reactors with recycle, (vii) Thermodynamics of environmental processes, and (viii) Problem solving tutorials.

4 Air pollution control

Air pollution and atmospheric air quality in developing countries has been a topic of major concern due to rapid industrialization. The nature of damages caused to human health and the environment due to air pollutants is worsening every year. Therefore, it is important to develop effective technologies for the management and control of air pollution. The following topics will be covered; (i) Classification of air pollutants, (ii) Air pollution control systems: particulate control & gaseous contaminants, and (iii) Biological odour control systems.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water treatment	3	0	0	16	0	0	19	41	JP Buiteman
2	Wastewater treatment	9	0	0	15	8	0	32	65	E.R. Raj, J.J.A. van Brugger J.L.C.M. van de Vossenberg
3	Environmental process technology	8	0	0	0	0	0	8	24	N.P. van der Steen
4	Air pollution control	3	1	0	0	0	0	3	10	E.R. Raj
	Total	23	1	0	31	8	0	62	140	

Education Material

Lecture notes	Lecture notes Wastewater Treatment + Tutorials
Lecture notes	Lecture notes on Air Pollution Control and powerpoint presentations
Lecture notes	Lecture notes on EPT, Problem solving in class
Lecture notes	Lecture notes on Water Treatment and assignments topics
Book	Text book on "Air Pollution Prevention and Control: Bioreactors and Bioenergy" by Christian Kennes and Maria C. Veiga (Wiley).
Book	Text book titled "Chemical Reaction Engineering" by O. Levenspiel
Book	Text book titled "Wastewater Engineering: Treatment and Reuse" by George Tchobanoglous, Franklin L. Burton and H. David Stensel (Metcalf and Eddy)

Scientific Software

M3041

Environmental Management and Water Services

Term	201617T07
Coordinator	A. Cabrera Flamini
Credit points	5.000000000
Specialization	

Target Group

Mid-career professionals dealing with or interested in planning and management aspects of water supply and sanitation systems, especially under consideration of growing environmental pressures, e.g. working for municipalities, governments, water/wastewater agencies, or consulting groups and NGO's operating in that space.

Prerequisites

Preferably experience in the water sector. A bachelor's degree or equivalent. Good command of English language.

Learning Objectives

1 Discuss the components that make up the urban water cycle and urban water systems

2 Explain and employ the basic technical/ecological and institutional principles of integrated urban water management

3 Discuss the potential impacts of climate change and anthropogenic impacts on the urban water cycle

4 Discuss and use different risk assessment/management frameworks applied to urban water systems

5 Discuss potential strategies to improve the sustainability of water services, both in terms of water quantity and quality management

Assessments

%	Type	Name
50	Assignment	
50	Oral examination	

Topics

1 Integrated Urban Water Management

2 Risk Management and Water Safety Planning

Introduction to Water Safety Plans/ Sanitation Safety Plans, Water Cycle Safety Planning, Source protection

3 Urban Water Security and Resilience

Alternative water supply systems, Water-Energy nexus,

8 Fieldvisit 1

Visit to Dutch water utilities: Integrated Urban Water Management, Green Utilities, Water Cycle Management

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Integrated Urban Water Management	8	0	4	0	0	0	12	28	F. Bichai
2	Risk Management and Water Safety Planning	10	10	12	0	0	0	22	52	F. Bichai
3	Urban Water Security and Resilience	16	0	2	0	0	0	18	50	
8	Fieldvisit 1	0	0	0	0	8	0	8	8	F. Bichai
	Total	34	10	18	0	8	0	60	138	

Education Material

Scientific Software

M2227

Groundwater Data Collection and Interpretation

Term	201617T07
Coordinator	T.Y. Stigter
Credit points	5.000000000
Specialization	Core Program

Target Group

MSc students in Hydrology and Water Resources, short course participants involved in groundwater and environmental impacts investigation and monitoring activities.

Prerequisites

Approved BSc degree and 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
30	Assignment	Groundwater Monitoring
15	Assignment	Groundwater Surveys
25	Written examination (closed book)	Groundwater Surveys
15	Assignment	Hydrogeostatistics
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

M1554

Hydrological Data Collection and Processing

Term	201617T07
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

M2541

Nanotechnology for Water and Wastewater Treatment

Term	201617T07
Coordinator	P.N.L. Lens
Credit points	0.000000000
Specialization	

Target Group

Young and mid-career professionals with a relevant wo bachelor (academic bachelor)

Prerequisites

BSc degree or equivalent qualification in a relevant field from a recognised university Several years of relevant working experience

Learning Objectives

1 Apply innovative applications of nanotechnology in drinking water production and wastewater treatment.

2 Be familiar with the state-of-the-art, impact and cost-benefit analysis of nanotechnology processes for water and wastewater treatment.

3 Communicate successfully on nanoscience and nanotechnology interfacing with environmental chemistry, environmental engineering and bioprocess.

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

M2665

River Basin Modelling

Term	201617T07
Coordinator	A. Jonoski
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants in WSE programmme - hydroinformatics; Participants in Erasmus Mundus Flood Risk Management Programme; Participants in short course "River Basin Modelling"

Prerequisites

Hydrology and Hydraulics

Learning Objectives

1 Understand and explain the multi-purpose nature of river basins and approaches for their integrated planning and management.
2 Understand and model flow processes in porous media
3 Use MODFLOW to simulate groundwater flow in the saturated zone
4 Understand and model hydrological processes in catchments
5 Use NAM to simulate rainfall runoff in a natural catchment
6 Know how to use MIKE-SHE to model both surface and groundwater flow in a natural catchment, including the unsaturated zone

Assessments

%	Type	Name
100	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; catchment yield; land use and agriculture; storage; groundwater; flood mitigation; irrigation; power generation; navigation; demand forecasting; dealing with droughts. Exercises and workshops with RIBASIM.

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 software package to solve a water resources analysis problems: problem definition, model building.

Topics

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, WNM van der 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

M1171

River Structures

Term	201617T07
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
- Joint MSc programme in Water Science and Engineering with specialisation in Hydraulic Engineering and River Basin Development with University of Kuala Lumpur, Malaysia

Prerequisites

Working knowledge in Applied Hydraulics, Sediment Transport and River Dynamics

Learning Objectives

1 1) to analyze the interaction between flow and hydraulic structures in natural open channels

2 2) to create preliminary hydraulic design of selected river structures

3 3) to determine the consequences of different design solutions on the natural river behavior

Assessments

%	Type	Name
100	Written examination (closed book)	River Structures

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 **Hydraulic structures auxiliary to engineering works**

Spillways; Bottom outlets; Energy dissipaters: principles of design and operation

4 **Vajont dam case study**

Study of the disaster of the Vajont dam.

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	8	0	0	0	0	4	12	36	A. Cattapan
2	Hydraulic structures in low land river training and flood protection	22	0	0	0	0	4	26	78	Mazzoleni, A. Cattapan, M. Maglionico
3	Hydraulic structures auxiliary to engineering works	4	0	8	0	0	0	12	20	A. Cattapan, L. Brandimarte
4	Vajont dam case study	0	0	6	0	0	0	6	6	L. Brandimarte
	Total	34	0	14	0	0	8	56	140	

Education Material

Handout	Handouts and references provided by Lecturers

Scientific Software

M2373

Wastewater Treatment Plants Design and Engineering

Term	201617T07
Coordinator	C.M. Lopez Vazquez
Credit points	5.000000000
Specialization	

Target Group

MSc participants enrolled in the Urban Water and Sanitation program from the Sanitary Engineering Specialization (UWS-SE). Wastewater professionals with background and/or proven qualifications in sanitary engineering.

Prerequisites

Preceding modules of the UWS-SE program and/or, in the case of short-course participants, required background on sanitary and wastewater engineering (see target group) in full compliance with UNESCO-IHE admission regulations.

Learning Objectives

1. Select the most suitable and cost-effective wastewater treatment process technology to treat certain wastewater stream given its composition and characteristics and taking into account the required effluent standards.
2. Carry out a preliminary design of a wastewater treatment system (based on the most widely applied anaerobic, aerobic, land-based and on-site systems) including the engineering process lay-out, hydraulic profile and process flow-diagram (PFD).
3. Identify and estimate the construction, operational and maintenance costs of a wastewater treatment plant and the investments required to secure its satisfactory operation throughout the expected life-span of the system.
4. Describe the main elements and components involved in the project planning, project management, and project administration for the design, engineering, construction, start-up and operation of a wastewater treatment plant.

Assessments

%	Type	Name
25	Assignment	
25	Oral examination	Based on the development of a design project.
50	Written examination (closed book)	

Topics

1 **Technology Selection**

Review of the most commonly applied wastewater treatment process technologies (among anaerobic, aerobic, land-based and on-site systems). Criteria selection guidelines for the determination of a suitable wastewater treatment process technology to treat a wastewater stream to the required degree to meet the required effluent standards taking into account local conditions and resources availability. Technology selection software tools.

2 **Engineering Economics**

Fundamentals and principles of economics (such as cash-flow, interest factors, return of investment and benefit-cost analyses, among others). Evaluation, comparison and selection of cost-effective wastewater treatment system alternatives.

3 **Costing**

Fundamentals and principles of costing. Identification and estimation of direct and indirect costs involved in the design, construction, operation and maintenance of wastewater treatment systems. (Project) budgeting.

4 **Engineering process layouts and process flow diagrams**

Design and calculation of engineering process layouts and process flow diagrams for the design and operation of wastewater treatment plants (for conventional anaerobic, aerobic, land-based and on-site systems). A detailed design exercise will be carried out on a selected wastewater treatment processes lay-out.

5 **Hydraulic design**

Calculation and design of hydraulic profiles (based on the behaviour and performance of hydraulic structures and elements) for the design and operation of wastewater treatment plants.

6 **Design and Engineering of Conventional Activated Sludge (CAS) Systems**

Preliminary design, including influent characteristics, sizing and dimensioning of a conventional activated sludge and conventional anaerobic wastewater treatment plant. Design and selection of equipment for monitoring, operation and control. Review of case-studies including planning, project management, and project administration of the construction and operation.

7 **Design and Engineering of Conventional UASB systems**

Preliminary design, including influent characteristics, sizing and dimensioning of a conventional activated sludge and conventional anaerobic wastewater treatment plant. Design and selection of equipment for monitoring, operation and control. Review of case-studies including planning, project management, and project administration of the construction and operation.

8 **Design and Engineering of land-based wastewater treatment systems**

Preliminary design, including influent characteristics, sizing and dimensioning of a land-based wastewater treatment plant (e.g. pond systems,constructed wetlands) and on-site sanitation systems. Design and selection of equipment for monitoring and operation. Review of case-studies including planning, project management, and project administration of the construction and operation.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Technology Selection	4	0	2	0	0	0	6	14	C.M. Hooijmans
2	Engineering Economics	4	0	2	0	0	0	6	14	
3	Costing	4	0	2	0	0	0	6	14	
4	Engineering process layouts and process flow diagrams	4	0	2	0	0	2	8	20	D. Brdanovic
5	Hydraulic design	4	0	2	0	0	2	8	20	C.M. Lopez Vazquez
6	Design and Engineering of Conventional Activated Sludge (CAS) Systems	4	0	2	0	0	2	8	20	
7	Design and Engineering of Conventional UASB systems	4	0	2	0	0	2	8	20	J.B. van Lier
8	Design and Engineering of land-based wastewater treatment systems	4	0	2	0	0	2	8	20	
	Total	32	0	16	0	0	10	58	142	

Education Material

Scientific Software

M3070

Water Conflict Management II

Term	201617T07
Coordinator	Z.S. Shubber
Credit points	5.000000000
Specialization	Core Program

Target Group

Current and future water managers, decision-makers and others involved in water management wanting to broaden their scope in water management. Professionals involved in dispute resolution wanting to broaden the scope of their activities to include water.

Students need to have a first degree in a relevant subject (economics, social sciences, law, engineering, biology etc.) and preferably several years of relevant working experience.

Prerequisites

Knowledge and appreciation of the principles of integrated water resources management, the water resources system and water governance.

Learning Objectives

1 Explain, discuss and analyse the basic concepts of conflict management and conflicts related to water.

2 Critically analyse cases of water sharing and use among different actors at different levels and from different sectors, from a conflict and cooperation perspective.

3 Identify, explain and analyse the elements of a negotiation process applied to the management of a water conflict, and prepare, organise and engage in them as a negotiator.

4 Prepare, organise and engage in different types of conflict resolution processes related to water conflicts.

Assessments

%	Type	Name
0,4	Assignment	Essay
0,6	Written examination (closed book)	Written

Topics

1 Theoretical background

The module will start with a summary of the previous module. It will then introduce new concepts and theories not covered in the previous module.

2 Case studies

Case studies of disputes around water, at different levels and between different sectors, are presented and discussed. They illustrate concepts set out in the theoretical background.

3 Climate change negotiations

This section will discuss the law of treaties, the rules of procedures of international treaty negotiations, and the actual negotiation process as it unfolded in the climate change negotiations. It will discuss both practical issues related to negotiations within a UN framework as well as the more abstract and enduring challenges of negotiations involving 192 countries.

4 International negotiations

This four day lecture on international negotiation processes confronts the theory and practice of bargaining. It helps participants to get a better understanding of how to handle processes and procedures, people and parties and positions and products, while not forgetting about perception and power and other important factors in negotiations. Cultural aspects and personal behaviour in negotiations are also covered. Bilateral and multilateral negotiations are practiced, also around a water dispute, and there is also a debrief of multilateral negotiations.

5 Role play

The purpose of the role play is to make participants aware of the various aspects (technical, managerial, political) relating to the management of transboundary waters; the complexity of applying integrated and participatory approaches in decision making; and the complexity of technical and human aspects of negotiations, consensus building, stakeholder participation and dialogue processes relating to water resources management.

6 Essay

The students will be required to write an essay on a topic related to water conflict management based on relevant scientific literature. They will have to submit it after the end of the module. For the students who followed WCM I, the essay will be based on their work for the annotated bibliography.

7 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Theoretical background	4	0	2	0	0	0	6	14	Z.S. Shubber
2	Case studies	0	0	6	0	0	0	6	6	
3	Climate change negotiations	2	0	2	0	0	0	4	8	J. Gupta
4	International negotiations	6	0	16	0	0	0	22	34	
5	Role play	0	0	12	0	0	0	12	12	
6	Essay	0	20	0	0	0	0	0	20	Z.S. Shubber
7	Exam	0	3	0	0	0	0	0	3	Z.S. Shubber
	Total	12	23	38	0	0	0	50	97	

Education Material

Handout	Workbook of International Negotiations, The Clingendael Institute.

Scientific Software

M2054

Water Systems Modelling

Term	201617T07
Coordinator	S. Graas
Credit points	5.000000000
Specialization	

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	
60	Written examination (closed book)	Written Exam

Topics

1 Water system modelling - Concepts

Introduction to water system modelling concepts, including procedure in the modelling protocol, different types of models (prescriptive vs descriptive, stochastic vs conceptual, lumped vs distributed), calibration and validation procedures, performance indicators and available software packages.

1.1 Why model

1.2 Modelling process

1.3 Calibration and Uncertainty analysis

1.4 Types of models

1.5 Software Packages for Water Systems Modelling

Topics

1.6 Explanation assignment and Q&A session

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

Several guest lecturers will come and share their experience with respect to modelling water systems.

5.1 Land use modelling & optimisation

5.2 New data sources for modelling

5.3 Systems Dynamic Modelling

6 Exam

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	Why model	2	0	0	0	0	0	2	6	S. Graas
1.2	Modelling process	4	0	0	0	0	0	4	12	S. Graas
1.3	Calibration and Uncertainty analysis	2	0	0	0	0	0	2	6	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
1.6	Explanation assignment and Q&A session	0	2	0	0	0	0	0	2	I. Masih, I.I. Popescu, S. Graas
2	River Basin Simulations - Practice	0	0	0	0	0	0	0	0	
2.1	HBV (rainfall-runoff)	0	0	0	12	0	0	12	24	I. Masih
2.2	Waflex (water allocation)	0	0	0	12	0	0	12	24	S. Graas
2.3	Mike 11 (flood)	0	0	0	12	0	0	12	24	I.I. Popescu
3	Analysis of model results	4	0	0	0	0	0	4	12	S. Graas
4	Paper discussion	4	0	0	0	0	0	4	12	I. Masih, S. Graas
5	Case studies	0	0	0	0	0	0	0	0	
5.1	Land use modelling & optimisation	0	0	4	0	0	0	4	4	Y. Jiang
5.2	New data sources for modelling	0	0	4	0	0	0	4	4	J.L. Alfonso Segura
5.3	Systems Dynamic Modelling	0	0	4	0	0	0	4	4	J. Susnik
6	Exam	0	3	0	0	0	0	0	3	
	Total	20	5	12	36	0	0	68	149	

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

M2553

Water Transport and Distribution

Term	201617T07
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 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;

2 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

3 analyse the implications of various operational modes of pumping stations and compare the investment and operational costs for various network layouts and supplying schemes;

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 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

Assessments

%	Type	Name
40	Assignment	Design exercise assignment Water Distribution, using EPANET network modelling software. Individual report should be submitted.
60	Written examination (open book)	The exam includes the part on Chapters 2 to 4 of the introductory subject and the other one on the leakage management and control.

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.

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	9	0	0	12	44	114	N. Trifunovic, P.D.A. Pathirana
2	Water Loss Management and Control	8	0	2	0	0	0	10	26	S.K. Sharma
	Total	31	0	11	0	0	12	54	140	

Education Material

Lecture notes	S.Sharma - Water Losses in Distribution Systems, lecture notes UNESCO-IHE 2010 (LN/ 0346/10/1)

Scientific Software

Epanet

M3082

Water and Environmental Policy Analysis

Term	201617T07
Coordinator	W.J.A.M. Douven
Credit points	5.000000000
Specialization	

Target Group

This module is intended for professionals with an interest in analysis and improvement of environmental policy in water management and/or a related context.

Prerequisites

Basic understanding of policy and planning concepts.

Learning Objectives

1 Structure complex policy problems.

2 Apply meaningfully and coherently three types of methods for rational-analytical problem exploration: System analysis (including analysis of objectives and initial problem demarcation), Actor analysis, and Future Scenarios.

3 Reflect on the possible roles of a policy analyst and discuss which role(s) a policy analyst can effectively fulfil in different situations to support individuals or organisations facing a complex policy problem.

4 Set up an agenda, based on previous problem exploration, for relevant, subsequent research activities to inform policy decisions.

5 Write an issue paper containing the results of a broad, exploratory problem analysis, including the proposal for meaningful, subsequent policy research.

Assessments

%	Type	Name
50	Assignment	Policy analysis report
50	Written examination (closed book)	Theory exam

Topics

1 Introduction: policy analysis, systems analysis

Understand the difference between policy analysis and policy making.

Learn and apply tools for problem formulation and problem demarcation: system diagram, analysis of objectives, means-ends and causal analysis

Topics

2 Actor and network analysis

Using actor and network analysis to enrich the systems analysis and reflect on the multi-actor setting of complex policy problems.

3 Future exploration and scenario development

Using scenario development tools to develop and compare possible future contexts of policy problems. Assess the consequences for formulating the problem and possible alternatives to solve it.

4 Synthesis and knowledge gaps, and issue paper

Combining the insights from the previous analytical steps to develop a rich definition of the problem. Based on this, identify knowledge gaps and specify a relevant research agenda for policy research follow-up.

The insights gained from the various analytical steps including the synthesis need to be reported in the form of an issue paper directed to a specific problem owner.

5 Policy analysis in practice

The practice of policy analysis for developing policies is much more complex than the practice of policy analysis for research. An experienced policy maker will discuss his experiences with the group.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction: policy analysis, systems analysis	4	12	0	0	0	0	4	24	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
2	Actor and network analysis	4	20	0	0	0	0	4	32	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
3	Future exploration and scenario development	8	20	0	0	0	0	8	44	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
4	Synthesis and knowledge gaps, and issue paper	4	16	0	0	0	0	4	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
5	Policy analysis in practice	4	0	0	0	0	0	4	12	A. Mendoza - Sammet, J Leentvaar, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
	Total	24	68	0	0	0	0	24	140	

Education Material

Book	Bert Enserink, Leon Hermans, Jan Kwakkel, Wil Thissen, Joop Koppenjan, Pieter Bots (2010) Policy Analysis of Multi-Actor Systems. Publisher: Lemma/Boom, The Hague. ISBN 978-90-5931-538-9. On-line videos.
Digital files	Copies of Lecturer's presentations
Lecture notes	Course and assignment guide

Scientific Software

M2335

Advanced Water Treatment and Re-use

Term	201617T08
Coordinator	S.G. Salinas Rodríguez
Credit points	5.000000000
Specialization	

Target Group

Students of the Urban Water and Sanitation master programme with specialization in Water Supply engineering. Professionals in water treatment, consulting agencies, ministries and equipment suppliers.

Prerequisites

Participants should meet the general UNESCO-IHE admission criteria, and possess a BSc degree in chemical, environmental, or civil engineering.

Learning Objectives

1 DESALINATION TECHNOLOGIES - identify technologies for desalination - explain and compare membrane-based and thermal-based desalination - tell current capacity of desalination in the world

2 SOFTENING AND ION EXCHANGE - explain the basic principles of chemical softening and ion exchange.

3 ADVANCED OXIDATION PROCESSES - explain and identify advantages of various AOPs - design AOPs for removal of contaminants

4 WATER REUSE - assess potential applications of water reuse systems - define water reuse and describe various case studies

5 LOW PRESSURE MEBRANES (UF and MF)

6 REVERSE OSMOSIS

Assessments

%	Type	Name
20	Assignment	Computer aided RO design
10	Lab. Report	
70	Written examination (closed book)	

Topics

1 Introduction to Desalination and Mem. Tech.

2 Microfiltration and Ultrafiltration

basic principles of membrane filtration, micro and ultrafiltration elements and systems, fouling and cleaning, membrane disinfection, exercises

Topics

3 Reverse Osmosis

fundamentals of desalination, reverse osmosis elements and systems, particulate and inorganic fouling, organic fouling and bioufouling, scaling, pre- and post-treatment; process design of RO systems

4 Ion Exchange and Softening

Basic principles of ion exchange and softening

5 Advanced oxidation processes

fundamentals of AOPs including ozone, H2O2, UV and combinations; applications

6 Introduction to Water Reuse

Fundamentals of water reuse, applications and case studies for potable reuse, industrial reuse and aquifer recharge

7 Interactive field trip Mem. Tech.

8 Ion Exchange

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to Desalination and Mem. Tech.	2	0	0	0	0	0	2	6	M.D. Kennedy
2	Microfiltration and Ultrafiltration	12	0	2	2	0	0	16	42	M.D. Kennedy, S.G. Salinas Rodríguez
3	Reverse Osmosis	12	0	2	0	0	4	18	50	M.D. Kennedy
4	Ion Exchange and Softening	2	0	1	0	0	0	3	7	JP Buiteman, S.G. Salinas Rodríguez
5	Advanced oxidation processes	4	0	0	0	0	0	4	12	
6	Introduction to Water Reuse	2	0	2	0	0	0	4	8	S.G. Salinas Rodríguez, S.K Sharma
7	Interactive field trip Mem. Tech.	0	0	0	0	6	0	6	6	M.D. Kennedy, S.G. Salinas Rodríguez
8	Ion Exchange	2	0	0	1	0	0	3	8	JP Buiteman, S.G. Salinas Rodríguez
	Total	36	0	7	3	6	4	56	139	

Education Material

Scientific Software

M3009

Dams and Hydropower

Term	201617T08
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.

1.3 Gravity dams

Gravity dam types and layouts. Structural features. Mass concrete and roller compacted concrete for dams. Design considerations.

Topics

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

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
	Total	39	0	0	16	0	0	55	149	

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

M2658

Environmental Monitoring and Modelling

Term	201617T08
Coordinator	K.A. Irvine
Credit points	5.000000000
Specialization	

Target Group

Young and mid-career professionals (scientists, consultants, decision makers) with a background in Water management or Environmental science

Prerequisites

Preferably a bachelor's degree in Chemistry, Biology, Environmental science, Hydrology, or related/equivalent. Basic knowledge in computer operations (MS Windows; Office). Good command of English

Learning Objectives

1 Describe and apply main monitoring requirements and programmes for surface water, groundwater and air, and some common analytical techniques used therein.

2 Describe and apply the different criteria for successful monitoring of lakes and rivers.

3 Describe and apply basic Environmental Impact Assessment techniques.

4 Describe and apply a number of water quality models as a tool in Environmental management.

Assessments

%	Type	Name
15	Assignment	Written individual assignment on Water Quality Modelling
70	Written examination (closed book)	Topics: water quality monitoring; water quality modelling; groundwater qu
15	Lab. Report	Written individual report on field/labwork

Topics

1 Water quality monitoring

Introduction on Environmental monitoring. Water quality parameters. Natural water quality and pollution parameters. The monitoring cycle. Items of the monitoring programme: why, what, where, how, how often. Fieldwork and sampling. Physico-chemical and biological water quality assessment. Monitoring in the EU Water Framework Directive. Practical field&lab work: sampling, preservation, field analyses; Quality control in the laboratory.

1.1 Introduction on Environmental monitoring

1.2 Water quality monitoring

Topics

2 Groundwater monitoring and modelling

Basics of hydrogeology. Pollutants reactions and transport in groundwater. Design of a groundwater monitoring network; surveys; design and installation; locations; monitoring frequency; optimization.

3 Air quality monitoring and modelling

Impacts of main air quality pollutants. Emission and dispersion under different meteorological conditions. Air quality monitoring: background; networks (EMEP, GEMS, etc.); automated instrumentation. Examples of air quality modesl: CAR, LOTOS, etc. Case studies and exercises: Emission data base; setting up a monitoring network; hands-on computer exercises with air quality models.

4 Water quality modelling

Introduction to Modelling: types of models and model components. BOD-DO model in a river. Spatial-Dynamic Modelling of Nitrate in the Scheldt Catchment, using a GIS based nutrient model. Modelling point and non-point sources. In-class exercise.

5 Environmental Impact assessment

Objectives of EIA; participants and approaches. Screening tables. Scoping and mitigation. Identification of impacts; Impact matrix: scaling and weighing. Factors of success; cost of EIA. Practical examples such as Impacts of dams and reservoirs. Hands-on exercises EIA.

6 Laboratory Environmental monitoring

Introduction to the different techniques and instruments. Analysis of heavy metals with AAS: sample destruction, use of conventional and graphite oven AAS. Analysis of organic micropollutants with GC; standards; detectors. Quality Control in AAS and GC.

7 Fieldtrip

Liable to change: Visits are planned to water quality monitoring/modelling as well as to air quality monitoring Institutions.

8 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water quality monitoring	0	0	0	0	0	0	0	0	
1.1	Introduction on Environmental monitoring	0	0	2	0	0	0	2	2	M.E. McClain
1.2	Water quality monitoring	7	0	0	8	0	0	15	37	G.F. Kruis
2	Groundwater monitoring and modelling	8	0	2	0	0	0	10	26	J.W.A. Foppen
3	Air quality monitoring and modelling	6	0	6	0	0	0	12	24	
4	Water quality modelling	0	0	2	8	0	0	10	18	J. van der Kwast
5	Environmental Impact assessment	0	0	0	8	0	0	8	16	A. Mendoza - Sammet
6	Laboratory Environmental monitoring	0	0	8	0	0	0	8	8	G.F. Kruis
7	Fieldtrip	0	0	0	0	6	0	6	6	
8	Exam	0	3	0	0	0	0	0	3	
	Total	21	3	20	24	6	0	71	140	

Education Material

Handout	G.F. Kruis and P. Kelderman (2011) - Handout Fieldwork water quality monitoring and Laboratory QA/QC. Febr. 2011.
Handout	J. van der Kwast - Handout Introduction to Modelling/Nitrate modelling in the Scheldt basin - Febr. 2013.
Handout	M.P. Keuken/J.S. Henzing (2014). Handout Air quality monitoring and modelling. U
Lecture notes	P. Kelderman (2011) - Water quality and monitoring. UIHE lecture notes LN5/11/1.

Scientific Software

M3021

Environmental Planning and Implementation

Term	201617T08
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 environmental management, water management and / or watershed management.

Prerequisites

Affinity with environment policy and enforcement, development economics, and preferably experience in water management arena. Good command of English.

Learning Objectives

1 Understand (partly) the complexities of the individual within the complex policy system
2 Develop (adaptive) strategies for network (stakeholder) and process management of water and environmental policy planning and implementation
3 Explain and critically reflect on the role of policy implementers (people) in the policy process
4 Reflect and further develop personal skills for policy planning and implementation
5 Apply and critically assess tools/approaches/strategies for (participatory) policy planning and implementation
6 Understand and apply economic valuation methods for environmental policy planning

Assessments

%	Type	Name
25	Group assignment	Environmental Economics
50	Written examination (closed book)	Environmental Planning and Implementation
25	Group assignment	Policy Plan Analysis

Topics

1 Environmental planning and implementation

Introduction to the module, theories on policy (process) analysis, case studies and experiences on Environmental planning and implementation

1.1 Introduction to EPI

Introducing the module, learning objectives, learning activities, and assessment.

1.2 Environmental Planning

Introducing key concepts of environmental planning

Topics

1.3 Policy Implementation

Introducing concepts of Contextual Interaction Theory, Street-level buraucracy, policy theory analysis

1.4 Assignment Policy plan analysis

In the assignment student groups will analyze a policy plan of action using the Policy Theory concept of Hoogerwerff.

2 Personal skills and experiences in planning and implementation

Team roles in policy planning and implementation, Emotional Intelligence, roundtable discussion with professionals in planning and implementation, field trip

2.1 Personal Experiences in Water and Environmental policy implemetation

Guests are invited from to discuss with the participants their experiences and personal lessons learned from many years of being involved in environmental policy planning and implementation

2.2 Roundtable discussion

A politician, civil servant, and NGO director will discuss with the participants their role around dealing with a specific environmental issue.

2.3 Personal skills in planning and implementation

We organize 2 workshops to develop personal skills: Teamroles; and Emotional Intelligence

3 Environmental Economics

Economic valuation methods, and economic tools for the management of natural (water) resources.

4 Decision support tools for EPI

What is the role of DSS/planning tools in Environmental Planning

4.1 MOTA analysis

In this session we use the MOTA framework to assess the implementation feasibilty of proposed measures in de River Basin Game.

4.2 Tools for planning

In this lecture we discuss the variety of tools which are used in planning processes, its role, and what tools do.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Environmental planning and implementation	0	0	0	0	0	0	0	0	
1.1	Introduction to EPI	2	0	0	0	0	0	2	6	J.G. Evers
1.2	Environmental Planning	4	0	0	0	0	0	4	12	J.G. Evers, W.J.A.M. Douve
1.3	Policy Implementation	4	0	0	0	0	0	4	12	J.G. Evers
1.4	Assignment Policy plan analysis	0	32	0	0	0	0	0	32	J.G. Evers, W.A.H. Thissen
2	Personal skills and experiences in planning and implementation	0	0	0	0	0	0	0	0	
2.1	Personal Experiences in Water and Environmental policy implemetation	0	0	4	0	0	0	4	4	J.G. Evers
2.2	Roundtable discussion	0	0	2	0	0	0	2	2	J.G. Evers
2.3	Personal skills in planning and implementation	0	0	12	0	0	0	12	12	J.G. Evers
3	Environmental Economics	14	8	0	0	0	0	14	50	Y. Jiang
4	Decision support tools for EPI	0	0	0	0	0	0	0	0	
4.1	MOTA analysis	0	0	4	0	0	0	4	4	J.G. Evers
4.2	Tools for planning	2	0	0	0	0	0	2	6	J.G. Evers, S. Hasan
	Total	26	40	22	0	0	0	48	140	

Education Material

Handout	Additional Reading Materials
Lecture notes	Lecture Notes

Scientific Software

M3044

Finance in the Water Sector

Term 201617T08
Coordinator M. Tutusaus Luque
Credit points 5.000000000
Specialization

Target Group

Young and mid-career professionals, (future) managers, and other operational functions in water utilities, NGOs or governmental organizations interested in the implication of financial reforms in the water sector to their operational work.

Prerequisites

Preferably a relevant water science, economics or finance related bachelor degree; Some experience in the water sector; Good command of the English language. Preferably having (successfully) completed Managing Water Organizations (WSM05)

Learning Objectives

1 Recognize the need for commercial accounting and identify the components of standard financial statements in water organisations.
2 Analyze the financial position of a water organisation through an analysis of financial statements
3 Recognize the implications of managerial decisions on the financial situation of the service provider
4 Place financial discussions in the greater context of water and sanitation provision services
5 Discuss ethical issues related to financial decisions in the water sector

Assessments

%	Type	Name
10	Assignment	- Financial analysis report: the participant is requested to determine the financial situation of the company based on their financial statements and provide advice for a specific financial decisions/investment.
15	Assignment	Group assignments: the participants are requested to develop a project analysis for the implementation of a specific infrastructural development project.
25	Assignment	Individual essay: the participant is requested to elaborate in written form about a relevant and current dilemma related to water and finance.
50	Written examination (open book)	

Topics

1 Introduction to Finance and financial tools: Corporate Finance

Tools: financial analysis and performance indicators

Link to concepts: performance, cost recovery, efficiency, commercialization

Linking finance – operations: Impacts of global debates on daily operations:

2 Finance in the water sector: (Project Finance/Corporate Finance)

From State support to Innovative finance constructions:

Financialization of water/resources

Hybrid financial constructions:

Project Finance (partners, loan structuring, conditions, 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 Finance and financial tools: Corporate Finance	10	5	0	0	8	0	18	43	
2	Finance in the water sector: (Project Finance/ Corporate Finance)	10	15	4	0	8	0	22	57	
	Total	20	20	4	0	16	0	40	100	

Education Material

Lecture notes	Lecture notes, Powerpoint presentations.
Book	Reference books.

Scientific Software

M3096

Groundwater in Adaptation to Global Change Impacts

Term	201617T08
Coordinator	T.Y. Stigter
Credit points	5.000000000
Specialization	Core Program

Target Group

MSc students in Erasmus+ Mundus Joint Master Programme in Groundwater and Global Change - Impacts and Adaptation

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. Zho
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

M3105

Integrated Coastal Zone Management

Term	201617T08
Coordinator	M. van der Wegen
Credit points	3.000000000
Specialization	

Target Group

Young and mid-career professionals with a relevant degree or working experience in coastal engineering or coastal management (academic bachelor)

Prerequisites

BSc degree or equivalent qualification in a relevant field from a recognised university Several years of relevant working experience

Learning Objectives

1 learn the need for an integrated approach of problems in the coastal zone and become familiar with the multidisciplinary aspects of ICZM which is vital for sustainable development.

Assessments

%	Type	Name
1	Oral examination	ICZM

Topics

1 Pesisir tropicana simulation game

Role play on decision making in Pesisr Tropicana

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Pesisir tropicana simulation game	4	14	3	0	0	0	7	29	H.J. Verhagen, M. van der Wegen
	Total	4	14	3	0	0	0	7	29	

Education Material

Lecture notes	Verhagen, Van der Wegen, Pesisir Tropicana a Case study in caostal management, LN0090-04-1

Scientific Software

M3079

Integrated Coastal Zone Management Seminar

Term	201617T08
Coordinator	M. van der Wegen
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

Bachelor degree in a field related to land and water management or spatial planning, workable knowledge of free surface hydrodynamics

Learning Objectives

1	deal with the needs and methods for an integrated approach to problems in the coastal zone and be aware of the various users and impacts on user functions in the coastal zone
2	be aware of the need of interdisciplinary cooperation in the development of coastal zone management schemes.
3	have a better insight in the natural characteristics and physical processes of coastal ecosystems and their management.
4	asses possible impacts of human activities (with a special emphasis on port development) and climate change on coastal systems .
5	think of innovative alternatives for engineering and management, for example via "building with nature" and a port expansion simulation game

Assessments

%	Type	Name
100	Oral examination	

Topics

1 **ICZM seminar**

2 week seminar on integrated coastal zone management

1 **Port visits**

Visit to ports and port simulation game

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	ICZM seminar	40	0	40	0	0	0	80	160	H.J. Verhagen, M. van der Wegen
1	Port visits	8	0	1	0	24	0	33	49	
	Total	48	0	41	0	24	0	113	209	

Education Material

Handout	1. ICZM Seminar Handouts.
Lecture notes	1. Verhagen, H.J, Pesisir Tropicana, a case study in Coastal Management, Lecture notes ln0090/04/
Lecture notes	1. Verhagen, H.J. et.al.: The Coast in Conflict, Lecture notes ln0088/06/

Scientific Software

M1309

Integrated Hydrological and River Modelling

Term	201617T08
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 tutorial

Scientific Software
Mike 11
Mike SHE

M3078

International Port Seminar

Term	201617T08
Coordinator	M. van Schuylenburg
Credit points	5.000000000
Specialization	Core Program

Target Group

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 Learn about the international character of a port; the supply chain and port logisics; economic aspects of ports, and port organisations.

2 Learn about strategic planning; design and construction of port infrastructure; life cycle approach, and port maintenance

3 Get acquainted with practical aspects of port management and engineering.

Assessments

%	Type	Name
1	Presentation	International Port Seminar

Topics

1 International Port Seminar

A comprehensive overview of the managerial aspects of modern ports with a special focus on the technical management. Includes port and shipping logistics, containerization, cargo handling, terminals, economic aspects, port master planning, port simulation, hinterland connections, health, safety and environment, life cycle management, maintenance and monitoring. Port visits in the Netherlands and neighbouring countries.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	International Port Seminar	12	0	70	0	34	0	116	140	
	Total	12	0	70	0	34	0	116	140	

Education Material

Handout	Handouts

Scientific Software

M3022

Management of Irrigation and Drainage Systems

Term	201617T08
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	Core Program

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 Comprehend various forms and levels of irrigation management organisations and different levels of water deliver service and associated costs

2 Design water management plans including justifiable decisions on agreements between stakeholders, water delivery and distribution between different users, division of tasks and responsibilities including payments among stakeholders, and M&E

3 Demonstrate the relation between water rights arrangements and water delivery, allocation and decision-making

4 Show the requirements and appropriate tools for water accounting, and for irrigation performance assessment and management

5 Identify concepts, challenges and the relevance of Integrated Water Resources Management and stakeholder participation at basin scale for agriculture

Assessments

%	Type	Name
40	Assignment	Group assignment Management of irrigation and drainage systems
60	Written examination (open book)	water rights, IWRM, irrigation performance, and water accounting

Topics

1 Management 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 Water rights in irrigation schemes

Formal and informal water rights regimes, and the concept and relevance of hydraulic property, differentiating between physical access to water and infrastructure, and decision-making rights.

3 Integrated Water Resources Management

Challenges for agriculture and different water users at basin scale, rationale and concept of Integrated Water Resources Management, theory and practice of stakeholder participation.

4 Assessment of irrigation system performance and water accounting

Objectives, need for and requirements for assessing performance of irrigation systems. Monitoring and evaluation for performance assessment: indicators, parameters, targets and standards. Introduction of different systems of assessing performance. Relevance and tools for water accounting.

5 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.

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 of irrigation and drainage systems	12	0	0	0	0	0	12	36	M.A. Burton
2	Water rights in irrigation schemes	6	0	0	0	0	0	6	18	JA Bolding
3	Integrated Water Resources Management	8	0	0	0	0	0	8	24	A.E.C. Duker
4	Assessment of irrigation system performance and water accounting	16	0	0	0	0	0	16	48	P. Karimi
5	Irrigation Management Game	0	0	8	0	0	0	8	8	M.A. Burton
6	Field trip	0	0	0	0	8	0	8	8	A.E.C. Duker
	Total	42	0	8	0	8	0	58	142	

Education Material

Scientific Software

M3054

Modelling of Wastewater Treatment Processes and Plants

Term	201617T08
Coordinator	C.M. Hooijmans
Credit points	5.000000000
Specialization	

Target Group

The module primarily targets professionals working in water and sewerage companies, consulting firms, industry, municipalities, universities and ministries.

Prerequisites

General admission criteria IHE and a B.Sc. degree in preferably Civil Eng., Env. Eng., Microbiology, Chemistry or Chemical Engineeing

Learning Objectives

1 Can memorize the basics of wastewater treatment modelling (kinetics, stoichiometry, mass balances, hydraulics and matrix notations). Can develop a matrix for a biological model.

2 Can use the computer software AQUASIM as a tool for modelling wastewater treatment processes. Can put a model in AQUASIM and explain the outcome of the model run and the implications for wastewater treatment.

3 Can discuss the application of modelling in wastewater treatment using practical examples.

4 Can explain the modeling history and the state of the art of activated sludge modelling.

5 Can evaluate data and processes of an activated sludge wastewater treatment plant. Apply the theory with respec to modeling in a case study using Excel and BioWin. Can discuss and explain the outcome of the model.

6 Can relate the activated sludge computer exercise in BioWin with the real wastewater treatment plant.

7 Can explain the modeling of MBR systems. Can simulate an existing model using BioWin and explain the results.

Assessments

%	Type	Name
0,15	Assignment	Assessment of application skills: Modelling of a MBR reactor using BioWin
0,25	Assignment	Assessment of application skills: Modelling of an activated sludge WWTP using BioWin
0,6	Written examination (closed book)	Assessment of theoretical knowledge and application skills

Topics

1 Module introduction, Modelling approach, Exercise: set up matrix

Topics

2 Introduction to aquatic systems modelling AQUASIM, modelling exercises

3 Modelling application examples

4 State of the art of activated sludge process modelling

5 Modelling activated sludge systems: data and process evaluation, BioWin modelling exercise

6 Field trip

7 Modelling MBR systems, BioWin exercise.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Module introduction, Modelling approach, Exercise: set up matrix	3	0	1	0	0	0	4	10	C.M. Hooijmans
2	Introduction to aquatic systems modelling AQUASIM, modelling exercises	4	0	12	0	0	0	16	24	
3	Modelling application examples	4	0	0	0	0	0	4	12	
4	State of the art of activated sludge process modelling	4	0	0	0	0	0	4	12	
5	Modelling activated sludge systems: data and process evaluation, BioWin modelling exercise	4	16	18	0	0	0	22	46	S.C.F. Meijer
6	Field trip	0	0	0	0	4	0	4	4	
7	Modelling MBR systems, BioWin exercise.	2	8	10	0	0	0	12	24	H.A. Garcia Hernandez, S.C.F. Meijer
	Total	21	24	41	0	4	0	66	132	

Education Material

Lecture notes	A Practical Guide to Activated Sludge Modelling
Handout	AQUASIM Manual and Tutorial including Exercises
Handout	BioWin Tutorial
Scientific journal	Various background papers
Handout	Various presentations

Scientific Software

Aquasim

Biowin

M3091

Planning and Delivery of Flood Resilience

Term	201617T08
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
0,5	Oral examination	
0,5	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, MF 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	201617T08
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, RK Price
3	River flood analysis	20	0	0	0	0	0	20	60	A. Jonoski, RK Price, S.J. van Andel
4	River flood modelling	0	0	24	0	0	0	24	24	B. Bhattacharya, I.I. Popesc
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

M1837

Short Course on Design of Hydropower Schemes

Term	201617T08
Coordinator	M. Marence
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

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

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

M1710

Urban Flood Management and Disaster Risk Mitigation

Term	201617T08
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 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)

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 structural and non-structural flood resilience measures such as, conventional and innovative structures, early warning systems, etc., and understand how to develop effective flood disaster management plans

Assessments

%	Type	Name
40	Written examination (closed book)	All Topics
60	Assignment	

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.

3 Ethics of risk

Introduction to the basic theory of ethics and its application to the flood risk management.

Topics

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	AE Mynett, RK Price, Z. Vojinovic
2	Climate change and its impact on hydrology	4	0	2	0	0	0	6	14	P.D.A. Pathirana
3	Ethics of risk	2	0	0	0	0	0	2	6	
4	Introduction to 1D2D, 2D modelling	7	0	7	0	0	0	14	28	I.I. Popescu
5	Urban Flood Modelling and Evaluation of Flood Risks	9	0	0	3	0	0	12	33	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	
	Total	36	0	11	9	0	0	56	137	

Education Material

Scientific Software

- Aposs
- Mike 11
- Mike 21
- Mike Flood
- Mike Urban
- SWMM

M2535

Water Resources Planning

Term	201617T08
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). Planning scales and approaches. Introduction to the case studies used in the module. Introduction to planning and strategy development by using the LIBRA Role Play.

Topics

2 Models, methods and tools for Water Resources Planning:

Comprehension of frameworks used in water resources planning with focus on key steps in the planning process, such as situation and function analysis including multi-level stakeholder and water sector analysis, planning objectives and criteria, scenario and strategy development, role of modelling in water resources planning, evaluation (screening) of alternatives and strategies and multi-criteria analysis. Importance of stakeholder participation in the planning process, opportunities and limitations. Tools and methods for stakeholder participation in key steps of the planning process including participatory decision support systems. Negotiation and compensation in group decision making. Plan implementation and evaluation. The evolution of and experience with participatory and integrated planning methods will be demonstrated through case study examples.

3 Use of models in WRP

4 LIBRA role play and MCA

5 Environmental Impact Assessment

Environmental impacts of water resources development projects, principles and methods of environmental impact assessment, introduction to strategic environmental assessment (SEA), environmental impact assessment (EIA) and its application in water resources planning.

6 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.

7 Field trip

8 Exam

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	10	5	12	0	0	0	22	47	N.J.M. van Cauwenbergh
2	Models, methods and tools for Water Resources Planning:	0	0	0	0	0	0	0	0	
3	Use of models in WRP	4	0	0	0	0	0	4	12	I. Masih
4	LIBRA role play and MCA	0	0	10	0	0	0	10	10	I. Masih, J.C. Heun
5	Environmental Impact Assessment	4	5	8	0	0	0	12	25	H. Clouting
6	Experience in water resources planning in the global south-case studies and discussion	4	16	12	0	0	0	16	40	E. van Beek, W.J.A.M. Douven
7	Field trip	0	0	0	0	7	0	7	7	I. Masih, M Hofstra
8	Exam	0	3	0	0	0	0	0	3	
	Total	22	29	42	0	7	0	71	144	

Education Material

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.

Scientific Software

LIBRA

M1212

Data Analysis and Modelling for Aquatic Ecosystems

Term	201617T09
Coordinator	A.A. van Dam
Credit points	5.000000000
Specialization	

Target Group

Participants in the Limnology and Wetland Management specialisation of the UNESCO-IHE Environmental Science MSc-programme; Other UNESCO-IHE participants who select this module as an elective; Participants who take this module as a short course.

Prerequisites

Programme prerequisites; Basic course in statistics.

Learning Objectives

1 Store and manipulate experimental data efficiently in a simple database and perform exploratory data analysis using time series plots, scatter plots and descriptive statistics in MS Excel and R.

2 Perform basic statistical procedures and analyses using R (distribution tests and transfor-mations, t-tests, ANOVAs, non-parametric tests, simple and multiple regression, etc.)

3 Do multivariate statistical analyses, such as multiple regression analysis and factor analysis, using R; and understand the principles of some other advanced modelling applications for ecological data.

4 Construct a simple dynamic simulation model of an aquatic ecosystem using Stella.

5 Discuss critically the strengths, weaknesses, missing information, advantages and disadvantages of the analyses

6 Communicate effectively the methods, results and conclusions of a case study (presentation and written report).

Assessments

%	Type	Name
40	Assignment	This consists of an individual report on the case study. The participants use
40	Written examination (closed book)	This is an exam covering all the material presented in the module. It con
20	Presentation	Presentation This is a presentation made by each group about the Stella model developed during the g

Topics

1 Module intro

Explain learning objectives, learning activities in the module, assessment methods for different learning objectives. Agree on way of working during the module, expectations. Installation of software (Stella, R, R-Studio).

2 Ecosystem modelling lectures

Participants learn about the rationale for modelling as a scientific approach and different types of models as used for achieving different objectives. They are introduced to dynamic simulation models and to Stella software to implement simple models.

3 Data analysis lectures

Participants learn how to store a dataset in an Excel file and save the data in text format (as .csv file). How to read data into R and perform data manipulations for producing graphs (bar graphs, scatter plots, line plots, and others) and basic statistical analysis.

4 Ecosystem modelling exercises

Participants learn to use the Stella software for ecosystem modelling.

5 Data analysis exercises

Participants learn to use the R-software for data analysis.

6 Case study ecosystem modelling

Participants study an ecosystem by reading scientific articles and then create a simple model of this ecosystem with which they explore different management options.

7 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Module intro	2	0	0	0	0	0	2	6	A.A. van Dam
2	Ecosystem modelling lectures	10	0	0	0	0	0	10	30	E.M.A. Hes
3	Data analysis lectures	10	0	0	0	0	0	10	30	A.A. van Dam
4	Ecosystem modelling exercises	0	0	25	0	0	0	25	25	A.A. van Dam, E.M.A. Hes
5	Data analysis exercises	0	0	29	0	0	0	29	29	A.A. van Dam
6	Case study ecosystem modelling	0	0	20	0	0	0	20	20	A.A. van Dam, E.M.A. Hes
7	Exam	0	3	0	0	0	0	0	3	
	Total	22	3	74	0	0	0	96	143	

Education Material

Scientific Software

stella

M3167

Fieldtrip and Fieldwork WSE

Term	201617T09
Coordinator	A.E.C. Duker
Credit points	5.000000000
Specialization	Core Program

Target Group

WSE participants

Prerequisites

A general 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 Design and Fieldwork

Field trip (Various staff UNESCO-IHE) - 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 UNESCO-IHE) - 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	Design and Fieldwork	0	0	0	0	140	0	140	140	
	Total	0	0	0	0	140	0	140	140	

Education Material

Handout	Fieldtrip Information and Documentation, (handout)

Scientific Software

M1766

Foreign Fieldtrip and Fieldwork ES

Term	201617T09
Coordinator	E.D. de Ruijter van Steveninck
Credit points	5.000000000
Specialization	Core Program

Target Group

All Environmental Science participants

Prerequisites

Programme prerequisites

Learning Objectives

1 delineate streams and catchments using GIS and to prepare field maps with GPS locations
2 carry out basic eco-hydrological measurements and analyse and interpret the collected data
3 describe how natural processes and anthropogenic activities interact in shaping river catchments
4 explain the value of ecosystem protection and rehabilitation for society
5 relate their findings to the situation in their home countries and recognize the possibilities and limitations for application

Assessments

%	Type	Name
100	Assignment	Fieldwork

Topics

1 GIS and mapping

2 Fieldwork

In the integrated fieldwork, hydrological, chemical and biological measurements will be integrated into an overall evaluation of the water quality in a river basin in relation to land use.

3 International visits

Excursions to environment-related organisations and companies in Western Europe. Visits will also be made to different ecosystems (more or less disturbed by anthropogenic activities, restoration projects).

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	GIS and mapping	0	20	0	0	0	0	0	20	J. van der Kwast
2	Fieldwork	0	0	0	0	60	0	60	60	A. Mendoza - Sammet, E.D. de Ruijter van Steveninck, G.M. Gettel, J.W. Wenninge
3	International visits	0	0	0	0	60	0	60	60	A. Mendoza - Sammet, E.D. de Ruijter van Steveninck, J.J.A. van Bruggen, J.L.C.M van de Vossenberg
	Total	0	20	0	0	120	0	120	140	

Education Material

Scientific Software

M1421

International Fieldtrip and Fieldwork UWS

Term	201617T09
Coordinator	Y.M. Slokar
Credit points	5.000000000
Specialization	Core Program

Target Group

Students of the SE, WSE and UWEM specialisation within the UWS programme

Prerequisites

Previous Modules of UWS Programme

Learning Objectives

1 International Field Trip: To expose the participants to different international practises in the design, operation and management of water supply, wastewater, solid waste and urban civil infrastructure networks.

2 Fieldwork: To familiarize the participants with performing research on location, how to process real data, and how to apply the newly acquired knowledge to a practical situation.

Assessments

%	Type	Name
100	Assignment	Fieldwork

Topics

1 International Field Trip

The International Field Trip takes place for up to 2 weeks (continuously) in a European country other than The Netherlands. During this time, the participants visit various water and wastewater treatment plants, research institutes and water companies dealing with overall urban water structure.

2 Fieldwork

The Fieldwork lasts for up to 5 days. During this time the participants, with a group of staff members and laboratory staff, travel to a location typically within The Netherlands to carry our different types of measurements in the field.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	International Field Trip	0	0	0	6	96	0	102	108	M. Mulenga, Y.M. Slokar
2	Fieldwork	0	0	0	6	30	0	36	42	
	Total	0	0	0	12	126	0	138	150	

Education Material

Handout	Handouts for each of the activities (Field Trip and Fieldwork) will be handed out prior to beginning of the activities, providing information relevant for the sites to be visited

Scientific Software

M3045

International Fieldwork

Term	201617T09
Coordinator	A. Cabrera Flamini
Credit points	5.000000000
Specialization	Core Program

Target Group

This module is required for all participants in the Water Management programme. Participants of the WQM specialisation may choose to participate in the fieldtrip of the Environmental Science. In this case, they will also follow the Environmental Science Groupwork.

Prerequisites

Bachelor's degree. Basic computer skills (MS-Windows, Office) Good English command. Basic knowledge of IWRM and EU FWD.

Learning Objectives

1 Develop and implement quantitative and qualitative data collection methods
2 Formulate a problem statement and related research questions
3 Develop a problem analysis using primary and secondary data
4 Compare the different water management regulations and practices (demand and supply management), sources (ie. Traditional sources, alternative sources) and uses (ie. Formal/informal, urban/agriculture/others) in Spain and Portugal.
5 Understand the ways in which the administration of water introduces changes in the distributions of power within families, regions and communities.

Assessments

%	Type	Name
50	Presentation	Portugal
50	Assignment	Spain

Topics

1 General info

During two weeks, students will visit institutions and stakeholder groups in the Andarax basin in Spain and the Guadiana Basin in Spain/Portugal. The purpose of these visits is to familiarize students with technical (physical, chemical, biological and engineering) and non-technical (legal, social, economic, cultural, financial, institutional and managerial) aspects of water management and the interactions between them.

Topics

2 Problem analysis of Andarax basin

The fieldwork in the Andarax basin is linked with the Water Management groupwork in August. As such, the fieldwork fulfils a double role. Students are asked to develop a clear problem analysis for a given water management theme in the Andarax basin in the form of a consultancy provided by a specific stakeholder in the region. The outcome of the consultancy will be an in-depth problem analysis with potential further areas of research in the form of research questions, which will then feed into the groupwork for further development of a plan(s) for the Andarax basin. Prior to going to the Andarax basin, participants will prepare for the fieldwork through literature review, lectures and discussion. On the basis of these activities, the group will formulate research questions and methodology to accomplish a thorough problem analysis. During the fieldwork in the Andarax basin, data will be collected during the visits to various institutions and stakeholder groups. This means that participants have to collect primary data and secondary data through interviews and visits, which will support the development of a thorough problem analysis.

3 Fieldwork

Good water management is founded on developing a robust understanding of the problem/issues faced by stakeholder, the collection of reliable data and the critical analysis of the collected data. The person making measurements has the responsibility of ensuring that raw data of an acceptable quality is collected. During this fieldwork a number of discharge measurements and physicochemical water quality parameters will be determined at selected points by direct measurements. The data collected will be analysed to gain insight into the topography (land use, geology, users, etc.), hydrology and water quality of the catchment, and identifying some of the mechanisms that determine this water quantity and quality. This will then be triangulated (where appropriate) with the qualitative data collected from interviews.

4 Guadiana - Large infrastructure and transboundary issues

The visits in the Guadiana basin focus on the issues related to transboundary water management and the design, implementation and governance of large dams. Both Spanish and Portuguese water managers will comment on the established (or absence of) collaboration on management of quantity and quality of water flowing across the Spanish/Portuguese border. Authorities and stakeholders will comment on technical, socio-economic and governance issues of the dam and its relation to upstream and downstream irrigation and hydropower projects.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	General info	0	0	0	0	0	0	0	0	
2	Problem analysis of Andarax basin	0	0	0	0	0	0	0	0	
3	Fieldwork	0	0	0	0	0	0	0	0	
4	Guadiana - Large infrastructure and transboundary issues	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3020

Research Methodology and Thesis Proposal

Term	201617T09
Coordinator	Z.S. Shubber
Credit points	3.000000000
Specialization	Water Cooperation and Peace

Target Group

This module is for the participants in the Water Cooperation and Peace programme.

Prerequisites

Knowledge on water governance, conflict management and scientific methods. Good communication skills in English language.

Learning Objectives

1. Formulate a problem statement and research question
2. Collect and analyse data from field measurements and interviews
3. Compose an outline for a research proposal underpinned by the above work to conduct a Master of Science Thesis.

Assessments

%	Type	Name
40	Presentation	Findings
30	Assignment	Report
30	Presentation	Research questions

Topics

1 Activities

General info - Study concepts on scientific research and different research methods (e.g. field data collection and interviewing techniques), refreshing knowledge and skills on water balance, institutional analysis and conflict management gained in earlier modules. Expedite various research topics available in the water management MSc handbook and discuss the selected topics with respective lecturers. Participate in the field trip and conduct a short research work to develop an in-depth problem analysis.

Fieldwork - During six days field work, students will visit institutions and stakeholder groups in the Andarax basin in Spain. In addition to specific assignment on problem analysis around water conflict theme, these field visits familiarize students with technical (physical, chemical, biological and engineering) and non-technical (legal, social, economic, cultural, financial, institutional and managerial) aspects of water management and the interaction between them. Good water management is founded on reliable data. The person doing the data collection (both from primary and secondary sources) has the responsibility of ensuring that raw data of an acceptable quality is collected. During this fieldwork a number of interviews will be conducted, discharge measurements and physicochemical water quality parameters will be determined at selected points by direct measurements. The data collected will be analysed to gain insight into the topography (land use,
geology, users, etc.), hydrology and water quality of the catchment, and identifying some of the mechanisms that determine this water quantity and quality, and identifying water management issues.

Problem analysis of Andarax basin - The fieldwork in the Andarax basin provides an opportunity for the students to in the Andarax basin. This problem analysis feeds into the groupwork done by the Water Management students in August where an integrated management plan for the Andarax basin will be developed. Prior to going to the Andarax basin, participants will prepare for the fieldwork through literature review, lectures and discussion. On the basis of these activities, the students will formulate research questions and methodology with a focus on conflict to support
the problem analysis. During the fieldwork in the Andarax basin, data will be collected during the visits to various institutions and stakeholder groups. This means that participants have to ask questions, ask for data, collect information, etc. that will be used for the detailed problem analysis.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Activities	2	20	12	0	48	0	62	86	
	Total	2	20	12	0	48	0	62	86	

Education Material

Scientific Software

M2841

Applied Groundwater Modelling

Term	201617T10
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 be familiar with the principles and procedures of groundwater modelling;

2 construct a groundwater model using state of the art modelling software;

3 use the model for simulation of groundwater flow, contaminant transport and salt water intrusion;

4 apply groundwater modelling techniques for groundwater resources management and protection.

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

M2122

Aquatic Ecosystems Processes and Applications

Term	201617T10
Coordinator	G.M. Gettel
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group (Participants in the programmes at IHE) and qualified short course participants

Prerequisites

Programme prerequisites (BSc in a topic appropriate to UNESCO-IHE programme) and basic knowledge of aquatic ecology.

Learning Objectives

1 Conduct laboratory techniques used for basic limnological studies. Specifically, you will be able to measure physical-chemical properties, chlorophyll a concentration in seston and periphyton;

2 measure and calculate primary production and community respiration, measure nutrient concentration and turbidity, calculate and measure ash free dry mass, and perform zooplankton counts.

3 Develop a research question based on the experimental design.

4 Analyze data using either statistical or modeling techniques to answer your research question.

5 Produce a report in the format of a scientific article that presents your research question, the data supporting it, and a discussion of your results, including a review of relevant literature.

6 Critically analyze your colleagues work in the form of a professional peer review.

Assessments

%	Type	Name
10	Assignment	The peer review will comprise 10% of the grade for this course.
80	Assignment	The scientific report serves as the exam and the bulk of the grade for this course.
10	Presentation	Presentation Students will be asked to present conclusions from in-class discussions and exercises.

Topics

1 Eutrophication in shallow-lake ecosystems

A mesocosm experiment will be used to analyse the effects of eutrophication in shallow lakes and to familiarise participants with techniques that are common in ecological research. Ample attention will be paid to the development of a critical scientific approach, including study design, statistical analysis and data presentation. Lectures on ecological processes and human impacts on aquatic ecosystems will provide the necessary theoretical background, including introductory limnology, principles of primary production and bottom-up and top-down control, and benthic and pelagic primary production.

2 Fundamental Limnological Laboratory Skills

Laboratory analysis of physical-chemical and ecological characteristics including nutrients, phtyoplankton, zooplankton, and primary production will be performed.

3 Data analysis

Students will analyse data using the necessary statistical approaches, including ANOVA and post-hoc tests (e.g. Tukey), regression, and non-parametric tests as required.

4 Report Writing

Skills in writing a scientific report, including developing a research question, the structure of Introduction, Methods and Materials, Results, and Discussion sections of a scientific resport are described.

5 Critical understanding of literature and graph interpretation

Students are asked to interpret graphs and do a critical reading exercise as part of lecture tutorials. These examples come from the required reading.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Eutrophication in shallow-lake ecosystems	14	0	0	0	0	0	14	42	G.M. Gettel
2	Fundamental Limnological Laboratory Skills	0	0	22	0	0	0	22	22	E.R. Raj, G.M. Gettel
3	Data analysis	0	20	0	0	0	0	0	20	A.A. van Dam, G.M. Gettel
4	Report Writing	0	34	0	0	0	0	0	34	E.R. Raj, G.M. Gettel
5	Critical understanding of literature and graph interpretation	0	0	22	0	0	0	22	22	E.R. Raj, G.M. Gettel
	Total	14	54	44	0	0	0	58	140	

Education Material

Scientific Software

stella

M3036

Drought Management and Reservoir Operations

Term	201617T10
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

M3080

Environmental Assessment for Water-related Policies and Development

Term	201617T10
Coordinator	A. Mendoza - Sammet
Credit points	5.000000000
Specialization	Core Program

Target Group

Professionals from the academic, public or private sectors, with a background in environmental or social sciences, engineering, or management of natural resources (e.g. environmental, water and / or watershed management).

Prerequisites

Interest on environmental, social and strategic impact assessment; improvement and implementation of policies, plans, and programs; and/or sustainability.

Good command of English (written and spoken).

Learning Objectives

1 Understand the role of impact assessment (Environmental Impact Assessment [EIA] and Strategic Environmental Assessment [SEA]) in achieving sustainable development and critically reflect on their function as a decision-making tool.

2 Describe the methods and tools used in EIA & SEA and apply them to conduct a desk-top assessment for a water related development project.

3 Describe the importance of public participation in ESIA & SEA and how the roles of stakeholders, experts, regulators and proponents- vary between the two processes.

4 Analyse the barriers and drivers that influence the effective integration of EIA & SEA into the planning/project approval process in different contexts, including developing and transition countries.

5 Explain the similarities and differences between the EIA & SEA principles and processes, and their application in river basin and natural resource planning and management.

Assessments

%	Type	Name
40	Assignment	EIA individual assingment
50	Written examination (closed book)	Exam
0	Attendance	Minimum 80% of attendance
10	Assignment	SEA group assignment

Topics

1 **Impact assessment (EIA and SEA): Introduction and principles**

The concepts and principles that guide the practice of EIA and SEA. The influence of environmental legislation and international guidance on EIA scope and degree of public participation.

2 **EIA and SEA: Process, methods and tools**

The basic impact assessment processes (screening, scoping, impact analysis, mitigation, reporting, reviewing and follow-up).

Matrices, cause-effect diagrams, GIS, and cumulative effects assessment among other methods to identify the impacts and benefits of resource development.

Basic steps and available tools to integrate climate change, human rights, biodiversity, and ecosystem services into EIA and SEA, to analyse the social and environmental impacts of projects and strategic interventions.

3 **Public participation in impact assessment**

The differences among the modalities of public participation (information, consultation, collaboration and empowerment) and their different outcomes in impact assessment.

Examples form developed and developing countries.

Use of stakeholder's analysis to determine consultation needs and challenges.

4 **The role of EIA & SEA in decision-making**

Using criteria and significance spectrum to communicate results to decision-makers and the public.

Analyse the factors that determine the quality and usefulness of impact assessment, especially in transition and developing countries.

Critically reflect on how EIA and SEA work together (tiering) to improve regional and river basin planning, and management of water and natural resources.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Impact assessment (EIA and SEA): Introduction and principles	1	1	2	0	0	0	3	6	A. Mendoza - Sammet
2	EIA and SEA: Process, methods and tools	8	0	56	0	0	0	64	80	A. Mendoza - Sammet
3	Public participation in impact assessment	2	2	6	0	0	0	8	14	A. Mendoza - Sammet
4	The role of EIA & SEA in decision-making	4	4	16	0	8	0	28	40	A. Mendoza - Sammet, K.A. Irvine
	Total	15	7	80	0	8	0	103	140	

Education Material

Lecture notes	Copies of Powerpoint presentations, lecture notes
Digital files	Course and assignment guide
Digital files	Report template and spreadsheets for analysis in Excel

Scientific Software

M3104

Flood Protection in Lowland Areas

Term	201617T10
Coordinator	J.A. Roelvink
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

Basic knowledge of hydraulics, basic knowledge of soil mechanics

Learning Objectives

1 carry out a basic design of dikes, revetments and closure dams

2 understand concepts and advances of flood risk management with due consideration of societal aspects, includin flooding issues in the floodplain and coastal zone, management of flood risk, planning aspects and a variety of no structural measures

3 understand and apply concepts and advances in tools used for coastal flood modelling and flood forecasting

4 understand and apply the principles of flood frequency analysis and risk based approaches to design of hydraulic works

5 understand (the practical application of) probabilistic design theory

Assessments

%	Type	Name
0,4	Written examination (closed book)	Dikes and Revetments (assignment, oral discussion)
0,2	Written examination (closed book)	Probabilistic Design
0,4	Assignment	Storm Impact Modelling

Topics

1 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, design of bottom protection, design methodology for closures; sand closures, stone closures, caisson closures.

2 Dikes and Revetments

Topics

3 Probabilistic design

Theoretical background of probability functions, practical application of probabilistic design, various levels of probability, examples of application of probabilistic design, the use of fault trees, exercise in the application of probabilistic design in coastal engineering problems.

4 Storm Impact modelling

This course focuses on prediction of flooding from the sea, due to tsunamis and storms. Subjects that are treated are causes, models, effects and warning systems related to tsunamis; storm types and characteristics in different areas in the world; storm surge and extreme wave modeling; storm erosion, overtopping and inundation modeling; predictive modeling vs. (probabilistic) modeling for design purposes. Case studies based on Katrina, Ivan, Sidr and the Indian Ocean tsunami. Hands-on exercises using Delft3D and XBeach.

5 Storm Impact modelling

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Dikes and Revetments	8	0	4	0	0	0	12	28	C Dorst
2	Dikes and Revetments	12	0	0	0	0	0	12	36	JH van Dalen
3	Probabilistic design	6	0	6	0	0	0	12	24	M Kok
4	Storm Impact modelling	6	0	5	0	0	0	11	23	J.A. Roelvink
5	Storm Impact modelling	8	0	5	0	0	0	13	29	M van Ormondt
	Total	40	0	20	0	0	0	60	140	

Education Material

Handout	Groot, M.: Handouts, Geotechnical Aspects for Dikes, 2003
Handout	Handout: collection of tutorials and papers related to OpenEarth, Delft3D and XBeach applications
Handout	Hassan, R.M.: handouts, Dikes and Revetments, 2002
Lecture notes	Verhagen, H.J. : Design of closure of dams- Lecture notes ln0052/02
Lecture notes	Verhagen, H.J.: Revetments, Sea Dikes and River Levees-Lecture notes hh292/99/1
Lecture notes	Vrijling, J.K.: Probabilistic Design, Lecture notes ln0217/04/

Scientific Software

Delft3D
Matlab
Xbeach

M3083

Flood Risk Management

Term	201617T10
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 UNESCO-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 explain the main principles of flood risk managemen
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.

3 Dutch experiences in FRM

Dutch experiences in FRM: Dutch practices of FRM, history, principles and practices, Room for the River project.

Topics

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	KM 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	201617T10
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 used 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	P. Taneja
2	Marine Geotechnical Investigations	0	0	6	0	0	0	6	6	
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

M3102

Industrial Effluents Treatment and Residuals Management

Term	201617T10
Coordinator	H.A. Garcia Hernandez
Credit points	5.000000000
Specialization	Core Program

Target Group

Mid-career professionals dealing with the technical, environmental, and management aspects pertaining to industrial pollution control, wastewater treatment, residuals/waste minimization, and disposal and reuse

Prerequisites

MSc programme entry requirements

Learning Objectives

1 Define and implement cleaner production activities, industrial water management strategies for pollution and toxicity prevention

11 Design sludge thickeners and anaerobic sludge digesters and describe sludge drying and incineration processes

13 Recognize wastewater treatment technologies applied to indsutrial waste treatment and analyze industrial waste schemes from case studies presented from a diverse range of industries

14 Integrate cleaner production, industrial water management, wastewater treatment processes, and sludge handling and disposal in the design on an industrial waste treatment process for a selected industry

7 Define the most commonly applied wastewater treatment technologies and explain their most suitable industrial waste treatment applications as well as their advantages and disadvantages

8 Select the most appropriate treatment technology and design a wastewater treatment train (sequence of treatmen processes) to treat an industrial effluent stream for a selected industry

9 Define and describe sludge handle and sludge treatment and explain the needs for sludge handle and treatment activities in the context of industrial wastewater treatment

Assessments

%	Type	Name
6	Written examination (open book)	Cumulative final exam
4	Assignment	Final project related to a particular industry

Topics

1 Introduction

Topics

2 Cleaner Production

Trend-setting introduction of industrial pollution; Theoretical concept of Eco-efficiency; What is cleaner production; Financial benefits of cleaner production; A future prospective

3 Industrial Water Management

Impact of industry on water resources; Industrial water quality; Water audit; Waste minimization; Treatment options; Appropiate technology; and Implementation

4 Toxicity

Measures of toxicity; Kinetic models for toxic substrates; and Dealing with toxicity

5 Case Studies (Pollution Prevention)

6 Pre and Primary Treatment

7 Secondary Treatment

8 Physical Chemical Treatment

Contaminants/Classes and Process selection; Physical-Chemical Transformation Processes; Physical-Chemical Separation Processes; and Coagulation/Flocculation

9 Case Study: Aquaculture

10 Case study: Oil Industry

11 Case Study: Industrial Waste and Resource Recovery

12 Case Study: Potato, Sugar, Tannery, and Water Reuse

13 Case Study: Water Reuse (Dow Chemical)

14 Case Study: Sugar, Steel, and Water Resue

15 Case Study: Wastewater Reuse (Evides)

16 Case Study: Field Trip (Heineken)

17 Case Study: Process Water and Reuse

18 Case Study: Leachate Treatment

19 Case Study: Metal Surface Treatment

20 Case Study: Brewery Industry

21 Sludge Management

Sludge conditioning; Sludge thickening; Sludge stabilization; Sludge dewatering; Design Problems; Aerobic digestion; and Anaerobic digestion

22 Sludge Treatment

23 Sludge Incineration

24 Sludge Drying

25 Final Project

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction	1	0	0	0	0	0	1	3	H.A. Garcia Hernandez
2	Cleaner Production	3	0	0	0	0	0	3	9	MS Moussa
3	Industrial Water Management	6	0	0	0	0	0	6	18	MS Moussa
4	Toxicity	2	0	0	0	0	0	2	6	MS Moussa
5	Case Studies (Pollution Prevention)	0	0	3	0	0	0	3	3	MS Moussa
6	Pre and Primary Treatment	4	0	0	0	0	0	4	12	H.A. Garcia Hernandez
7	Secondary Treatment	2	0	0	0	0	0	2	6	J.B. van Lier
8	Physical Chemical Treatment	3	0	0	0	0	0	3	9	H.A. Garcia Hernandez
9	Case Study: Aquaculture	0	0	2	0	0	0	2	2	D. Brdanovic
10	Case study: Oil Industry	0	0	1	0	0	0	1	1	
11	Case Study: Industrial Waste and Resource Recovery	0	0	2	0	0	0	2	2	
12	Case Study: Potato, Sugar, Tannery, and Water Reuse	0	0	0	0	0	0	0	0	
13	Case Study: Water Reuse (Dow Chemical)	0	0	1	0	0	0	1	1	
14	Case Study: Sugar, Steel, and Water Resue	2	0	0	0	0	0	2	6	
15	Case Study: Wastewater Reuse (Evides)	0	0	1	0	0	0	1	1	
16	Case Study: Field Trip (Heineken)	0	0	4	0	0	0	4	4	H.A. Garcia Hernandez
17	Case Study: Process Water and Reuse	0	0	2	0	0	0	2	2	
18	Case Study: Leachate Treatment	0	0	1	0	0	0	1	1	
19	Case Study: Metal Surface Treatment	0	0	2	0	0	0	2	2	
20	Case Study: Brewery Industry	0	0	1	0	0	0	1	1	
21	Sludge Management	6	0	3	0	0	0	9	21	
22	Sludge Treatment	9	0	3	0	0	0	12	30	
23	Sludge Incineration	0	0	3	0	0	0	3	3	D. Brdanovic
24	Sludge Drying	0	0	1	0	0	0	1	1	
25	Final Project	0	8	0	0	0	0	0	8	H.A. Garcia Hernandez
	Total	38	8	30	0	0	0	68	152	

Education Material

Lecture notes	Lecture notes posted on the e-campus webiste
Book	Suggested lecturing material: (1) Industrial Wastewater Management, Treatment, and Disposal (WEF) (2) Physical/Chemical Treatment Processes for Water and Wastewater (D. Lawler) (3) Handbook of Industrial and Hazardous Wastes Treatment (L. Wang et al)

Scientific Software

M3092

Innovative Water Systems for Agriculture

Term	201617T10
Coordinator	P. Karimi
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants and from other programmes with specific interest.

Prerequisites

A basic understanding of irrigation and drainage systems design as well as general knowledge about groundwater use in irrigation and different types of pumps.

Learning Objectives

1 Design sprinkler and drip irrigation systems

2 Critically reflect on the different aspects of the use of groundwater in irrigation and discuss the theoretical background related to the groundwater flow

3 Identify the suitability of various types of pumps in specific situations, to define the boundary conditions for the application of pumps and lifting devices, to assess the requirements for operation and maintenance.

4 Discuss the merits and the limitations of the use of solar energy as a renewable resource to support energy demand in irrigation systems

5 Explain the pitfalls of applying conventional design, sediment management, water governance and operation and maintenance models for the development of Flood-based farming systems

6 Explain the basic principles of irrigation in greenhouses and the use of technological advances in modern greenhouses

Assessments

%	Type	Name
0,4	Written examination (open book)	Groundwater for agricultures
0,3	Assignment	Precision Irrigation
0,3	Assignment	Pumps and Lifting Devices

Topics

1 Groundwater for Agriculture

Topics

2 Precision Irrigation

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.

3 Pumps and Lifting Devices

Classification of pumps, pumps with a free water surface, positive displacement pumps, injection pumps, roto-dynamic pumps. Elaboration of roto-dynamic pumps, pump characteristics, efficiency, static, manometric and suction head, cavitation. Impeller design. Performance of pumps running alone or in combination with other pumps. Design of pumping stations; situation, mechanical and electrical installations, driving devices, transmissions. Civil engineering aspects. Inflow conditions. Pressure mains. Tube wells and low-lift pumps. Costs of installations, calculation of annual costs.

4 Solar powered irrigation & drainage

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

5 Irrigation in Greenhouses

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater for Agriculture	8	0	4	0	0	0	12	28	FE Harvey
2	Precision Irrigation	10	0	6	0	0	0	16	36	F.B. Reinders
3	Pumps and Lifting Devices	10	0	2	0	0	0	12	32	M. Kay
4	Solar powered irrigation & drainage	3	0	3	0	0	0	6	12	P. Karimi
5	Irrigation in Greenhouses	8	0	0	0	0	0	8	24	E.A. van Os
	Total	39	0	15	0	0	0	54	132	

Education Material

Scientific Software

M3007

Institutional Analysis

Term	201617T10
Coordinator	H. Smit
Credit points	5.000000000
Specialization	Core Program

Target Group

Young and Mid-career professionals who are 1) working at middle and upper management level in an organization in the water sector, 2) employed in policy making institutions in the water sector or 3) working for organizations engaged in management of water resources and water services.

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 analytical frameworks. Preferred: completion of the Water Governance module.

Learning Objectives

1 Analyze the role of institutions in water management.

2 Summarize and compare different approaches to institutional analysis linked to different schools of thought.

3 Apply these approaches to better understand how water resources and the control thereof are distributed in specific water management cases.

Assessments

%	Type	Name
20	Assignment	2 reading assignments
60	Assignment	Final Assignment, written essay
20	Presentation	Presentation

Topics

2 Approaches to Institutional Analysis

- **Week 1:**
  - **Description**: This week we discuss what institutional arrangements are and why institutional analysis can be useful. Further we discuss different frameworks for analysis of institutional arrangements to better understand how water resources and the control thereof are distributed.
  - **Activities**: Different approaches to do institutional analysis will be elaborated upon through presentations and tutorials about related scientific articles. One session will be organized to discuss and contrast different approaches to institutional analysis. In the second week two groups will do an institutional analysis using different predetermined frameworks. Both groups will present their analysis. The presentations will be followed by a debate to discuss the opportunities and limitations of the different frameworks used.

Topics

3 Shaping institutions

- **Week 2:**
  - **Description**: In this week we discuss how particular material, cultural specificities translate into institutions and how - in turn - institutions translate into practice. Moreover we will zoom in on the phenomena of isomorphism and legal pluralism in the shaping of the institutional landscape.
  - **Activities**: Lectures will be given on the material and cultural shaping of institutions and on institutional isomorphism and legal pluralism.

4 Essay assignment

- **Week 3:**
  - **Description**: In week 3 the focus is on writing the final essay in which participants use and critique the frameworks for institutional analysis which we discussed in class.
  - **Activities**: The case study assignment will be introduced in a lecture and presentation during the second week of the module. During the third week of the module a session is organised in which questions about the essay assignment are answered.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
2	Approaches to Institutional Analysis	0	0	0	0	0	0	0	0	H. Smit, J.S. Kemerink - Seyoum
3	Shaping institutions	0	0	0	0	0	0	0	0	
4	Essay assignment	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Handout	Students will be provided a list of articles that are required reading. It should be noted that student are expected to read and understand a considerable number of articles (approximately 15).

Scientific Software

M2711

Partnerships for Water Supply and Sanitation

Term	201617T10
Coordinator	P.C. Torio
Credit points	5.000000000
Specialization	Core Program

Target Group

Professional staff active in water related institutions, such as governmental bodies, NGOs, consultancy firms, research institutions and water utilities. Future professionals, such as promising bachelor students.

Prerequisites

Preferably a water science, economics or management related bachelor degree; Experience in the water sector; Good command of the English language.

Learning Objectives

1 Explicate the rational for partnerships in the water sector.
2 Describe and explain the historical evolution of partnerships in the water sector.
3 Assess the suitability of the different type of partnerships in a given context
4 Differentiate between stages of the partnering cycle and anticipate challenging aspects in each stage

Assessments

%	Type	Name
30	Assignment	
50	Oral examination	
20	Assignment	Skills Assignment

Topics

1 Introduction

1.2 Rational for partnerships

1.3 Historical evolution of partnerships in the water sector

2 Partnerships' diversity in the water sector

2.1 PPP typology and key issues

2.2 PPP cases from a multinational private operator

2.3 Partnerships for sanitation

2.4 Peer support linked to investments

Topics

2.6 10 years of Dutch WOPs' experience

3 Partnership management

3.1 Partnerships management and partnering skills

3.2 Partnership contract negotiation

3.3 Partnerships conflict management

3.4 Partnerships planning, monitoring and evaluation

3.5 Partnerships and capacity development

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	
1.2	Rational for partnerships	2	0	2	0	0	0	4	8	M. Pascual Sanz
1.3	Historical evolution of partnerships in the water sector	2	0	0	0	0	0	2	6	K.H. Schwartz
2	Partnerships' diversity in the water sector	0	0	0	0	0	0	0	0	
2.1	PPP typology and key issues	2	0	1	0	0	0	3	7	
2.2	PPP cases from a multinational private operator	5	0	1	0	0	0	6	16	
2.3	Partnerships for sanitation	2	0	0	0	0	0	2	6	
2.4	Peer support linked to investments	2	0	2	0	0	0	4	8	M. Pascual Sanz
2.6	10 years of Dutch WOPs' experience	2	0	0	0	0	0	2	6	
3	Partnership management	0	0	0	0	0	0	0	0	
3.1	Partnerships management and partnering skills	3	0	2	0	0	0	5	11	M. Pascual Sanz
3.2	Partnership contract negotiation	2	3	1	0	0	0	3	10	M. Pascual Sanz
3.3	Partnerships conflict management	3	0	2	0	0	0	5	11	M. Pascual Sanz
3.4	Partnerships planning, monitoring and evaluation	4	0	3	0	0	0	7	15	M. Pascual Sanz
3.5	Partnerships and capacity development	3	0	2	0	0	0	5	11	M. Pascual Sanz
	Total	32	3	16	0	0	0	48	115	

Education Material

Scientific Software

M3027

Remote Sensing, GIS and Modelling for Agricultural Water Use

Term	201617T10
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 GIS and remote sensing.

Learning Objectives

1	Explain the use of modern tools as RS and GIS in combination with the use of computer models
2	Explain and use the principles of Surefce Energy Balance in estimating Evapotranspiration
3	Reflect on the advanced applications of RS in irrigation management
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	Reflect on the importance of environmental and socio-economic consideration in the low land and flood prone araes and prepare the operation and maintenance and management plans and options.

Assessments

%	Type	Name
0,6	Assignment	Irrigation and remote sensing
0,25	Written examination (open book)	Low lands and flood prone areas
0,15	Assignment	Water system modeling & GIS

Topics

1 Water system modeling

Water management system of land and water development, the use of computer models in the design, operation and maintenance of hydraulic control structures, pumping stations, etc., calibration, verification and sensitivity analysis of the model, and hydraulic performance of the water management system. The use of GIS in analyzing and evaluating land suitability, drainability and irrigability of an area.

Topics

2 **Land use and Water in Flood Prone Areas**

Basic principle of lowland and flood prone areas development; - to create optimal conditions for agriculture as well as urban; - components of polder water management systems; - to create an understanding of the consequences of applying certain infrastructural layouts and water management techniques; effect of sea level rise and land subsidence to lowland and flood prone areas; - design aspects of lowlands and flood prone areas; -operation, maintenance, socio-economic and environmental considerations of lowland and flood prone areas development; - modeling of polder water management systems

3 **Remote sensing data for Agricultural Water Management**

4 **Remote sensing for Evapotransipration assessment (SEBAL)**

5 **Remote sensing for irrigation performance assessment**

6 **Water productivity as a tool for design, management, and evaluation of irrigation systems**

7 **Remote Sensing for Water Accounting**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water system modeling	6	0	8	0	0	2	16	32	F.X. Suryadi
2	Land use and Water in Flood Prone Areas	8	0	0	0	0	0	8	24	F.X. Suryadi
3	Remote sensing data for Agricultural Water Management	4	0	2	0	0	0	6	14	X. Cai
4	Remote sensing for Evapotransipration assessment (SEBAL)	6	0	4	0	0	0	10	22	J.D. van Opstal, P. Karimi
5	Remote sensing for irrigation performance assessment	2	0	4	0	0	0	6	10	P. Karimi
6	Water productivity as a tool for design, management, and evaluation of irrigation systems	2	0	2	0	0	0	4	8	X. Cai
7	Remote Sensing for Water Accounting	8	0	6	0	0	0	14	30	P. Karimi
	Total	36	0	26	0	0	2	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

M2185

Short Course on River Restoration and Rehabilitation

Term	201617T10
Coordinator	E.D. de Ruijter van Steveninck
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

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

M3086

Strategic Planning for River Basins and Deltas

Term	201617T10
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 watershed management.

Prerequisites

Affinity with hydrology, development economics, agronomy or geography (preferably a relevant water science or engineering related bachelor's degree or equivalent) and preferably experience in watershed and / or river basin management. Good command of English.

Learning Objectives

1 Understand strategic planning concepts and principles

2 Describe social-physical relations and interdependencies, in particular among water and environmental systems, and socio-economic development

3 Use of the concepts of adaptive and strategic planning and design for developing river basin management and development plans.

4 Use Strategic Environmental Assessment (SEA) as a planning tool for developing sustainable river basin management and development plans.

Assessments

%	Type	Name
50	Assignment	Case study
50	Written examination (closed book)	Written exam (closed book)

Topics

1 Introduction

In this session the participants are introduced to the modules learning objectives, learning activities , and the assessment (case study group assignment and written exam)

Topics

2 River basins as socio-physical systems

Human-water systems, driving forces and development dynamics, interdependencies of land use and development and water and environmental systems, complexity, cross-cutting models and modelling approaches, meta modelling.

3 Strategic planning and design for river basins and deltas

Strategic planning versus programming and project planning; tiering; issues of scale; spatial quality and design, land use planning; design methods from plan development to implementation; river basin/delta governance issues.

Strategic impact assessment, including environmental (SEA), economic and social impact assessment

4 Dealing with Uncertainties

Examples of key social, economic and physical uncertainties in river basin systems Concepts and methods for uncertainty identification and assessment, for system and policy design, and governance. This includes, for example, exploratory analysis, scenario planning, resilience and robustness, adaptive policy making and adaptation pathways.Uncertainties in strategic planning, concepts and methods for uncertainty identification and assessment, and for system and policy design. This includes, for example, exploratory analysis, scenario planning, resilience and robustness, and adaptive policy making.

5 Case study

During the course, students will work on integrated application of the concepts, theories and methods introduced in this course on a case. A limited number of cases will be prepared, so that students can focus on a field of their interest. 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	0	0	1	0	0	0	1	1	J.G. Evers, Y. Jiang
2	River basins as socio-physical systems	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven, Y. Jiang
3	Strategic planning and design for river basins and deltas	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
4	Dealing with Uncertainties	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, B. Gersonius, C. Zevenbergen, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
5	Case study	0	55	0	0	0	0	0	55	A. Mendoza - Sammet, B. Gersonius, C. Zevenbergen, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven, Y. Jiang
	Total	24	55	13	0	0	0	37	140	

Education Material

Scientific journal	Additional reading materials
Lecture notes	Lecture Notes
Digital files	Lecture powerpoint slides

Scientific Software

M3006

Urban Water Systems

Term	201617T10
Coordinator	Z. Vojinovic
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Urban Drainage I (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.

Assessments

%	Type	Name
60	Assignment	Computer workshop, Homework, Class work, participation
40	Written examination (closed book)	Written exam

Topics

1 Urban Water Systems Theory and Workshops

2 Hydrology for Urban Drainage

3 Water Quality for Urban Drainage

4 Impacts on Receiving Environment

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Urban Water Systems Theory and Workshops	20	10	20	0	0	0	40	90	A. Sanchez Torres, N. Trifunovic, Z. Vojinovic
2	Hydrology for Urban Drainage	4	0	0	0	0	0	4	12	P.D.A. Pathirana
3	Water Quality for Urban Drainage	2	4	0	0	0	0	2	10	Z. Vojinovic
4	Impacts on Receiving Environment	1	3	0	0	0	0	1	6	A.B.K. van Griensven, AE Mynett, M.E. McClain
	Total	27	17	20	0	0	0	47	118	

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

Aposs
ArcGIS
Epanet
Mike Flood
Mike Urban
West

M3048

Water Sensitive Cities

Term	201617T10
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

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

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

M2371

Water Treatment Processes and Plants

Term	201617T10
Coordinator	S.K. Sharma
Credit points	5.000000000
Specialization	Core Program

Target Group

Mid-career professionals dealing with technical aspects of water abstraction and drinking water treatment, working for municipal assemblies, water supply companies or consulting agencies.

Prerequisites

BSc degree in Civil Engineering or similar technical background; good command of English language; basic knowledge of water treatment methods.

Learning Objectives

1 apply (gained) knowledge and experience regarding water quality and treatment methods in design, operation & maintenance and rehabilitation of conventional water treatment processes and plants;

2 analyse water quality data and to select the most attractive raw water resource;

3 design and engineer a water treatment plant (conventional and advanced) for both groundwater and surface wate treatment);

4 execute plant performance studies and to evaluate results, as well as to propose improvements in order to rehabilitate a malfunctioning plant;

5 show professional knowledge and know-how for operating (process & quality control, troubleshooting) and maintaining water treatment plants;

6 acquire and improve their skills on problem solving, decision making, oral presentations, writing reports, working i small task forces.

Assessments

%	Type	Name
40	Assignment	Design exercise
60	Oral examination	and presentation

Topics

1 Water Treatment Processes and Plants

Raw water and drinking water quality aspects. Conventional treatment processes for groundwater and surface water. Introduction to process, plant and plant-site design.

Topics

2 Process modelling

Identification of model structure and parameters; integrated hydraulic, water quality models; use of the Stimela model for the design of drinking water plants.

3 Operation & Maintenance and Residual Management

Importance of adequate O&M, O&M of individual units, equipment and plants, Basics of process and quality control, water quality control during all steps of water supply system, Management of residuals: treatment, disposal and reuse

4 Water Treatment Plant Design

Examples/Case studies of the detailed design of conventional water treatment plants

5 Design Exercise WTP

Identification of water resources, comparison and evaluation of various treatment methods and processes for ground and surface water, calculation of water demand, process design, calculation of achieved drinking water quality, calculation of cost, engineering details.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water Treatment Processes and Plants	5	0	4	0	0	0	9	19	JP Buiteman, S.K. Sharma
2	Process modelling	2	0	4	0	0	0	6	10	
3	Operation & Maintenance and Residual Management	4	0	4	0	0	0	8	16	
4	Water Treatment Plant Design	0	0	4	0	7	0	11	11	B. Petrusevski, S.K. Sharma
5	Design Exercise WTP	0	0	0	0	0	28	28	84	JP Buiteman, S.K. Sharma
	Total	11	0	16	0	7	28	62	140	

Education Material

Handout	Sharma, S. (2016) Water Treatment Processes and Plants - Introduction

Scientific Software

Matlab

M3089

Wetlands for Livelihoods and Conservation

Term	201617T10
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 concept of ecosystem functions and services, and means of assessing it;
2 develop adaptive management for wetlands in response to climate change;
3 analyse problems and formulate objectives according to the Objective Oriented Planning (OOP) method;
4 analyse systematically the role that stakeholders have in wetland planning and management;
5 develop and carry out stakeholder interviews and surveys;
6 construct a wetland management plan based on the guidelines of the Ramsar Convention.

Assessments

%	Type	Name
10	Presentation	Group presentation
10	Attendance	Individual performance during fieldweek
80	Assignment	Individual written assignment

Topics

1 Ecosystem functions and services

2 Climate change as a driver of change in wetland management planning

3 Objective Oriented Planning

4 Stakeholder analysis and participatory approaches

5 Assignment

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Ecosystem functions and services	8	0	4	0	16	0	28	44	
2	Climate change as a driver of change in wetland management planning	8	0	4	0	0	0	12	28	
3	Objective Oriented Planning	2	0	16	0	16	0	34	38	
4	Stakeholder analysis and participatory approaches	2	0	14	0	8	0	24	28	
5	Assignment	0	2	0	0	0	0	0	2	
	Total	20	2	38	0	40	0	98	140	

Education Material

Scientific Software

M2602

Advanced Water Transport and Distribution

Term	201617T11
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 distinguish between various sources of water quality problems in distribution networks;understand the basic corrosion mechanisms and suggest the list of preventive and reactive measures;

2 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.

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 select modern tools for monitoring of operation, and planning of maintenance of WTD systems.

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 and corrosion in distribution networks and (3)water hammer (20% each)
28	Assignment	Report on four short assignments regarding advanced water distribution modelling done in WaterGEMS software: (1) Network design using GA optimiser, (2) Network criticality analysis, (3) Water quality analysis,

Topics

1 Water Quality in 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.

2 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.

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 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.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water Quality in Distribution Networks	6	0	0	0	0	4	10	30	N. Trifunovic, S Velickov, S.K. Sharma
2	Advanced Water Distribution Modelling	6	0	12	0	0	6	24	48	N. Trifunovic, S Velickov
3	GIS in Water Distribution	4	0	0	0	0	4	8	24	A. Sanchez Torres, Z. Vojinovic
4	Introduction to Water Hammer	6	0	4	0	4	0	14	26	N. Trifunovic, S Velickov
5	Advanced O&M Practices in Water Distribution	0	4	0	0	8	0	8	12	
	Total	22	4	16	0	12	14	64	140	

Education Material

Lecture notes	S.Sharma - Corrosion of Pipe Materials, lecture notes UNESCO-IHE 2009 (LN/0310/09/1)

Scientific Software

WaterGEMS

M2810

Decentralised Water Supply and Sanitation

Term	201617T11
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

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

Ecological sanitation (introduction to ecosan approach; characteristics of urine, faeces and greywater; overview of technologies for ecosan; treatment aspects for urine, faeces and greywater; conventional on-site sanitation; storage and transport logistics; introduction to anaerobic treatment, composting and constructed wetlands; safe reuse of ecosan products in agriculture with WHO guidelines; financial institutional, social and policy aspects of ecosan). 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 Ecological sanitation

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 of DWSS systems, demand responsive approach; Institutional arrangements (community based management; small-scale independent providers), Financial and Operational aspects (financing, cost recovery, operation and maintenance of DWSS systems)

4.1 Participatory planning and evaluation

4.2 Institutional arrangements

4.3 Financing and cost recovery aspects

4.4 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	
1.2	Introduction to decentralised water supply and sanitation	2	0	0	0	0	0	2	6	
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	
2.2	Rain water harvesting	2	0	2	0	0	0	4	8	
2.3	Small-scale water treatment	6	6	0	0	0	0	6	24	
3	Decentralised Sanitation Systems	0	0	0	0	0	0	0	0	
3.1	Ecological sanitation	6	0	2	0	4	0	12	24	M. Ronteltap
3.2	Soild waste management in small towns and urban poor areas	4	0	0	0	0	0	4	12	M.A. Siebel
3.3	Sanitation planning and strategic tools	2	0	2	0	0	0	4	8	
3.4	Fecal sludge management	2	0	4	0	0	0	6	10	M. Ronteltap
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	M. Mulenga
4.2	Institutional arrangements	2	0	2	0	0	0	4	8	K.H. Schwartz
4.3	Financing and cost recovery aspects	2	0	2	0	0	0	4	8	
4.4	Operation and maintenance aspects	2	0	2	0	0	0	4	8	S.K. Sharma
5	Presentation of the Participants	0	0	6	0	0	0	6	6	S.K. Sharma
	Total	35	8	23	0	4	0	62	140	

Education Material

Handout	Schwartz, K. (2015) Institutional Arranagements (Handouts)
Handout	Siebel, M (2015) Solid Waste Management in Urban Poor Areas (Handouts)

Scientific Software

M2873

Faecal Sludge Management

Term	201617T11
Coordinator	M. Ronteltap
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.

4 Describe the relationship between sanitation and health.

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
15	Assignment	
85	Written examination (closed book)	

Topics

1 Faecal sludge management

Faecal sludge management (FSM) is incredibly important in sanitation. While the focus has been on the provision of toilets mainly in the light of the MDGs, the adequate collection and treatment of the remaining faecal sludge was not always a priority, to say the least. As so many factors play a role in faecal sludge management / climate, hardware, a vast number of stakeholders, willingness to pay, space to store and treat, groundwater pollution, different toilet types / a proper and well-functioning faecal sludge management system is hard to achieve. In this module we will address a holistic approach on FSM. There will be a focus on technology; however, technology cannot be seen separately from planning and management aspects; therefore, non-technical aspects will also be addressed in this module.

2 Public Health

3 Institutional Aspects

4 Collection and Transport

5 Emergency Sanitation

6 Co treatment

7 Sludge characterisation

8 Treatment Mechanisms

9 Operation and Maintenance

10 Financial Aspects

11 Slum sanitation

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	0	0	0	0	0	0	0	0	
2	Public Health	6	0	0	0	0	0	6	18	
3	Institutional Aspects	4	0	4	0	0	0	8	16	
4	Collection and Transport	6	0	0	0	0	0	6	18	
5	Emergency Sanitation	4	0	0	0	0	0	4	12	C.M. Hooijmans
6	Co treatment	2	0	0	0	0	0	2	6	C.M. Lopez Vazquez
7	Sludge characterisation	2	0	0	0	0	0	2	6	M. Ronteltap
8	Treatment Mechanisms	6	6	0	0	0	0	6	24	M. Ronteltap
9	Operation and Maintenance	4	0	0	0	0	0	4	12	M. Mulenga
10	Financial Aspects	6	0	0	0	0	0	6	18	
11	Slum sanitation	2	0	0	0	0	0	2	6	M. Ronteltap
	Total	42	6	4	0	0	0	46	136	

Education Material

Book	Faecal Sludge Management Book (IWA; Editors Linda Strande, Mariska Ronteltap, Damir Brdjanovic)
Handout	Handouts.

Scientific Software

SWMM

sobek-RUR

M3104

Flood Protection in Lowland Areas

Term	201617T11
Coordinator	J.A. Roelvink
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

Basic knowledge of hydraulics, basic knowledge of soil mechanics

Learning Objectives

1 carry out a basic design of dikes, revetments and closure dams

2 understand concepts and advances of flood risk management with due consideration of societal aspects, includin flooding issues in the floodplain and coastal zone, management of flood risk, planning aspects and a variety of no structural measures

3 understand and apply concepts and advances in tools used for coastal flood modelling and flood forecasting

4 understand and apply the principles of flood frequency analysis and risk based approaches to design of hydraulic works

5 understand (the practical application of) probabilistic design theory

Assessments

%	Type	Name
0,4	Written examination (closed book)	Dikes and Revetments (assignment, oral discussion)
0,2	Written examination (closed book)	Probabilistic Design
0,4	Assignment	Storm Impact Modelling

Topics

1 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, design of bottom protection, design methodology for closures; sand closures, stone closures, caisson closures.

2 Dikes and Revetments

Topics

3 Probabilistic design

Theoretical background of probability functions, practical application of probabilistic design, various levels of probability, examples of application of probabilistic design, the use of fault trees, exercise in the application of probabilistic design in coastal engineering problems.

4 Storm Impact modelling

This course focuses on prediction of flooding from the sea, due to tsunamis and storms. Subjects that are treated are causes, models, effects and warning systems related to tsunamis; storm types and characteristics in different areas in the world; storm surge and extreme wave modeling; storm erosion, overtopping and inundation modeling; predictive modeling vs. (probabilistic) modeling for design purposes. Case studies based on Katrina, Ivan, Sidr and the Indian Ocean tsunami. Hands-on exercises using Delft3D and XBeach.

5 Storm Impact modelling

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Dikes and Revetments	8	0	4	0	0	0	12	28	C Dorst
2	Dikes and Revetments	12	0	0	0	0	0	12	36	JH van Dalen
3	Probabilistic design	6	0	6	0	0	0	12	24	M Kok
4	Storm Impact modelling	6	0	5	0	0	0	11	23	J.A. Roelvink
5	Storm Impact modelling	8	0	5	0	0	0	13	29	M van Ormondt
	Total	40	0	20	0	0	0	60	140	

Education Material

Handout	Groot, M.: Handouts, Geotechnical Aspects for Dikes, 2003
Handout	Handout: collection of tutorials and papers related to OpenEarth, Delft3D and XBeach applications
Handout	Hassan, R.M.: handouts, Dikes and Revetments, 2002
Lecture notes	Verhagen, H.J. : Design of closure of dams- Lecture notes ln0052/02
Lecture notes	Verhagen, H.J.: Revetments, Sea Dikes and River Levees-Lecture notes hh292/99/1
Lecture notes	Vrijling, J.K.: Probabilistic Design, Lecture notes ln0217/04/

Scientific Software

Delft3D

Matlab

Xbeach

M3001

Hydroinformatics for Decision Support

Term	201617T11
Coordinator	A. Jonoski
Credit points	5.000000000
Specialization	Core Program

Target Group

Participants from all Master Programmes of UNESCO-IHE. The participants need to choose either *Software technologies for integration* OR *Flood resilience of urban areas and communities*.

Prerequisites

Hydrological and hydraulic modelling concepts; Basic programming skills

Learning Objectives

1 Understand the role of system analysis in water resources planning and management

2 Formulate and solve water resources problems as optimisation problems

3 Distinguish and properly use different types of decision support methods for water problems

4 Build simple software applications that integrate data and models across Internet OR Explain and analyse the key qualities of urban areas and communities that improve resilience for flooding

5 Understand the potential of newly available data sources (e.g. remote sensing, web resources, data generated from climate and meteorological models) in advanced integrated modelling and decision support

Assessments

%	Type	Name
30	Assignment	Exercise report on Decision support systems
30	Assignment	Exercise report on Software technologies for integration OR Assignment Flood resilience
40	Assignment	Exercise report on Systems analysis in water resources

Topics

1 Systems analysis in water resources

Definition and role of systems analysis in engineering planning. Basic concepts. Linear and Dynamic programming for water resources problems. Development and use of static and dynamic stochastic simulation models of river systems. Introduction to decision support systems and their use. Exercises in multipurpose integrated river basin (or regional) water resources management modelling.

Topics

2 Decision support systems

Introduction to decision making process; objectives and alternatives. Optimisation in decision support (single and multi-objective0. Multi-attribute decision methods and tools: formulation of decision matrix, generating and using weights, compensatory and non-compensatory decision methods. Introduction to mDSS4 decision support software; exercises and assignments with case studies implemented in mDSS4.

3 Software technologies for integration OR Flood resilience of urban areas and communities

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.

OR

Introduction to methods for explaining and analysing flood resilience: Manageability of flood impacts in an area. Set of adaptive capacities of a community. Preparedness and emergency response: Protection of critical infrastructure. Building community resilience. Flood insurance.

4 Integration of weather prediction and water models

Approaches and methods for integration of weather models with hydrological and hydraulic models. Integration of remote sensing data. Downscaling and upscaling issues.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Systems analysis in water resources	12	0	4	4	0	0	20	48	DP Loucks
2	Decision support systems	6	0	4	4	0	0	14	30	A. Jonoski, I.I. Popescu
3	Software technologies for integration OR Flood resilience of urban areas and communities	4	0	10	10	0	0	24	42	A. Jonoski, B. Gersonius, C. Zevenbergen, G.A. Corzo Perez, J.L. Alfonso Segura, J.S. Craven, K.A. Anema, S. Rath
4	Integration of weather prediction and water models	4	0	4	0	0	0	8	16	S.J. van Andel
	Total	26	0	22	18	0	0	66	136	

Education Material

Digital files	A. Jonoski, G. Corzo, L. Alfonso, J. Craven: Handouts - Software technologies for Integration exercises
Digital files	A. Jonoski: Introduction to Decision Making and Decision Support Systems (PowerPoint Slides)
Digital files	A. Jonoski: Software Technologies for Integration (PowerPoint Slides)
Digital files	B. Gersonius: Flood resilience of urban areas and communities (PowerPoint Slides)
Lecture notes	D.P. Loucks: Lecture Notes on Water Resource Systems Modelling: Its Role in Planning and Management (chapters 2, 3, 4, 10 and 11)
Handout	I.Popescu: Handout DSS exercises with mDSS4
Digital files	S.J van Andel: Integration of weather prediction and water models (PowerPoint Slides)
Digital files	Software for the subject Software technologies for integration: PMWin, Notepad++ text editor, Apache web server with PHP, Openlayers API, Phonegap

Scientific Software

Lingo

mDSS

M2155

IWRM as a Tool for Adaptation to Climate Change

Term	201617T11
Coordinator	E.D. de Ruijter van Steveninck
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group (Participants in the programmes at IHE) and qualified short course participants.

Prerequisites

Programme prerequisites (BSc in a topic appropriate to UNESCO-IHE programme) and basic knowledge of water management.

Learning Objectives

1 describe the expected impacts of climate change on water resources and water use sectors in relation to (other) human activities

2 identify the consequences of the predicted impacts of climate change and climate variability for integrated water resources management

3 integrate climatic change conditions at different time and spatial scales into (risk) management in the water sector

4 justify decisions on adaption to the impacts of climate change under uncertainty

Assessments

%	Type	Name
30	Presentation	
70	Written examination (closed book)	

Topics

1 IWRM, climate change and the hydrological cycle

Introduction into the concept of IWRM. The climate system and the causes of climate change and variability. Impacts of climate change on the hydrological cycle. Integrating IWRM and climate change.

2 Climate change: impacts and adaptation

Impacts of climate change on the environment and on water use sectors. Adaptation measures and economic aspects.

Topics

3 **Vulnerability and adaptation under uncertainty**

What determines vulnerability to climate change. Adaptation strategies how to adapt under a high level of uncertainty.

4 **Institutional aspects and stakeholder participation**

The importance of involving stakeholders in water management and climate change adaptation and strategies on involving stakeholders.

5 **Multi sector/multicriteria decision making**

Modelling effects of climate change on water resources using Climateland as a case study.

6 **Country presentations**

Presentations by participants covering impacts of climate change and adaptation measures in their countries/ regions.

7 **Field trip**

Field trip to Dordrecht. Adaptation to climate change in an urban setting.

8 **Examination**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	IWRM, climate change and the hydrological cycle	6	0	6	0	0	0	12	24	E.D. de Ruijter van Steveninck, S. Maskey
2	Climate change: impacts and adaptation	17	0	7	0	0	0	24	58	C.M.S. de Fraiture, E.D. de Ruijter van Steveninck, F va der Meulen, I.I. Popescu, P.D.A. Pathirana, T.Y. Stigter, Y. Jiang
3	Vulnerability and adaptation under uncertainty	4	0	2	0	0	0	6	14	A.H.M. Bresser, E.D. de Ruijter van Steveninck
4	Institutional aspects and stakeholder participation	0	0	6	0	0	0	6	6	J.S. Kemerink - Seyoum
5	Multi sector/multicriteria decision making	0	0	26	0	0	0	26	26	J.W. Wenninger, R.G.W. Venneker
6	Country presentations	0	0	3	0	0	0	3	3	E.D. de Ruijter van Steveninck
7	Field trip	0	0	0	0	6	0	6	6	B. Gersonius
8	Examination	0	0	3	0	0	0	3	3	
	Total	27	0	53	0	6	0	86	140	

Education Material

Lecture notes	Lecture notes, power point presentations, background materials

Scientific Software

WEAP

M3092

Innovative Water Systems for Agriculture

Term	201617T11
Coordinator	P. Karimi
Credit points	5.000000000
Specialization	Core Program

Target Group

All WSE participants and from other programmes with specific interest.

Prerequisites

A basic understanding of irrigation and drainage systems design as well as general knowledge about groundwater use in irrigation and different types of pumps.

Learning Objectives

1 Design sprinkler and drip irrigation systems

2 Critically reflect on the different aspects of the use of groundwater in irrigation and discuss the theoretical background related to the groundwater flow

3 Identify the suitability of various types of pumps in specific situations, to define the boundary conditions for the application of pumps and lifting devices, to assess the requirements for operation and maintenance.

4 Discuss the merits and the limitations of the use of solar energy as a renewable resource to support energy demand in irrigation systems

5 Explain the pitfalls of applying conventional design, sediment management, water governance and operation and maintenance models for the development of Flood-based farming systems

6 Explain the basic principles of irrigation in greenhouses and the use of technological advances in modern greenhouses

Assessments

%	Type	Name
0,4	Written examination (open book)	Groundwater for agricultures
0,3	Assignment	Precision Irrigation
0,3	Assignment	Pumps and Lifting Devices

Topics

1 Groundwater for Agriculture

Topics

2 Precision Irrigation

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.

3 Pumps and Lifting Devices

Classification of pumps, pumps with a free water surface, positive displacement pumps, injection pumps, roto-dynamic pumps. Elaboration of roto-dynamic pumps, pump characteristics, efficiency, static, manometric and suction head, cavitation. Impeller design. Performance of pumps running alone or in combination with other pumps. Design of pumping stations; situation, mechanical and electrical installations, driving devices, transmissions. Civil engineering aspects. Inflow conditions. Pressure mains. Tube wells and low-lift pumps. Costs of installations, calculation of annual costs.

4 Solar powered irrigation & drainage

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

5 Irrigation in Greenhouses

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Groundwater for Agriculture	8	0	4	0	0	0	12	28	FE Harvey
2	Precision Irrigation	10	0	6	0	0	0	16	36	F.B. Reinders
3	Pumps and Lifting Devices	10	0	2	0	0	0	12	32	M. Kay
4	Solar powered irrigation & drainage	3	0	3	0	0	0	6	12	P. Karimi
5	Irrigation in Greenhouses	8	0	0	0	0	0	8	24	E.A. van Os
	Total	39	0	15	0	0	0	54	132	

Education Material

Scientific Software

M3014

MSc Preparatory Course and Thesis Research Proposal

Term	201617T11
Coordinator	Y.M. Slokar
Credit points	5.000000000
Specialization	Core Program

Target Group

Students in the joint programme with Universidad del Valle, Cali, Colombia and students in the joint programme with Kwame Nkrumah University of Science and Technology (KNUST), Ghana (Kumasi)

Prerequisites

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

M3012

MSc Preparatory Course and Thesis Research Proposal for UWS

Term	201617T11
Coordinator	Y.M. Slokar
Credit points	9.000000000
Specialization	Core Program

Target Group

Prerequisites

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

M3039

MSc Thesis Research Proposal for AIT

Term	201617T11
Coordinator	E.R. Raj
Credit points	0.000000000
Specialization	Core Program

Target Group

Students of the following joint programme specialisations:

- Urban Water Engineering and Management (UWEM)

- Environmental Technology for Sustainable Development (ETSuD)

- Agricultural Water Management for Enhanced Land and Water Productivity (AWMELWP)

Prerequisites

Learning Objectives

Assessments

%	Type	Name
100	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

M3077

Modelling River Systems and Lakes

Term	201617T11
Coordinator	A. Cattapan
Credit points	5.000000000
Specialization	Core Program

Target Group

All participants in the WSE programme

Prerequisites

Hydraulics & Basic mathematics

Learning Objectives

1 Familiarize participants with structure of equations used to represent water phenomenas, numerical solution techniques and their representation in modelling systems and practical use of these.

2 Provide participants practical experience with standard models and develop an understanding of modelling in rive and lake systems

3 Understanding rainfall run-off processes that will contribute to river flow and applying them to determine flow hydrographs as upstream conditions to a river

4 Develop critical assessment in assessing quality of model calibration and validation, verification and uncertainty

Assessments

%	Type	Name
40	Assignment	This component is comprised of 3 components, assignments on modelling subjects of the module. (20%) Lake modelling + (10%) Hec-RAS modelling + (10%) Hec-HMS modelling
30	Written examination (closed book)	This component reffers to the Computational Hydraulics subject. (30%)
30	Written examination (closed book)	This component reffers to the hydrological and river modelling part of the course. (30%)

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 **Model quality assessment & uncertainty**

Practical concepts for analysing quality of models used in modelling water resources. Techniques for calibration and validation. Sensitivity analysis and uncertainty estimation. Verification methods.

3 **modelling river flow and corresponding hydrological run-off contributions**

Description of rainfall run-off processes. Mathematical represeentation of flow processes both at catchment and river scales.

4 **Modelling Applications: Hydrology**

Practical experience with computational numerical models will be gained by students. The objective of this component will be the application of the theory gained in the theoretical components of the course using HEC-HMS for practical examples.

5 **Modelling Applications: lakes**

Practical experience with computational numerical models will be gained by students. The objective of this component will be the application of the theory gained in the theoretical components of the course.

6 **Modelling Applications: rivers**

Practical experience with computational numerical models will be gained by students. The objective of this component will be the application of the theory gained in the theoretical components of the course using HEC-RAS for practical examples.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Computational Hydraulics	6	0	8	0	0	0	14	26	I.I. Popescu
2	Model quality assessment & uncertainty	2	0	0	0	0	0	2	6	I.I. Popescu
3	modelling river flow and corresponding hydrological run-off contributions	2	0	0	0	0	0	2	6	I.I. Popescu
4	Modelling Applications: Hydrology	0	0	0	12	0	0	12	24	I.I. Popescu
5	Modelling Applications: lakes	4	0	0	14	0	0	18	40	FA Bastos da Cruz Martins
6	Modelling Applications: rivers	0	0	0	16	0	0	16	32	A. Cattapan
	Total	14	0	8	42	0	0	64	134	

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
HEC-HMS
HEC-RAS
Mohid

M3027

Remote Sensing, GIS and Modelling for Agricultural Water Use

Term	201617T11
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 GIS and remote sensing.

Learning Objectives

1	Explain the use of modern tools as RS and GIS in combination with the use of computer models
2	Explain and use the principles of Surefce Energy Balance in estimating Evapotranspiration
3	Reflect on the advanced applications of RS in irrigation management
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	Reflect on the importance of environmental and socio-economic consideration in the low land and flood prone araes and prepare the operation and maintenance and management plans and options.

Assessments

%	Type	Name
0,6	Assignment	Irrigation and remote sensing
0,25	Written examination (open book)	Low lands and flood prone areas
0,15	Assignment	Water system modeling & GIS

Topics

1 Water system modeling

Water management system of land and water development, the use of computer models in the design, operation and maintenance of hydraulic control structures, pumping stations, etc., calibration, verification and sensitivity analysis of the model, and hydraulic performance of the water management system. The use of GIS in analyzing and evaluating land suitability, drainability and irrigability of an area.

Topics

2 **Land use and Water in Flood Prone Areas**

Basic principle of lowland and flood prone areas development; - to create optimal conditions for agriculture as well as urban; - components of polder water management systems; - to create an understanding of the consequences of applying certain infrastructural layouts and water management techniques; effect of sea level rise and land subsidence to lowland and flood prone areas; - design aspects of lowlands and flood prone areas; -operation, maintenance, socio-economic and environmental considerations of lowland and flood prone areas development; - modeling of polder water management systems

3 **Remote sensing data for Agricultural Water Management**

4 **Remote sensing for Evapotransipration assessment (SEBAL)**

5 **Remote sensing for irrigation performance assessment**

6 **Water productivity as a tool for design, management, and evaluation of irrigation systems**

7 **Remote Sensing for Water Accounting**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water system modeling	6	0	8	0	0	2	16	32	F.X. Suryadi
2	Land use and Water in Flood Prone Areas	8	0	0	0	0	0	8	24	F.X. Suryadi
3	Remote sensing data for Agricultural Water Management	4	0	2	0	0	0	6	14	X. Cai
4	Remote sensing for Evapotransipration assessment (SEBAL)	6	0	4	0	0	0	10	22	J.D. van Opstal, P. Karimi
5	Remote sensing for irrigation performance assessment	2	0	4	0	0	0	6	10	P. Karimi
6	Water productivity as a tool for design, management, and evaluation of irrigation systems	2	0	2	0	0	0	4	8	X. Cai
7	Remote Sensing for Water Accounting	8	0	6	0	0	0	14	30	P. Karimi
	Total	36	0	26	0	0	2	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

M1331

Solid Waste Management

Term	201617T11
Coordinator	M.A. Siebel
Credit points	5.000000000
Specialization	Core Program

Target Group

Engineers, academicians, staff from Non-Government Organizations, Community-based Organizations, politicians, health officials, students, scientists, local, regional or national government officials, etc., involved or interested in the management of solid waste.

Prerequisites

1) Involved in or familiar with one or more of the key elements of solid waste management, or 2) having studied the topic in a formal educational setting, or 3) having a university engineering degree.

Learning Objectives

1 suggest options for waste reduction at source so as to reduce quantities of waste generated;

2 choose from an array of options to turn waste into economic goods;

3 suggest treatment/disposal methods for waste from which the value has been taken out and to make basic calculations related to the conceptual design thereof;

4 assess the impact of waste and waste management on other environmental compartments;

5 roughly assess financial consequences of proposed management aspects in SWM;

6 conceptually develop a solid waste management scheme for an urban area.

Assessments

%	Type	Name
35	Assignment	All s together
60	Written examination (open book)	MOODLE multiple choice
5	Presentation	Presentation Participation in class or fora

Topics

1 Introduction

what is solid waste? what are the key problems (social, financial, environmental)? who are involved?

2 Waste collection & stakeholders

How/why is SW generated? how can generation be reduced? what are collection schemes & means, what means waste separation? at what point in the process? what are advantages? how can separation/reuse be stimulated?

Topics

3 Bioconversion processes

4 Composting & anaerobic digestion

5 Landfill processes

6 Landfill technology

What are main waste management technolgies? in more or in less developed countries? design elements, application areas? GHG issues

7 Mechanical biologial treatment

8 Incineration

9 Waste prevention & recycling

10 Finance & planning

11 Presentations

12 Assignments

13 Exam

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	4	0	0	0	4	4	M.A. Siebel
2	Waste collection & stakeholders	1	0	9	0	0	0	10	12	M.A. Siebel, VS Rotter
3	Bioconversion processes	0	0	6	0	0	0	6	6	VS Rotter
4	Composting & anaerobic digestion	1	0	9	0	4	0	14	16	VS Rotter
5	Landfill processes	0	0	6	0	0	0	6	6	VS Rotter
6	Landfill technology	1	0	7	0	4	0	12	14	VS Rotter
7	Mechanical biologial treatment	1	0	5	0	0	0	6	8	VS Rotter
8	Incineration	1	0	7	0	0	0	8	10	VS Rotter
9	Waste prevention & recycling	1	0	5	0	2	0	8	10	M.A. Siebel
10	Finance & planning	0	0	12	0	0	0	12	12	Abarca Guerrero
11	Presentations	0	0	4	0	0	0	4	4	M.A. Siebel, VS Rotter
12	Assignments	0	24	0	0	0	0	0	24	M.A. Siebel, VS Rotter
13	Exam	0	10	4	0	0	0	4	14	M.A. Siebel
	Total	6	34	78	0	10	0	94	140	

Education Material

Book	1) PPT's; reviewed paper; BOOK: Waste Technology and Management; BOOK: Vital waste statistics
Book	2) PPT's; reviewed paper; BOOK: From waste to resource; BOOK: Solid Waste Management in World Cities
Book	3) PPT's; reviewed paper; BOOK: Waste Technology and Management; Video: Anaerobic degradation processes
Book	4) PPT's; reviewed paper; BOOK: Waste Technology and Management; Video Bioreactor Landfill; UNEP SWM Landfill chapter
Book	5) PPT's; reviewed paper; BOOK: Waste Technology and Management
Book	6) PPT's; reviewed paper; BOOK: Waste Technology and Management

Scientific Software

M3086

Strategic Planning for River Basins and Deltas

Term	201617T11
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 watershed management.

Prerequisites

Affinity with hydrology, development economics, agronomy or geography (preferably a relevant water science or engineering related bachelor’s degree or equivalent) and preferably experience in watershed and / or river basin management. Good command of English.

Learning Objectives

1 Understand strategic planning concepts and principles

2 Describe social-physical relations and interdependencies, in particular among water and environmental systems, and socio-economic development

3 Use of the concepts of adaptive and strategic planning and design for developing river basin management and development plans.

4 Use Strategic Environmental Assessment (SEA) as a planning tool for developing sustainable river basin management and development plans.

Assessments

%	Type	Name
50	Assignment	Case study
50	Written examination (closed book)	Written exam (closed book)

Topics

1 Introduction

In this session the participants are introduced to the modules learning objectives, learning activities , and the assessment (case study group assignment and written exam)

Topics

2 River basins as socio-physical systems

Human-water systems, driving forces and development dynamics, interdependencies of land use and development and water and environmental systems, complexity, cross-cutting models and modelling approaches, meta modelling.

3 Strategic planning and design for river basins and deltas

Strategic planning versus programming and project planning; tiering; issues of scale; spatial quality and design, land use planning; design methods from plan development to implementation; river basin/delta governance issues.

Strategic impact assessment, including environmental (SEA), economic and social impact assessment

4 Dealing with Uncertainties

Examples of key social, economic and physical uncertainties in river basin systems Concepts and methods for uncertainty identification and assessment, for system and policy design, and governance. This includes, for example, exploratory analysis, scenario planning, resilience and robustness, adaptive policy making and adaptation pathways.Uncertainties in strategic planning, concepts and methods for uncertainty identification and assessment, and for system and policy design. This includes, for example, exploratory analysis, scenario planning, resilience and robustness, and adaptive policy making.

5 Case study

During the course, students will work on integrated application of the concepts, theories and methods introduced in this course on a case. A limited number of cases will be prepared, so that students can focus on a field of their interest. 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	0	0	1	0	0	0	1	1	J.G. Evers, Y. Jiang
2	River basins as socio-physical systems	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven, Y. Jiang
3	Strategic planning and design for river basins and deltas	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
4	Dealing with Uncertainties	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, B. Gersonius, C. Zevenbergen, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
5	Case study	0	55	0	0	0	0	0	55	A. Mendoza - Sammet, B. Gersonius, C. Zevenbergen, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven, Y. Jiang
	Total	24	55	13	0	0	0	37	140	

Education Material

Scientific journal	Additional reading materials
Lecture notes	Lecture Notes
Digital files	Lecture powerpoint slides

Scientific Software

M1568

Urban Water Governance

Term	201617T11
Coordinator	T. Acevedo Guerrero
Credit points	5.000000000
Specialization	Core Program

Target Group

The module is elective, and therefore open to all students within the WM stream, but it will build on key concepts introduced in the Water Governance core module. Students who have not taken this previous module will be expected to do additional reading to familiarize themselves with necessary terms and concepts. This module is run on the style of a seminar class. Students will be required to do the majority of work (reading, assignments) outside of class. Class time will then be used to discuss and debate what students have learned through self-study.

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 southern cities in all their speed and complexity. As AbdouMaliq Simone (in his 2004 epic For the City Yet to Come, p. 1) puts it:"African cities are works in progress, at the same time exceedingly creative and extremely stalled. In city after city, one can witness an incessant throbbing produced by the intense proximity of hundreds of activities: cooking, reciting, selling, loading and unloading, fighting, praying, relaxing, pounding, and buying, all side by side on stages too cramped, too deteriorated, too cloged with waste, history, and disparate energy, and sweat to sustain all of them. And yet they persist".

Learning Objectives

1 Define key terms: the "urban", "urban waters", "governance", according to assigned readings, learning activities, and class lectures;

2 Identify implications of the above definitions for urban water governance (how to define and diagnose; identify stakeholders);

3 Analyze the ways in which urban waters channel the politics of the city in presented case studies.

Assessments

%	Type	Name
30	Assignment	3 pre-class written assignments topics 1,2,3

30	Assignment	Final Essay
40	Assignment	Groupwork

Topics

1 **Introduction to the module**

2 **Refresher: water governance**

3 **Urban futures**

What conditions characterize current and future urban conditions, in terms of ecological sustainability and social equity?

4 **What is the urban?**

How do we define the urban as something more than a spatial category, and what does thinking about the urban as a process imply for thinking about water?

5 **Case study: planetary urbanization**

6 **What is the Southern urban?**

What is a southern urbanism; what conditions characterize processes happening in the global South; how do we need to think - and intervene - in Southern cities differently than in the North?

7 **Case study: water in the southern city**

8 **The politics of water in the southern city**

9 **What then is urban water governance?**

What are the implications for how we rethink the urban, and southern cities, for how we think about governing water in cities?

10 **What then is urban water governance?**

What are the implications for how we rethink the urban, and southern cities, for how we think about governing water in cities?

11 **Tutorial**

12 **Individual and group assignments**

13 **Essay assignment**

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 module	1	0	0	0	0	0	1	3	M.E. Kooy
2	Refresher: water governance	1	0	0	0	0	0	1	3	M.E. Kooy
3	Urban futures	2	0	0	0	0	0	2	6	M.E. Kooy
4	What is the urban?	2	0	0	0	0	0	2	6	M.E. Kooy
5	Case study: planetary urbanization	2	0	0	0	0	0	2	6	
6	What is the Southern urban?	2	0	0	0	0	0	2	6	M.E. Kooy
7	Case study: water in the southern city	3	0	0	0	0	0	3	9	M.E. Kooy
8	The politics of water in the southern city	3	0	0	0	0	0	3	9	M.E. Kooy
9	What then is urban water governance?	2	0	0	0	0	0	2	6	M.E. Kooy
10	What then is urban water governance?	2	0	0	0	0	0	2	6	M.E. Kooy
11	Tutorial	0	1	0	0	0	0	0	1	
12	Individual and group assignments	0	48	0	0	0	0	0	48	
13	Essay assignment	0	30	0	0	0	0	0	30	
	Total	20	79	0	0	0	0	20	139	

Education Material

Scientific Software

M3048

Water Sensitive Cities

Term	201617T11
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

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

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

M3089

Wetlands for Livelihoods and Conservation

Term	201617T11
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 concept of ecosystem functions and services, and means of assessing it;
2 develop adaptive management for wetlands in response to climate change;
3 analyse problems and formulate objectives according to the Objective Oriented Planning (OOP) method;
4 analyse systematically the role that stakeholders have in wetland planning and management;
5 develop and carry out stakeholder interviews and surveys;
6 construct a wetland management plan based on the guidelines of the Ramsar Convention.

Assessments

%	Type	Name
10	Presentation	Group presentation
10	Attendance	Individual performance during fieldweek
80	Assignment	Individual written assignment

Topics

1 Ecosystem functions and services

2 Climate change as a driver of change in wetland management planning

3 Objective Oriented Planning

4 Stakeholder analysis and participatory approaches

5 Assignment

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Ecosystem functions and services	8	0	4	0	16	0	28	44	
2	Climate change as a driver of change in wetland management planning	8	0	4	0	0	0	12	28	
3	Objective Oriented Planning	2	0	16	0	16	0	34	38	
4	Stakeholder analysis and participatory approaches	2	0	14	0	8	0	24	28	
5	Assignment	0	2	0	0	0	0	0	2	
	Total	20	2	38	0	40	0	98	140	

Education Material

Scientific Software

M3106

Summer Course - Becoming a Water Leader

Term	201617T12
Coordinator	C.W.H. Keuls
Credit points	1.000000000
Specialization	

Target Group

Max. 20 interested and motivated MSc participants.

Prerequisites

Prerequisite is the will and committment to self develop and explore your potential water leadership. Active participation of all participants is required to work on their personal leadership development.

Learning Objectives

1 Present their individual strengths and styles as a leader
2 Explain the difference between leadership and management
3 Understand how leadership is expressed as influence
4 Choose from different leadership approaches to suit a situation
5 Expand their situational awareness for effective leadership
6 Interpret intercultural dimensions of leadership
7 Implement a personal leadership development plan

Assessments

%	Type	Name
1	Assignment	Individual Leadership development plan
1	Attendance	Summer course

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

Handout	Several handouts regarding aspects of water leadership

Scientific Software

M3142

Summer Course - Environmental and Social Management Systems for the Water Sector

Term	201617T12
Coordinator	A. Mendoza - Sammet
Credit points	1.000000000
Specialization	

Target Group

The course is directed to professional interested in learning the basis of environmental and social management systems. This includes their application to improving the performance of water sector organizations, projects, and public or private organizations.

Prerequisites

A basic understanding of these concepts is required as a foundation for the course

- Environmental Performance
- Environmental Impact
- Social Impact
- Mitigation measures

Learning Objectives

1 Understand the principles of Environmental Management Systems (EMS), their evolution into Environmental and Social Management Systems (ESMS), and their application to improve the sustainable management of water resources and water development projects.

2 Describe differences and similarities between the key elements of an EMS and an ESMS, and explain the advantages that each one has for private and public water organizations.

3 Apply their learning to outline the elements of an ESMS for a water infrastructure development

Assessments

%	Type	Name
1	Attendance	
1	Assignment	Draft Enviromental and Social Management system and plan

Topics

1 Basis of Environmental Management Systems

Basic concepts in Environmental Management and environmental auditing

2 ESMS and sustainable development

Guidnace for ESMS

- Role of ESMS to reduce and manage risks and impacts
- ISO standards for EMS, EMAS standard
- Development and International standards for ESMS

3 The Environmental and Social mangement Plan (ESMP): Applications of ESMS

From the EMS to the ESMP and follow-up

Examples of applications of ESMS/ESMP

- In the water sector and
- Project developments

4 Exercise

Drafting an ESMS for a case study

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Basis of Environmental Management Systems	6	0	2	0	0	0	8	20	A. Mendoza - Sammet
2	ESMS and sustainable development	4	0	4	0	0	0	8	16	A. Mendoza - Sammet
3	The Environmental and Social mangement Plan (ESMP): Applications of ESMS	3	0	5	0	0	0	8	14	A. Mendoza - Sammet
4	Exercise	1	0	7	0	0	0	8	10	A. Mendoza - Sammet
	Total	14	0	18	0	0	0	32	60	

Education Material

Digital files	Journal articles and web resources
Handout	Lecture notes

Scientific Software

M3141

Summer Course - Nature Based Solutions in Water Management

Term	201617T12
Coordinator	C. Zevenbergen
Credit points	1.000000000
Specialization	

Target Group

This course offers a multidisciplinary program with short introductions from the different Water Management fields such as coastal management, urban flood management, Land & Water management, sanitation and wetland management.

Hence, the target group is broad.

Prerequisites

This course is a general introduction to the topic of NBS.

Learning Objectives

1 Define the basic design and operation principles of Nature Based Solutions

2 Explain how these principles work in in the fields of water engineering, water management, water supply and sanitation in practice for a number of case studies across the world

3 Apply these principles in a concrete context (e.g. related to his/her home country)

Assessments

%	Type	Name
1	Presentation	Groupwork (poster session) and Group Presentations

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

M3140

Summer Course - Visual Methods for Water Communication

Term	201617T12
Coordinator	E. Fantini
Credit points	1.000000000
Specialization	

Target Group

The course aims at offering an introduction to visual methods to students and water professionals with different backgrounds (engineering, social sciences, and natural sciences).

The course is trans-disciplinary since it builds not only on academic competences from different chairgroups (Water Governance, Hydro informatics, River Basin Development) but also on media and communication professionals.

Prerequisites

Participants must have a smartphone (android or apple) capable of filming and a laptop for editing.

Learning Objectives

1 The course aims at building students theoretical and practical skills to apply visual methods (photography and video) to communicate water issues related to their research or their professional work.

2 The course will equip students to communicate techno-scientific issues related to water to broader audiences and the general public.

3 The course will equip students to facilitate communication between different stakeholders involved in water governance and water conflicts by dint of visual tools (photos and documentary).

Assessments

%	Type	Name
1	Attendance	
1	Presentation	Peer-evaluation: students will be invited to give feedback on the work of their peers during the public presentation of videos and photos.
1	Oral examination	Self-assessment: students will be invited to evaluate their own work and the overall course by dint of a video-box (a booth with a camera) where they can record their messages.

1	Presentation	Students will be assessed on the outputs of the workshops by the workshops coordinators.

Topics

E1 Special event: “Show and tell evening”

Students will be invited to practice their presentation skills by sharing visual/artistic products to introduce their country and their work.

E2 Special event: Movie night

Screening of video documentaries on water issues (in collaboration with

This event is organised in collaboration with "Let’s talk about water" film festival and Filmhuis Lumen, and it will be open to the public.

E3 Special event: FInal presentation

Students will present and discuss their outputs (videos and photos) first in class and then during a session open to the public.

Courses activities, events and outputs will be shared through social media throughout the week.

L1 Introduction to participatory visual research on water governance

The lecture will present the Photovoice, a participatory visual research method whose objectives are: (1) to enable people to record and reflect their community's strengths and concerns, (2) to promote critical dialogue and knowledge about important issues through large and small group discussion of photographs, and (3) to reach policymakers.

Photovoice method places the camera in the hands of research participants – usually small groups of maximum 20 persons - , asking them to take pictures about the matter of concern for at least one week. Pictures are later used to elicit information and reflection on participants’ life experiences, both in individual interviews and group discussions, to raise awareness, trigger debate, and instigate social change. To these ends, visual outputs are often presented to the wider community or policy makers by dint of photo-exhibitions, publications or public events.

L2 Video as a tool for education in water governance

L3 Video as a research tool on everyday waters in Mozambique

L4 Visualisation for water communication

Topics

L5 Water from Above: how changing the viewing perspective let you understand reality from a different perspective

The use of Unmanned Aerial Vehicles (UAV) or Commercial Drones has revolutionized the aerial photography and videography in recent years. It is used by Human Rights Associations as well as Environmental groups, Journalists and Natural Resource Managers among others. During this seminar you will learn the basics, potential and limitations of this technology and you will play with some data that have been collected by the Lecturer.

W1 Photovoice

Student will apply the Photovoice methods to document and reflect on everyday water issues in Delft.

Output: a photo exhibition/presentation.

W2 Video storytelling

Students will learn to report, shoot and edit short video stories.

Output: short videos designed specifically for the web.

Coordinator: Roland Postma (Ventoux-The Flow of Water)

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
E1	Special event: “Show and tell evening”	0	0	2	0	0	0	2	2	
E2	Special event: Movie night	0	0	3	0	0	0	3	3	
E3	Special event: FInal presentation	0	0	3	0	0	0	3	3	
L1	Introduction to participatory visual research on water governance	2	0	0	0	0	0	2	6	E. Fantini
L2	Video as a tool for education in water governance	2	0	0	0	0	0	2	6	J.S. Kemerink - Seyoum
L3	Video as a research tool on everyday waters in Mozambique	2	0	0	0	0	0	2	6	M. Rusca
L4	Visualisation for water communication	2	0	0	0	0	0	2	6	J.S. Craven
L5	Water from Above: how changing the viewing perspective let you understand reality from a different perspective	2	0	0	0	0	0	2	6	P. Paron
W1	Photovoice	0	0	4	0	0	0	4	4	E. Fantini
W2	Video storytelling	0	0	9	0	8	0	17	17	
	Total	10	0	21	0	8	0	39	59	

Education Material

Scientific Software

M3139

Summer Course - Water Accounting Plus for Standardized Reporting of Water Resources in River Basins

Term	201617T12
Coordinator	E. Salvadore
Credit points	1.000000000
Specialization	

Target Group

25-30 participants.

Academic IHE-Delft students and external participants from national and international, public and private water sector.

Prerequisites

Basic knowloedge of hydrology, GIS.

Knowledge of Remote Sensing can be an advantage.

Learning Objectives

1 Becoming familiar with the concept of Water Accounting, and specifically with the Water Accounting Plus framework
2 Gain knowledge existing open access databases for (RS) water related data
3 Being able to perform simple spatial calculations (using QGIS for Water Accounting)
4 Learn how to compute water productivity
5 Being able to understand (interpret) the WA+ accounting sheets. How can I use WA+ fact sheets to support IWRM
6 Being able to understand and use Water-Pix (pixel-based RS water balance tool)
7 Learn how to separate evapotranspiration (ET) into green and blue ET

Assessments

%	Type	Name

Topics

1 FUNDAMENTAL CONCEPTS OF WATER ACCOUNTING PLUS (WA+)

Introduction to the need of an open access data. Discussion of the power of having verified information on water budgets for water policy negotiations and water management in general. Introduction to the Water Accounting Plus system. Fundamental concepts: water balance, green and blue water consumption, Budyko theory, explain coupled radiation - energy - water - carbon balances, consumptive and non-consumptive use, return flows, atmospheric moisture recycling. Theory and excel exercises (ET separation, water budget, green and blue water).

2 ACCOUNTING SHEETS AND SPATIAL DATA

Group discussion on major challenges in water management. Computational steps of the Water Accounting Plus framework. Sheet 1,2 and 3: theory, exercise and group discussion. Discuss exploitable, available, utilized, non-utilized and utilizable flows in river basin. Introduction to earth observation science and the progress achieved on spatially identifying hydrological processes (rainfall, evapotranspiration, soil moisture, water levels, land use, net primary production) and water management (withdrawals, irrigation, drainage) from satellite measurements. Hands-on QGIS. DEMO on spatial data platform from where water resources related information can be collected. Introduction to the case study: Tonle Sap basin (Cambodia), QGIS exercise: coordinate reference system, basic statistics per land use using Remote Sensing Data

3 ACCOUNTING SHEETS AND SPATIAL DATA (QGIS HANDS-ON)

Sheet 4, 5, 6, 7, and 8: theory, exercises and group discussion. Spatial data analysis: QGIS hands-on exercises (bias correction of Remote Sensing Precipitation, ET separation into green and blue water, ET partitioning into beneficial and non-beneficial, Remote Sensing vegetation data)

4 WATER PRODUCTIVITY AND HYDROLOGICAL MODELING

Introduction to Water Productivity. Exercises on: Net Primary Production, accumulated biomass production and crop yield, biomass water productivity and crop water productivity (target values). Hydrological modelling of the earth systems with and without remote sensing assimilation. Exercise on soil moisture and surface runoff. Introduction to Water-Pix, pixel-based water balance, groundwater recharge and abstraction, exercises.

5 CASE STUDY, DISCUSSION AND CLOSING REMARKS

Group work: prepare and discuss Sheet 1, Sheet 2 and Sheet 3 for the Tonle Sap basin, accounting sheets interpretation and scenario analysis. Discuss the services and benefits from water depletion, including agricultural and ecosystem services. Discuss sustainability of basin current and future conditions. Link these processes to water flows and fluxes. DEMO: water accounting software repository (GitHub). Closing remarks and final group discussion

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	FUNDAMENTAL CONCEPTS OF WATER ACCOUNTING PLUS (WA+)	8	0	0	0	0	0	8	24	C.I.B. Michailovsky, E. Salvadore, W.G.M. Bastiaanssen
2	ACCOUNTING SHEETS AND SPATIAL DATA	8	0	0	0	0	0	8	24	C.I.B. Michailovsky, E. Salvadore, H.M. Coerver, W.G.M. Bastiaanssen
3	ACCOUNTING SHEETS AND SPATIAL DATA (QGIS HANDS-ON)	8	0	0	0	0	0	8	24	C.I.B. Michailovsky, E. Salvadore, H.M. Coerver, W.G.M. Bastiaanssen
4	WATER PRODUCTIVITY AND HYDROLOGICAL MODELING	0	0	0	0	0	0	0	0	E. Salvadore, G.E. Espinoza Davalos, J.D. van Opstal
5	CASE STUDY, DISCUSSION AND CLOSING REMARKS	8	0	0	0	0	0	8	24	C.I.B. Michailovsky, E. Salvadore, H.M. Coerver, W.G.M. Bastiaanssen
	Total	32	0	0	0	0	0	32	96	

Education Material

Handout	Accounting Sheets for the group exercise
Lecture notes	presentations and notes explaining the exercises
Digital files	various Remote Sensing spatial data

Scientific Software

QGis

M3138

Summer Course - Water Diplomacy

Term	201617T12
Coordinator	Z.S. Shubber
Credit points	1.000000000
Specialization	

Target Group

Water professionals, water diplomats or professionals involved in water diplomacy activities interested in broadening their understanding of concepts, challenges and tools relating to water diplomacy. These range from the resource itself to the skills required to navigate and manage water related disputes.

Prerequisites

Basic knowledge of water; some experience of or involvement in water related conflicts or disputes.

Learning Objectives

1 Critically discuss the concept of water diplomacy and its implications
2 Identify and understand key concepts, relevant frameworks and challenges relating to water conflict and cooperation, including interdependencies (climate change, food, energy, etc.)
3 Distinguish between different conflict resolution mechanisms
4 Apply an analytical framework to prepare for, engage with and resolve latent or actual water related disputes
5 Understand, recognize and respond to water negotiation processes
6 Apply acquired skills and competencies in negotiation in the context of water projects, including dealing with uncertainty, science, and deadlocks in negotiations

Assessments

%	Type	Name
1	Assignment	

Topics

1 Water diplomacy

2 Conflict analysis and resolution

3 Negotiations

Topics

4 Case studies

5 Role play

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Water diplomacy	0	0	0	0	0	0	0	0	
2	Conflict analysis and resolution	0	0	0	0	0	0	0	0	
3	Negotiations	0	0	0	0	0	0	0	0	
4	Case studies	0	0	0	0	0	0	0	0	
5	Role play	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3108

Summer Course Asset Management of Water Systems

Term	201617T12
Coordinator	P.D.A. Pathirana
Credit points	1.000000000
Specialization	

Target Group

Water professionals and enthusiasts (anyone who is interested in the water sector, its issues, solutions etc.).

Prerequisites

There are no special entry requirements for this course. It being a post-graduate course however, you are required to already posess a batchelors' degree or higher.

Learning Objectives

1 Explain why expertise on asset management is beneficial for water engineers, managers and other water experts

2 Argue that asset management as a subject, (while initially developed in the countries like the UK, Canada, Australia and the USA, it is even more) relevant to the developing countries

3 List and explain the essential components of an asset management plan

4 Explain how risk-based decisions can be made in a given water utility/system

5 Describe condition assessment methods, particularly for buried assets

6 Argue that establishing criteria for significance (failure consequence) assessment of asset components is a context-specific task that demands intimate knowledge about the asset system, its stake-holders and background

7 Demonstrate how significance assessment is performed for an asset system under a simple failure criterion and Develop a simple asset management framework for a water utility/system

Assessments

%	Type	Name
1	Attendance	Summer course

Topics

01 Why Asset Management? Historical and current perspectives

Topics

02 Asset management principles and practice

03 Asset management in Dutch flood protection programmes

04 Challenges for infrastructure today and scenario planning exercise

05 Asset Management and oppotunistic adaptaion

06 Optimization in Asset Management - computer workshop

07 Asset Management of Large scale flood management infrastructure - with case studies from the UK

07 Risk based asset management (example Water distribution networks)

Computer exercise

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
01	Why Asset Management? Historical and current perspectives	1	1	0	0	0	0	1	4	P.D.A. Pathirana
02	Asset management principles and practice	1	0	0	0	0	0	1	3	P.D.A. Pathirana
03	Asset management in Dutch flood protection programmes	2	0	0	0	0	0	2	6	
04	Challenges for infrastructure today and scenario planning exercise	1	0	2	0	0	0	3	5	
05	Asset Management and oppotunistic adaptaion	2	0	0	0	0	0	2	6	
06	Optimization in Asset Management - computer workshop	1	0	3	0	0	0	4	6	P.D.A. Pathirana
07	Asset Management of Large scale flood management infrastructure - with case studies from the UK	6	0	0	0	0	0	6	18	PB Sayers
07	Risk based asset management (example Water distribution networks)	0	0	2	0	0	0	2	2	P.D.A. Pathirana
	Total	14	1	7	0	0	0	21	50	

Education Material

Scientific Software

M3062

World History of Water Management

Term	201617T12
Coordinator	L.G. Hayde
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

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

M2240

Groupwork ES

Term	201617T13
Coordinator	J.J.A. van Bruggen
Credit points	5.000000000
Specialization	Core Program

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Solve complex environmental problems by integrating the content of the preceding modules
2 Make decisions on the basis of a limited amount of information
3 Work in a team to solve complex environmental problems

Assessments

%	Type	Name
100	Assignment	The assessment is based on the final report, the oral presentations and the individual co

Topics

1 Introduction

The group work Ghana consists of a case study in which the techniques and knowledge obtained in the preceding modules are integrated. The group work is located in the Densu Basin in Ghana. This basin is facing enormous environmental problems, which have to be addressed by the participants in their role as consultant or EPA member. During the group work participants have progress meetings with UNESCO-IHE staff (government), they give progress presentations, a final presentation and they write a final report.

The participants are distributed, in a roleplay, over three consultants and one Environmental Protection Agency.

2 Progress Meetings

Meetings with IHE staff to discuss progress

3 Progress Presentations

Topics

4 Working in groups and report writing.

5 Final presentation

6 Final report

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction	0	2	0	0	0	0	0	2	A. Mendoza - Sammet, J.G. Evers, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg N.P. van der Steen
2	Progress Meetings	0	0	6	0	0	0	6	6	A. Mendoza - Sammet, J.G. Evers, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg N.P. van der Steen
3	Progress Presentations	0	12	0	0	0	0	0	12	A. Mendoza - Sammet, J.G. Evers, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg N.P. van der Steen
4	Working in groups and report writing.	0	0	100	0	0	0	100	100	A. Mendoza - Sammet, J.G. Evers, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg N.P. van der Steen
5	Final presentation	0	4	0	0	0	0	0	4	A. Mendoza - Sammet, J.G. Evers, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg N.P. van der Steen
6	Final report	0	16	0	0	0	0	0	16	A. Mendoza - Sammet, J.G. Evers, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg N.P. van der Steen
	Total	0	34	106	0	0	0	106	140	

Education Material

Handout	Ghana Densu Basin
Digital files	Selected literature is available

Scientific Software

M3114

Groupwork Sint Maarten

Term	201617T13
Coordinator	Y.M. Slokar
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

Learning Objectives

1 Apply and integrate the knowledge obtained during the specialisation to solve water and sanitation related issues

2 Analyze complex water and sanitation issues in a limited time frame and with limited background information available.

3 Defend his/her input in an (interdisciplinary) team of specialists.

4 Assess his/her own strengths and weaknesses with respect to working in a group.

5 Recommend engineering solutions to water and sanitation related problems.

6 Defend the groups' findings in front of a team of experts in the field.

Assessments

%	Type	Name
20	Assignment	Phase 1: Assessment of the report (specialized assignment) by the "client"; group evaluation.
20	Presentation	Phase 1: Individual presentations of the work included in the report to the "client"; individual evaluation
10	Assignment	Phase 1: Peer scoring; individual evaluation.
20	Assignment	Phase 2: Assessment of the report (Master plan assignment) by the "panel"; group evaluation.
20	Presentation	Phase 2: Group presentations of the work included in the report to the panel; group evaluation.
10	Assignment	Phase 2: Peer scoring; individual evaluation.

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

M3161

Groupwork WM

Term	201617T13
Coordinator	J. Susnik
Credit points	5.000000000
Specialization	Core Program

Target Group

This module is required for all participants in the Water Management programme. Participants of the WQM specialisation may, however, choose to participate in the group work of the Environmental Science.

Prerequisites

Bachelor`s degree. Basic computer skills (MS-Windows, Office) Good English command. Participation in the WM Fieldwork.

Learning Objectives

1 Use data from a variety of sources in order to answer research questions relating to water management issues in specific locations in the Andarax Basin from a number of perspectives

2 To use appropriate assessment to judge the potential of many possible solutions for decision making, taking into account the local context

3 To address research questions in the context of a multidisciplinary team, accounting for many viewpoints held by different members

4 develop a synthesis report on a specific problem identified as part of the WM09 fieldtrip

5 present main findings to a group, and be able to argue for selected solutions for the issues identified

Assessments

%	Type	Name
50		Group report, in accordance with the Terms of Reference
50	Assignment	Individual component (specific ToR, critical self-reflection, observation).

Topics

1 Introduction and presentation of the Groupwork tasks

2 Using multicriteria analysis for decision making

3 Draft group presentations

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction and presentation of the Groupwork tasks	0	0	0	0	0	0	0	0	
2	Using multicriteria analysis for decision making	0	0	0	0	0	0	0	0	
3	Draft group presentations	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M1284

Groupwork WSE

Term	201617T13
Coordinator	W. Veerbeek
Credit points	5.000000000
Specialization	Core Program

Target Group

Prerequisites

All previous modules

Learning Objectives

1 elaborate (a first outline of) an Integrated Coastal Area and River Basin Management (ICARM) Plan

2 provide a detailed and fully integrated (interlinked) diagnosis of the main problems and threats in the area for which the ICARM Plan has to be developed, with regard to water resources, coastal zone, river basin developmer and environment

3 perform specialized studies (using an engineering approach) in their own discipline to support the implementation of measures and assess their impacts and efficiency

4 present a programme of measures to address, in an integrated and interdisciplinary manner, the problems/threats and achieve the objectives/opportunities identified for the different disciplines

5 develop inter- and multi-disciplinary project activities in integrated teams

Assessments

%	Type	Name
25	Presentation	Group mark Phase 1 determined by report and presentation
25	Presentation	Group mark Phase 2 determined by report and presentation
50	Presentation	Individual mark Phase 2 determined by report and feedback sessions

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 the main opportunities and objectives with regard to each of the disciplines (including environmental objectives) and then goes on to suggests the main (structural and/or non-structural) measures that need to be implemented during a certain time frame (for instance five years), 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 the performance of specialized studies that support the implementation of these measures and assess their impacts and efficiency, as well as their interrelations (positive or negative) with other measures that are being proposed.

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	Abitew, A. Cattapan, A. Crosato, A. Dastgheib, A.Y.A. Omer, I. Masih, J.A.H Reyns, J.L. Alfonso Segura, M. van der Wegen, ML Blatchford, P. Karimi, R.G.W Venneker, R.W.M.R.J.B. Ranasinghe, S. Maskey, S.J van Andel, T.M. Duong, T.Y. Stigter
	Total	0	0	140	0	0	0	140	140	

Education Material

Handout	Handouts group work, information and data

Scientific Software

M3035

Data Acquisition, Preprocessing and Modelling using HEC-RAS

Term	201617T14
Coordinator	I.I. Popescu
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

1	Find and analyse freely available GIS and Remote Sensing datasets
2	Preprocess data (GIS, remote sensing, tabular data) for use in models (e.g. conversion, projection, catchment delineation, etc.) using open source software (QGIS, GDAL)
3	Use scripts (Python) to batch process datasets
4	Implement HEC-RAS for hydraulic modelling

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

M3052

Data Acquisition, Preprocessing and Modelling using SWAT

Term 201617T14
Coordinator I. Masih
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

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

M1679

MSc Preparatory Course and Thesis Research Proposal

Term	201617T14
Coordinator	J.W.A. Foppen
Credit points	9.000000000
Specialization	Core Program

Target Group

All students of the Water Science and Engineering programme

Prerequisites

The successful completion of at least 8 of the first 11 modules

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

M1288

MSc Preparatory Course and Thesis Research Proposal for ES

Term	201617T14
Coordinator	J.J.A. van Bruggen
Credit points	9.000000000
Specialization	Core Program

Target Group

All students of the Environmental Science programme

Prerequisites

The successful completion of at least 8 of the first 11 modules

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 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 each stage of the research project;
5	develop and formulate the research proposal in a clearly written, well argued and convincing report, submitted within a set deadline;
6	develop and formulate the research proposal in a clearly written, well argued and convincing report, submitted within a set deadline; successfully present and defend individual work, cross-reference it to and critically evaluate in light of contem

Assessments

%	Type	Name
100	Assignment	Research proposal

Topics

1 General Introduction

2 Introduction for ES participants

Topics

3 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.

4 Exercise developing research questions

5 Critical Reading Exercise

6 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.

7 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	General Introduction	3	0	0	0	0	0	3	9	C.M.S. de Fraiture
2	Introduction for ES participants	0	2	0	0	0	0	0	2	J.J.A. van Bruggen
3	Selection of Research Topic	0	4	0	0	0	0	0	4	
4	Exercise developing research questions	0	0	4	0	0	0	4	4	A. Mendoza - Sammet, E.R. Raj, J.J.A. van Bruggen, J.L.C.M. van de Vossenberg
5	Critical Reading Exercise	0	0	6	0	0	0	6	6	A. Mendoza - Sammet, E.R. Raj, J.L.C.M. van de Vossenberg
6	Proposal Drafting	0	221	0	0	0	0	0	221	
7	Proposal Presentation	0	4	0	0	0	0	0	4	
	Total	3	231	10	0	0	0	13	250	

Education Material

Scientific Software

M3012

MSc Preparatory Course and Thesis Research Proposal for UWS

Term	201617T14
Coordinator	Y.M. Slokar
Credit points	9.000000000
Specialization	Core Program

Target Group

Prerequisites

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

M2169

MSc Preparatory Course and Thesis Research Proposal for WM

Term	201617T14
Coordinator	M.E. Kooy
Credit points	9.000000000
Specialization	Core Program

Target Group

This module is available to all WM participants. It is also open to participants of the WQM specialisations who started under the Environmental Science programme.

Prerequisites

The successful completion of at least 9 of the first 11 modules of the Water Management Programme.

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 each st

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 MSc preparatory course

Project plan - The initial research topic of study will be selected in a consultative process with a mentor, the MSc coordinator and a WM professor.

Proposal development and formulation - 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.

Presentation and defence - The resulting proposal will be presented in written form and orally defended before an audience of critical peers and a panel of staff members.

2 writing proposal

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	MSc preparatory course	16	8	0	0	0	0	16	56	M. Rusca
2	writing proposal	0	196	0	0	0	0	0	196	
	Total	16	204	0	0	0	0	16	252	

Education Material

Scientific Software

M2004

Morphological Modelling Using Delft3D

Term	201617T14
Coordinator	M. van der Wegen
Credit points	0.000000000
Specialization	

Target Group

Young and mid-career professionals with a relevant wo bachelor (academic bachelor)

Prerequisites

BSc degree or equivalent qualification in a relevant field from a recognised university. Several years of relevant working experience

Learning Objectives

1 understand the principles of modeling morphodynamic developments using the numerical software package Delft3D (with emphasis on the flow module and the morphological module) and to apply this knowledge to simple but realistic cases.

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
Delft3D

M1810

Small Hydropower Development

Term	201617T14
Coordinator	M. Marence
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

1 To address the various stages of a small hydropower project cycle

2 To be familiar with the main components required for the development of a small hydropower scheme

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

M2927

MSc research, thesis and defence

Term	201617T15
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

M3085

Environmental Assessment for Water-related Policies and Development

Term	
Coordinator	A. Mendoza - Sammet
Credit points	5.000000000
Specialization	

Target Group

Professionals from the academic, public or private sectors, with a background in environmental or social sciences, engineering, or management of natural resources (e.g. environmental, water and / or watershed management).

Prerequisites

Interest on environmental, social and strategic impact assessment; improvement and implementation of policies, plans, and programs; and/or sustainability.

Good command of English (written and spoken).

Learning Objectives

1 Understand the role of impact assessment (Environmental Impact Assessment [EIA] and Strategic Environmental Assessment [SEA]) in achieving sustainable development and critically reflect on their function as a decision-making tool.

2 Describe the methods and tools used in EIA & SEA and apply them to conduct a desk-top assessment for a water related development project.

3 Describe the importance of public participation in ESIA & SEA and how the roles of stakeholders, experts, regulators and proponents- vary between the two processes.

4 Analyse the barriers and drivers that influence the effective integration of EIA & SEA into the planning/project approval process in different contexts, including developing and transition countries.

5 Explain the similarities and differences between the EIA & SEA principles and processes, and their application in river basin and natural resource planning and management.

Assessments

%	Type	Name
40	Assignment	EIA individual assingment
50	Written examination (closed book)	Exam
0	Attendance	Minimum 80% of attendance
10	Assignment	SEA group assignment

Topics

1 **Impact assessment (EIA and SEA): Introduction and principles**

The concepts and principles that guide the practice of EIA and SEA. The influence of environmental legislation and international guidance on EIA scope and degree of public participation.

2 **EIA and SEA: Process, methods and tools**

The basic impact assessment processes (screening, scoping, impact analysis, mitigation, reporting, reviewing and follow-up).

Matrices, cause-effect diagrams, GIS, and cumulative effects assessment among other methods to identify the impacts and benefits of resource development.

Basic steps and available tools to integrate climate change, human rights, biodiversity, and ecosystem services into EIA and SEA, to analyse the social and environmental impacts of projects and strategic interventions.

3 **Public participation in impact assessment**

The differences among the modalities of public participation (information, consultation, collaboration and empowerment) and their different outcomes in impact assessment.

Examples form developed and developing countries.

Use of stakeholder's analysis to determine consultation needs and challenges.

4 **The role of EIA & SEA in decision-making**

Using criteria and significance spectrum to communicate results to decision-makers and the public.

Analyse the factors that determine the quality and usefulness of impact assessment, especially in transition and developing countries.

Critically reflect on how EIA and SEA work together (tiering) to improve regional and river basin planning, and management of water and natural resources.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Impact assessment (EIA and SEA): Introduction and principles	4	1	1	0	0	0	5	14	A. Mendoza - Sammet
2	EIA and SEA: Process, methods and tools	8	52	0	0	0	0	8	76	A. Mendoza - Sammet
3	Public participation in impact assessment	6	6	0	0	0	0	6	24	A. Mendoza - Sammet
4	The role of EIA & SEA in decision-making	4	8	0	0	8	0	12	28	A. Mendoza - Sammet, K.A. Irvine
	Total	22	67	1	0	8	0	31	142	

Education Material

Lecture notes	Copies of Powerpoint presentations, lecture notes
Digital files	Course and assignment guide
Digital files	Report template and spreadsheets for analysis in Excel

Scientific Software

M3101

Fieldtrip and Fieldwork WSE

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

Target Group

WSE participants

Prerequisites

A general 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
100	Homework	

Topics

1 Design and Fieldwork

Field trip (Various staff UNESCO-IHE) - 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 UNESCO-IHE) - 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	Design and Fieldwork	0	0	0	0	140	0	140	140	
	Total	0	0	0	0	140	0	140	140	

Education Material

Handout	Fieldtrip Information and Documentation, (handout)

Scientific Software

M2422

Fisheries and Aquaculture

Term	
Coordinator	J.J.A. van Bruggen
Credit points	5.000000000
Specialization	

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Evaluate global/national production trends and emerging issues in fisheries
2 Appraise and apply the ecology of fish to fisheries management and aquaculture exploitation
3 Evaluate the interaction of fish and the environment (water quality, environmental impacts, etc.)
4 Appraisal of aquaculture systems and their productivity potential
5 Assess interactions and emerging issues on fish and people
6 Evaluate techniques for fish post-harvest handling (preservation, processing, packaging & Marketing)
7 Appraise measures to reduce fish diseases and fish parasites in aquaculture

Assessments

%	Type	Name
10	Integrated in Modules	1
10	Integrated in Modules	
20	Presentation	
60	Written examination (closed book)	

Topics

1 Fisheries and management

global and regional production trends; economic contribution of capture fisheries; status and dynamics of inland fisheries; marine fisheries; fisheries management (fishermen, fishing gears, destructive fishing methods and efforts, environmental impacts of fisheries); emerging fisheries issues (e.g. transboundary conflicts, alien species).

1.1 Socio-economics: fish & people

People and fish;- socio-economic challenges in fisheries development (sectorial conflicts, trade, poverty alleviation); policies and emerging issues; economic valuation in fisheries and aquaculture

Topics

2.1 Fish ecology

Temporal and spatial distribution (abiotic and biotic factors); life history and reproduction strategies; habitats and resources partitioning; food habits; trophic relationships; sampling techniques and methods of fish stock assessment; wild fish diseases and parasites.

2.2 Fish diseases and parasites

parasites and diseases, zoonotic fish diseases and economic importance

2.3 Aquaculture & ecology of fishponds

Introduction to aquaculture. Definition & principles, species & site selection, types of ponds. production trends, potential, limitations and risks; water quality and pond management (liming, fertilization, environmental carrying capacity, stocking densities, predation control); main culture systems; key factors affecting fish growth; fish breeding; fingerling production enhancement; manipulation of production systems (feeding rates/frequencies, integrated systems, etc.); fish breeding & genetics, selective breeding, Fish nutrition fish feed formulation, processing and handling; environmental impacts of aquaculture practices, introduction to mariculture

2.4 Data Analysis

3 Excursion

4 Exam

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Fisheries and management	4	0	8	0	0	0	12	20	
1.1	Socio-economics: fish & people	2	0	2	0	0	0	4	8	
2.1	Fish ecology	4	0	8	0	0	0	12	20	
2.2	Fish diseases and parasites	2	0	10	0	0	0	12	16	
2.3	Aquaculture & ecology of fishponds	12	0	15	0	0	0	27	51	
2.4	Data Analysis	0	0	12	0	0	0	12	12	
3	Excursion	0	0	0	0	13	0	13	13	
4	Exam	0	0	3	0	0	0	3	3	
	Total	24	0	58	0	13	0	95	143	

Education Material

Book	Lecture notes, laboratory & fieldwork, Excursion, manuals, videos, reference materials (text books scientific publications)

Scientific Software

M2118

GIS and Remote Sensing Applications for the Water Sector

Term	
Coordinator	Z. Vojinovic
Credit points	0.000000000
Specialization	

Target Group

Young and mid-career professionals with a relevant wo bachelor (academic bachelor)

Prerequisites

BSc degree or equivalent qualification in a relevant field from a recognised university Several years of relevant working experience Basic knowledge of computing and water/environmental related disciplines.

Learning Objectives

1 gain a sound fundamental understanding of the GIS and remote sensing technologies

2 to understand the basic principles underlying the GIS/model-based management of water resources and environment

3 to become familiar with the GIS-based analytical and problem-solving techniques for sustainable planning and management of water resources and environmental problems.

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

ArcGIS

M2252

IWRM Groupwork

Term	
Coordinator	J. Susnik
Credit points	5.000000000
Specialization	

Target Group

This module is required for all participants in the Water Management programme. Participants of the WQM specialisation may, however, choose to participate in the group work of the Environmental Science.

Prerequisites

Bachelor`s degree. Basic computer skills (MS-Windows, Office) Good English command. Participation in the WM Fieldwork.

Learning Objectives

1 Develop a final problem analysis on specific problems relating to water management in the Andarax Basin.

2 Design approaches for mitigating the specific problems in the Andarax Basin.

3 Evaluate the different approaches and argue for a preferred approach to mitigate identified problems.

4 Integrate different approaches (targeted at different themes/problems) into a basin-wide integrated water management plan.

5 Present and argue for the integrated water management plan.

Assessments

%	Type	Name
35	Assignment	Integrated Report
65	Assignment	Thematic Report

Topics

1 Introduction Groupwork

Introduction to the Module - The Groupwork is based on the Andarax basin in southern Spain. As such, the Groupwork is a continuation of the Fieldwork undertaken in June. Information and data collected during the fieldwork forms the basis for the 3-week groupwork. In the introduction session the activities in the module are introduced.

Fine-tune Andarax Problem Analysis - Prior to developing an integrated plan, students finalize and present the problem analysis that was started during the international fieldwork in June.

Options and Multi-criteria Analysis - Based on the problem analyses, the groups will propose possible approaches/ solutions to mitigate the identified problems. In addition, the groups present an approach to analyze the different solutions and identify a preferred solution.

Integrated Water Management Report - In this report, an integrated plan will be presented aimed to mitigate the problems identified by the different thematic groups.

2 How to write an IWRM plan

3 Presentations thematic groups

4 Introduction Integrated Groups

5 Draft Presentations Integrated Groups

6 Groupwork

7 Final Presentations Integrated Groups

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction Groupwork	1	0	0	0	0	0	1	3	K.H. Schwartz
2	How to write an IWRM plan	3	0	0	0	0	0	3	9	J. Susnik
3	Presentations thematic groups	0	0	2	0	0	0	2	2	
4	Introduction Integrated Groups	1	0	0	0	0	0	1	3	J. Susnik, M. Tutusaus Luqu
5	Draft Presentations Integrated Groups	0	0	2	0	0	0	2	2	
6	Groupwork	0	126	0	0	0	0	0	126	
7	Final Presentations Integrated Groups	0	0	4	0	0	0	4	4	
	Total	5	126	8	0	0	0	13	149	

Education Material

Scientific Software

M3026

Introduction to Environmental Science 1-2

Term
Coordinator E.D. de Ruijter van Steveninck
Credit points 10.000000000
Specialization

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Make a critical analysis of the global and national agendas and policies for "Water and Environment" in the contex of sustainable development
2 Identify and describe the major global, regional and local environmental problems
3 Identify and describe the basic natural, chemical, hydrological and socio-economic processes in relation to the environment
4 Explain basic environmental concepts, such as ecological footprint, feedback mechanisms, ecosystem dynamics, carrying capacity and nutrient cycling
5 Apply basic principles of data analysis, statistics, environmental modelling and GIS
6 Apply the principles of the scientific method to design, develop and communicate a research project

Assessments

%	Type	Name
0,35	Written examination (closed book)	1: Chemistry (35%)
0,2	Written examination (closed book)	1: Ecology (20%)
0,2	Assignment	1: GIS (20%)
0,25	Written examination (closed book)	1: Hydrology (25%)
0,15	Assignment	2 Integration topics: Evidence-based policy making (15%)
0,1	Assignment	2 Integration topics: Information research & retrieval (10%)
0,1	Assignment	2 Integration topics: Reading & reviewing literature (10%)
0,3	Written examination (closed book)	2: Economics (30%)
0,35	Written examination (closed book)	2: Microbiology (35%)

Topics

1 **Water, environment and sustainable development**

Week 1 will provide an introduction to the global agendas and policies for water and environment. Participants will be introduced to key documents in these fields (World Water Vision, Vision21, Earth Summit on Sustainable Development, WWF-3). The concept of IWRM will be explained and illustrated by examples.

2 **Introduction Environmental Science**

Introduction to the module objectives and procedures. The river basin as the context to study environmental science.

3 **Hydrology**

Precipitation and collection of meteorological data, evaporation, soil moisture, geo-hydrology and the hydrodynamics of ecosystems.

4 **Chemistry**

Phosphorus, nitrogen, redox systems and acidity. Ecotoxicology. The lectures will be supported by laboratory sessions.

5 **Microbiology**

The basic aspects of natural processes in relation to the environment will be discussed. In microbiology the (micro-)biological actors in the cyclic processes of the most important elements (C, N, P, S) will be discussed. The lectures in microbiology are supported by laboratory sessions in the module Introduction to Environmental Science 3.

6 **Ecology**

Food webs, trophic levels, flow of energy, cycling of nutrients, biological communities and species interactions, population dynamics.

7 **Economics with special focus on use and scarcity of natural resources**

The subject of use and scarcity of natural resources starts with reviewing resource and scarcity concepts and mechanisms leading towards and away from scarcity. In a second part, the cases of specific resources are treated: food, wood, fish, biodiversity, water and energy.

8 **GIS**

Introduction to GIS, vector data, projections, raster data,file types, raster analysis, map design. Introduction to remote sensing.

Exercises on: 1) digitizing vector data from a scanned map; 2) importing tabular data and interpolation; 3) map algebra; and 4) file conversion and geodatabase.

In Module 3 GIS has to be applied in a case study.

9 **Environmental modelling, data analysis and statistics**

You will apply the basic principles with practical examples and case studies.

10 **Integration topics**

Developing critical thinking, academic writing and communication/presentation skills..

11 **Examinations**

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Water, environment and sustainable development	0	0	20	0	0	0	20	20	
2	Introduction Environmental Science	0	0	4	0	0	0	4	4	E.D. de Ruijter van Steveninck, E.M.A. Hes
3	Hydrology	8	0	6	0	0	0	14	30	J.W. Wenninger, T.Y. Stigte
4	Chemistry	10	0	12	0	0	0	22	42	C.A.M. van Gestel, G.M. Gettel, K.A. Irvine, Y.M. Slokar
5	Microbiology	10	0	0	0	0	0	10	30	J.L.C.M. van de Vossenberg
6	Ecology	8	0	0	0	0	0	8	24	E.D. de Ruijter van Steveninck
7	Economics with special focus on use and scarcity of natural resources	8	0	8	0	0	0	16	32	Y. Jiang
8	GIS	4	0	12	0	0	0	16	24	J. van der Kwast
9	Environmental modelling, data analysis and statistics	8	0	14	0	0	0	22	38	A.A. van Dam, E.M.A. Hes
10	Integration topics	6	0	12	0	0	0	18	30	A.A. van Dam, G.M. Gettel, K.A. Irvine, L.P. Darvis
11	Examinations	0	0	6	0	0	0	6	6	
	Total	62	0	94	0	0	0	156	280	

Education Material

Book	Cunningham & Cunningham, Environmental Science, a global concern. 13th ed.
Lecture notes	Lecture notes

Scientific Software

QGis

R_statistics

stella

M1829

Introduction to Environmental Science 2

Term

Coordinator E.D. de Ruijter van Steveninck

Credit points 5.000000000

Specialization

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 See under module 1

Assessments

%	Type	Name
10	Assignment	Annoted Bibliography
60	Written examination (closed book)	Data Analysis, Statistics and Environmental Modelling
10	Assignment	Enquiry 1
20	Assignment	Statistics

Topics

1 Hydrology

In hydrology the main items will be precipitation and collection of meteorological data, evaporation, soil moisture, geo-hydrology and the hydrodynamics of ecosystems.

2 lecture

3 Integration Topics

4 Integration Topics

5 Demography

In demography the components of demographic change (fertility, mortality, migration, population models) will be discussed in relation with sustainable development.

6 Introduction of module 123

7 Chemistry

Topics

8 Environmental economics with special focus on use and scarcity of natural resources

The subject of use and scarcity of natural resources starts with reviewing resource and scarcity concepts and mechanisms leading towards and away from scarcity. In a second part, the cases of specific resources are treated: food, wood, fish, biodiversity,

9 Human health

In human health the relation between environmental pollution and human diseases is discussed.

10 Eutrophication

11 Eutrophication

12 Microbiology

13 Microbiology

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Hydrology	0	0	0	0	0	0	0	0	J.W. Wenninger, T.Y. Stigte
2	lecture	0	0	0	0	0	0	0	0	N.P. van der Steen
3	Integration Topics	0	0	0	0	0	0	0	0	L.P. Darvis
4	Integration Topics	0	0	0	0	0	0	0	0	G.M. Gettel
5	Demography	0	0	0	0	0	0	0	0	
6	Introduction of module 123	0	0	0	0	0	0	0	0	A.A. van Dam
7	Chemistry	0	0	0	0	0	0	0	0	P Kelderman
8	Environmental economics with special focus on use and scarcity of natural resources	0	0	0	0	0	0	0	0	
9	Human health	0	0	0	0	0	0	0	0	
10	Eutrophication	0	0	0	0	0	0	0	0	K.A. Irvine
11	Eutrophication	0	0	0	0	0	0	0	0	E.D. de Ruijter van Steveninck
12	Microbiology	0	0	0	0	0	0	0	0	J.L.C.M. van de Vossenberg
13	Microbiology	0	0	0	0	0	0	0	0	J.J.A. van Bruggen
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

R_statistics

stella

M2194

Lake Ecology

Term	
Coordinator	J.J.A. van Bruggen
Credit points	5.000000000
Specialization	

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Characterise lakes based on formation, morphometry, mixing types and chemical composition of water;

2 Describe the composition and production of plankton and benthic communities

3 Evaluate factors influencing trophic interactions in lakes

4 Evaluate climate change and anthropogenic impacts on lake ecosystems; generate suitable methods for their protection and management.

5 Overall objective At the end of this course the participants should be able to demonstrate the understanding of the structure and functioning of lake ecosystems, the interaction of physical, chemical and biological processes in lakes for their wise u

Assessments

%	Type	Name
10	Assignment	
10	Lab. Report	
20	Presentation	
60	Written examination (closed book)	

Topics

1 Physical limnology and limno-chemistry

introduction to formation and structure of different lake ecosystems; lake morphometry; physical, chemical and biological characteristics of lake ecosystems; interactions of geomorphology and physico-chemical characteristics;

2 Plankton and benthic community composition & ecology

Plankton community composition (a. Phytoplankton composition and biomass estimation; b. Zooplankton composition (Rotifera, Cladocera, Copepoda)), macrophytes and macrozoobenthos composition; and biomass estimation:

Topics

3 Production (Primary and secondary production) and trophic relationships(energy flow) in lakes

Production in lakes: Primary (phytoplankton, macrophytes and periphyton) and secondary production. trophic relationships and energy flow in lakes; Role of microbes, zooplankton, fish and other organisms in trophic interactions;

4 Lake Management Strategies and Impact of Climate Change on Lakes

Climate change and anthropogenic impacts on lake ecosystems. Lake restoration and management strategies. Role of lakes in livelihoods: Case studies (L. Victoria, L. Baringo, L. Bogoria, L. Naivasha).

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Physical limnology and limno-chemistry	0	0	0	0	0	0	0	0	
2	Plankton and benthic community composition & ecology	0	0	0	0	0	0	0	0	
3	Production (Primary and secondary production) and trophic relationships(energy flow) in lakes	0	0	0	0	0	0	0	0	
4	Lake Management Strategies and Impact of Climate Change on Lakes	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Book	Lecture notes, laboratory manuals, reference materials (text books, scientific publications)

Scientific Software

M3231

MSc research, thesis and defence

Term	
Coordinator	E.A. de Jong
Credit points	30.000000000
Specialization	

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

M3296

MSc research, thesis and defence for IMETE

Term

Coordinator E.L. Ploeger

Credit points 30.000000000

Specialization

Target Group

Prerequisites

Learning Objectives

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

M3075

Modelling and Operation of River Systems

Term	
Coordinator	A. Cattapan
Credit points	5.000000000
Specialization	

Target Group

All participants in the WSE programme

Prerequisites

Hydraulics & Basic mathematics

Learning Objectives

1 Familiarize participants with structure of equations used to represent water phenomenas, numerical solution techniques and their representation in modelling systems and practical use of these.

2 Provide participants practical experience with standard models and develop an understanding of modelling in rive and lake systems

3 Understanding rainfall run-off processes that will contribute to river flow and applying them to determine flow hydrographs as upstream conditions to a river

4 Develop critical assessment in assessing quality of model calibration and validation, verification and uncertainty

Assessments

%	Type	Name
	Assignment	This component is comprised of 3 assignments on the modelling subjects of the module. (20%) Lake modelling + (10%) Hec-RAS modelling + (10%) Hec-HMS modelling
	Written examination (closed book)	This component is comprised of 3 parts: Computational Hydraulics (20%) + Hydrological modelling with HEC-HMS (20%) + Hydrodynamic modelling with HEC-RAS (20%)

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 Model quality assessment & uncertainty

Practical concepts for analysing quality of models used in modelling water resources. Techniques for calibration and validation. Sensitivity analysis and uncertainty estimation. Verification methods.

3 Modelling river flow and corresponding hydrological run-off contributions

Description of rainfall run-off processes. Mathematical represeentation of flow processes both at catchment and river scales.

4 Modelling Applications: Hydrology

Practical experience with computational numerical models will be gained by students. The objective of this component will be the application of the theory gained in the theoretical components of the course using HEC-HMS for practical examples.

5 Modelling Applications: lakes

Practical experience with computational numerical models will be gained by students. The objective of this component will be the application of the theory gained in the theoretical components of the course.

6 Modelling Applications: rivers

Practical experience with computational numerical models will be gained by students. The objective of this component will be the application of the theory gained in the theoretical components of the course using HEC-RAS for practical examples.

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Computational Hydraulics	6	0	8	0	0	0	14	26	I.I. Popescu
2	Model quality assessment & uncertainty	2	0	2	0	0	0	4	8	I.I. Popescu
3	Modelling river flow and corresponding hydrological run-off contributions	2	0	0	0	0	0	2	6	I.I. Popescu
4	Modelling Applications: Hydrology	0	0	0	12	0	0	12	24	I.I. Popescu
5	Modelling Applications: lakes	4	0	0	12	0	0	16	36	FA Bastos da Cruz Martins
6	Modelling Applications: rivers	0	0	0	16	0	0	16	32	A. Cattapan
	Total	14	0	10	40	0	0	64	132	

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
HEC-HMS
HEC-RAS
Mohid

M2899

Refresher Course Managing flood for spate irrigation development related to food crops security refl

Term
Coordinator F.X. Suryadi
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

1 Improve the role of female participation knowledge and know-how in flood management and irrigation developmer

2 Disseminate the recent experience, knowledge, development and state of the art in managing flood for irrigation related to food crops security, and climate changes resilience in water management system in relation to food security in particular

3 Set up a network on flood management for irrigation development in South and South East Asia

4 Gain practical experience by modelling case studies on flood management for irrigation and how to analyze, evaluate and resolve the effect of climate change

5 Get feedback for improving the related courses in Delft

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

M1533

Refresher Course Modelling practice and tools: their roles in water resources management in the 21st

Term
Coordinator S.D. Seyoum
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

1 Advanced their knowledge on various roles modelling has on water resources management
2 Discuss on practice of water resources modelling and what type of tools are available for what purpose
3 Develop good modelling practice in order to stimulate the correct use of models and to stimulate more careful use of models in water management
4 Be able to discuss limitations of modelling practice
5 Be able to discuss methods of accounting uncertainties in modelling practice
6 Be able to considered innovative tools that can be applicable in their own cases to support decision making process in water resources management and to facilitate academic and research activities
7 Benefit from the course by being connected to each other in a network of professionals to share their practice, information and experience

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

ArcGIS

Matlab

M2843

Refresher Course Research & Action: the politics and practices of participation in the water sector

Term
Coordinator M.E. Kooy
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

1 Increase awareness of the politics vs. potentials of participation across the water sector, with a specific emphasis on gender differences
2 Increase ability of participants to conduct meaningful methods of participation in applied projects
3 Increase ability of participants to conduct participatory methods of applied research and analysis

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

M2019

Refresher Course Understanding, monitoring and controlling water/sediment dynamics for river basin m

Term	
Coordinator	L. Brandimarte
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

1 Be able to identify and assess the main sources of sediment income in a river basin (theme A); . Understand the water-sediment transport dynamics (theme B); . Be able to select the most appropriate river training works for controlling water/sediment proce

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

M1373

Refresher Course Water harvesting: a missed potential for food security in the semi-arid regions of

Term	
Coordinator	A. Mehari Haile
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

1 Equip the participants from arid and semi-arid climates of Sub Sahara Africa (SSA) with up-to-date and practical scientific knowledge on water harvesting techniques for optimal design, operation, and management of water harvesting projects

2 Provide the participants with experience from bright spots in the region

3 Critically evaluate successful/failed water harvesting schemes in the region

4 Fill gaps in research and capacity building on water harvesting issues and to discuss possibility of issuing manuals, guidelines for different stakeholders involved in water harvesting projects

5 Highlight the water governance issues with relevance to water harvesting;

6 Discuss the role of women in the chain of water harvesting to improve livelihood of the poor in the dry parts of SS

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

M3135

Refresher Course: Urban and Rural Polder Development in Coastal Areas: Impact of Climate Change and Land Subsidence on Food Security and Environmental Integrity

Term	
Coordinator	F.X. Suryadi
Credit points	0.000000000
Specialization	

Target Group

Target group are alumni of UNESCO-IHE/IHE Delft, Master of Engineering (ME), Master of Science (MSc) and PhD degree holders who have completed NFP-funded training or education. The target group focuses on alumni from lowland environments in South East Asia as these are often densely populated and vulnerable. We will focus on the following countries: Myanmar, Indonesia, Bangladesh, India, Pakistan, Sri Lanka, Philippines and Vietnam. The selection will be done based on the working area which is related to Land and Water Development, Coastal and Aquatic ecosystems & Environmental Science. Priority will be given to women. All participants should have good knowledge of English and should be less than 45 years old.

Prerequisites

Learning Objectives

1 to create and to improve the link or network between alumni, EP-NUFFIC, IHE Delft and water related business community in the region;

2 to disseminate the recent experience, knowledge, development of the effect of climate changes, sea level rise and land subsidence in polder systems;

3 to learn the women participation and their experience in operation and maintenance of polder systems;

4 to discuss the effect of climate changes & land subsidence to the environmental integrity and the possible solution to cope with that;

5 to exercise by a case study of polder systems and how to analyse, evaluate and solve the effect of climate changes, sea level rise & land subsidence.

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

M2585

Short Course on Small Island Natural Resource Development: Sustainable Coastal Management

Term	
Coordinator	E.D. de Ruijter van Steveninck
Credit points	0.000000000
Specialization	

Target Group

Professionals, preferably with a Bachelor’s degree, working in areas related to natural resource management on (small) islands. This includes academicians and students, civil servants, as well as staff form NGOs and sector organisations like health, water

Prerequisites

Learning Objectives

1 Describe the major natural and socio-economic components and processes in small island coastal zones.
2 Identify interactions between various user functions and possible conflicts of interest.
3 Design an outline for participatory planning in coastal zone management.
4 Propose measures for adaptation to climate change.
5 Design an integrated coastal zone management strategy for small islands.

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

M3133

Short Course on Water Economics

Term
Coordinator Y. Jiang
Credit points 0.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

1 Describe the principles of economics and the relevance of economics to water management
2 Discuss and compare different economic perspectives/approaches with respect to water management
3 Characterize and explain water resource issues using economic concepts and theory
4 Describe the economic efficiency perspective for addressing water scarcity and allocation
5 Conduct simple cost-benefit analysis and policy analysis of water-related decision-making
6 List and review economic instruments for water management
7 Describe economic methods and techniques for estimating the value of water in different uses

Assessments

%	Type	Name
1	Attendance	

Topics

1 Introduction to water economics

1.1 Introduction to module

1.2 Water issues and management agenda

1.3 Principles of economics, economist role and the relevance of economics to water management

2 Understanding water demand and supply

2.1 Economic concepts of demand and supply

2.2 Empirics of water demand and supply

3 Characterizing water and use issues in socio-economic context

3.1 Typology of goods in economics

Topics

3.2 Socio-economic conception of water

4 Economic approaches to water management

4.1 Resource scarcity

4.2 Tradable water rights, markets

4.3 Water pricing

4.4 Application of economic instruments

4.5 Policy analysis of water demand and supply

4.6 Benefit-cost analysis

5 The economic value of water

6 The role of economics in water management: synthesis and reflection

7 Ravilla role play

8 Group assignment

9 Exam

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 economics	0	0	0	0	0	0	0	0	
1.1	Introduction to module	0	0	1	0	0	0	1	1	Y. Jiang
1.2	Water issues and management agenda	0	2	2	0	0	0	2	4	Y. Jiang
1.3	Principles of economics, economist role and the relevance of economics to water management	2	0	2	0	0	0	4	8	Y. Jiang
2	Understanding water demand and supply	0	0	0	0	0	0	0	0	
2.1	Economic concepts of demand and supply	2	0	4	0	0	0	6	10	Y. Jiang
2.2	Empirics of water demand and supply	2	0	2	0	0	0	4	8	Y. Jiang
3	Characterizing water and use issues in socio-economic context	0	0	0	0	0	0	0	0	
3.1	Typology of goods in economics	2	0	2	0	0	0	4	8	Y. Jiang
3.2	Socio-economic conception of water	0	3	2	0	0	0	2	5	Y. Jiang
4	Economic approaches to water management	0	0	0	0	0	0	0	0	
4.1	Resource scarcity	1	0	3	0	0	0	4	6	Y. Jiang
4.2	Tradable water rights, markets	2	0	2	0	0	0	4	8	
4.3	Water pricing	2	2	2	0	0	0	4	10	Y. Jiang
4.4	Application of economic instruments	0	2	4	0	0	0	4	6	Y. Jiang
4.5	Policy analysis of water demand and supply	0	0	4	0	0	0	4	4	Y. Jiang
4.6	Benefit-cost analysis	2	0	4	0	0	0	6	10	Y. Jiang
5	The economic value of water	4	0	0	0	0	0	4	12	Y. Jiang
6	The role of economics in water management: synthesis and reflection	0	4	4	0	0	0	4	8	Y. Jiang
7	Ravilla role play	0	0	21	0	0	0	21	21	I. Masih, S. Graas
8	Group assignment	0	12	0	0	0	0	0	12	Y. Jiang
9	Exam	0	3	0	0	0	0	0	3	
	Total	19	28	59	0	0	0	78	144	

Education Material

Lecture notes	Lecture notes by Prof. M.P. van Dijk and Dr. Y. Jiang

Scientific Software

M2045

Stream and River Ecology

Term

Coordinator J.J.A. van Bruggen

Credit points 5.000000000

Specialization

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Overall Objective The aim of this module is to equip the participants with the skills and knowledge necessary in conservation and management of stream and river ecosystems for the benefit of humankind.

2 Distinguish the main stream ecosystem boundaries at watershed, ecosystem and stream segment scales;

3 Characterize the bio-geophysical components of watersheds;

4 Relate and conceptualize the inter connectedness between riverine and other ecosystems;

5 Analyse, identify and discriminate the various riparian vegetation in terms of their importance as sources of energ to streams;

6 Assess water quality using physical and biological characteristics of the stream;Evaluate the importance of socio-economics in sustainable management of watersheds; Design suitable sampling strategies for stream benthos

Assessments

%	Type	Name
20	Lab. Report	
20	Presentation	
60	Written examination (closed book)	

Topics

1 Introduction

2 Watershed ecology

Concepts of the watershed ecology and management. Watershed characteristics and geomorphology (climate, slopes, geology, geological structures, soils, geomorphology and land-use).

3 Geomorphology and landuse

Topics

4 **Stream characterization, morphometry, ecosystems theories and concepts**

structure and function of streams, basic concepts (river continuum, disturbance/stability, habitat template, connectivity, matter & energy flow and decomposition processes, drift, biozoenotic zonation, substrate characterization. Hydrological exchange processes in the hyporheic zone, floodplain ecology, Ecological integrity

5 **Riparian vegetation**

6 **Organic matter, biofilms and nutrient dynamics**

7 **Stream hydrology & Physico-chemical parameters**

hydrologic flow paths and hydrodynamic exchange processes; aquatic-terrestrial connectivity; water current measurements; discharge calculations.

8 **Invertebrate ecology**

9 **Stream integrity**

10 **Floodplain, regulated rivers in tropics**

11 **Socioeconomics, water and gender**

12 **Group work/lab**

13 **Excursion (Naromoru River)**

14 **Sample processing, Data analysis, presentations, and discussion**

15 **Exam**

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	1	0	0	0	1	1	
2	Watershed ecology	1	0	0	0	3	0	4	6	
3	Geomorphology and landuse	2	0	0	0	0	0	2	6	
4	Stream characterization, morphometry, ecosystems theories and concepts	3	0	0	0	3	0	6	12	
5	Riparian vegetation	3	0	0	0	3	0	6	12	
6	Organic matter, biofilms and nutrient dynamics	4	0	0	0	1	0	5	13	
7	Stream hydrology & Physico-chemical parameters	0	0	2	0	3	0	5	5	
8	Invertebrate ecology	3	0	3	0	6	0	12	18	
9	Stream integrity	3	0	0	0	0	0	3	9	
10	Floodplain, regulated rivers in tropics	2	0	0	0	0	0	2	6	
11	Socioeconomics, water and gender	2	0	0	0	0	0	2	6	
12	Group work/lab	0	1	6	0	6	0	12	13	
13	Excursion (Naromoru River)	0	0	7	0	0	0	7	7	
14	Sample processing, Data analysis, presentations, and discussion	0	0	23	0	0	0	23	23	
15	Exam	0	0	2	0	0	0	2	2	
	Total	23	1	44	0	25	0	92	139	

Education Material

Lecture notes	Lecture notes, laboratory guidelines & method descriptions, reference materials

Scientific Software

M3288

Summer Course Environmental and Social Management Systems for the Water Sector/ Research Methodology for ES

Term	
Coordinator	A. Mendoza - Sammet
Credit points	3.000000000
Specialization	Limnology and Wetland Management

Target Group

Prerequisites

Learning Objectives

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

M3156

Summer Course Project Management in Water Management Contexts

Term	
Coordinator	U.W.C. Wehn
Credit points	1.000000000
Specialization	

Target Group

- Water Professionals

Project Management is a generic set of skills and methods universally applied in the water management context, ranging from team organization to risk assessment to communication. As such, the course deals with the context in which water professionals bring their technical expertise to bear on a daily basis. Rather than focussing on civil engineering projects, this summer course considers project management practices for a broader range of settings, such as start-ups, development agencies, research projects or NGOs, especially in developing countries.

With some emphasis on issues of leadership, the course seeks to prepare participants for future roles as project managers and team leaders for sustainable water management. In this, participants will be considering their technical expertise from the perspective of a decision-maker, thus gaining a better grasp of the subjective aspects and broad contextual factors of their field.

The course will provide participants with an overview of the main principles, tools, and techniques supporting decision making in water-related projects. During the summer course, participants will work in a team on a specific case study, preparing a project plan for a water-related issue. On the last day of the course, each team will present their project plans to the other teams.

Prerequisites

The summer course is designed as problem-based active learning. Participants will be encouraged to share their own project experience.

Learning Objectives

1 Understand the specific challenges of decision-making in a project context

2 Develop and assess the rationale for a project and facilitate stakeholder-based project planning

3 Understand projects as social systems and develop criteria to establish functioning multi-functional project teams

4 Apply probabilistic risk analysis techniques and understand risk as core aspect of project management and decision making

5 Understand the role of culture, internal, and external communication in achieving project goals and managing conflicts

Assessments

%	Type	Name
1	Attendance	summer course project management in water management contexts

Topics

1 The project cycle

The project cycle: characteristics of projects, managing multi-stakeholder projects in environmental management

2 Project Initiation

Project Initiation: Selection and justification of projects, stakeholder assessment and definition of goals and scope

3 Projects as social systems

Projects as social systems: project roles, teams, and organization

4 Risk Management

Risk Management: principles, tools and techniques for risk assessment and probabilistic risk management (in collaboration with TU Delft)

5 From management to leadership

From management to leadership: Communication, culture and conflicts

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	The project cycle	0	0	0	0	0	0	0	0	
2	Project Initiation	0	0	0	0	0	0	0	0	
3	Projects as social systems	0	0	0	0	0	0	0	0	
4	Risk Management	0	0	0	0	0	0	0	0	
5	From management to leadership	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

M3098

Summer Course Project Management in Water Management Contexts/Research Methodology for ES

Term
Coordinator U.W.C. Wehn
Credit points 3.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

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

M3152

Summer Course Serious Gaming for the Water Sector

Term	
Coordinator	J.S. Craven
Credit points	1.000000000
Specialization	

Target Group

MSc participants from all specializations and professionals in the water sector interested in using serious gaming for stakeholder engagement or capacity building.

Prerequisites

No mandatory prerequisites.

Learning Objectives

1 Identify opportunities to innovate with serious games in their professional life
2 Analyse serious games using the Triadic Game Design theoretical framework
3 Select appropriate serious gaming methodologies
4 Design a game outline
5 Feel confident to implement and facilitate sessions using serious gaming

Assessments

%	Type	Name
1	Presentation	Group presentation reflecting on the game prototype developed by the students.
1	Attendance	summer course serious gaming for the water sector

Topics

1 Introduction to serious gaming

Topics

2 Serious game application and facilitation

3 Serious game design

Study load

Nr	Topic	Lecture	Assignment	Excercise	Lab session and report	Fieldtrip	Design Excercise	SUM: contact hours	SUM: workload hours	**Lecturers**
1	Introduction to serious gaming	0	0	0	0	0	0	0	0	
2	Serious game application and facilitation	0	0	0	0	0	0	0	0	
3	Serious game design	0	0	0	0	0	0	0	0	
	Total	0	0	0	0	0	0	0	0	

Education Material

Scientific Software

WEAP

M3287

Summer Course Visual Methods for Water Communication/Research Methodology for ES

Term

Coordinator	E. Fantini
Credit points	3.000000000
Specialization	Limnology and Wetland Management

Target Group

Prerequisites

Learning Objectives

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

M3015

Summer Course Water Accounting

Term
Coordinator E. Salvadore
Credit points 1.000000000
Specialization

Target Group

Prerequisites

Learning Objectives

Assessments

%	Type	Name
1	Attendance	summer course water accounting

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

M3286

Summer Course Water Diplomacy/Research Methodology for ES

Term
Coordinator E. Salvadore
Credit points 3.000000000
Specialization Limnology and Wetland Management

Target Group

Prerequisites

Learning Objectives

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

M3019

Summer Course Young Entrepeneurs - Key for Social Innovation and Sustainable Development

Term	
Coordinator	U.W.C. Wehn
Credit points	1.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

1 describe (sustainable) entrepreneurship and its role for economic and sustainable development

2 describe the basic principles of (sustainable) entrepreneurship frameworks

3 distinguish between different types of business models

4 describe and apply the business model canvas of Osterwalder to a variety of situations

5 apply entrepreneurial skills

6 give a two minute pitch about their business plans

Assessments

%	Type	Name
1	Attendance	summer course young entrepeneurs - key for social innovation and sustainable development

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

M1020

Tailor Made Course Strengthening Irrigation Development for Sustainable Food, Nutrition and Liveliho

Term	
Coordinator	F.X. Suryadi
Credit points	0.000000000
Specialization	

Target Group

Prerequisites

Learning Objectives

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

M2492

Tropical Wetlands for Water Quality

Term	
Coordinator	J.J.A. van Bruggen
Credit points	5.000000000
Specialization	

Target Group

Programme target group

Prerequisites

Programme prerequisites

Learning Objectives

1 Identify types of wetlands and explain processes in natural wetlands, assess their functions and values

2 Evaluate the water quality function and explain the process of wastewater purification by natural and constructed wetlands

3 Design and operate constructed wetland for wastewater treatment

Assessments

%	Type	Name
10	Assignment	
10	Integrated in Modules	
20	Presentation	
60	Written examination (closed book)	

Topics

1 Introduction

2 Natural wetlands

Definition and characteristics of wetlands, classification, wetland biota, vegetation zonation and dynamics, wetland assessment and monitoring, functions and values, sustainable use and community based wetland management, wetlands and climate.

3 Wastewater and treatment options

challenges and options for wastewater management-conventional wastewater treatment, use of wetlands and Eco-sanitation.

4 Natural wetlands for WWT

basic principles, the role of the different wetland components (biota, soil and water), contaminant removal mechanisms, Natural wetlands for water treatment-Case studies on wetlands for water quality.

Topics

5 Constructed wetlands for WWT

6 Examination

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	1	0	0	0	1	1	
2	Natural wetlands	8	3	9	0	6	0	23	42	
3	Wastewater and treatment options	3	0	1	0	8	0	12	18	
4	Natural wetlands for WWT	5	0	2	0	0	0	7	17	
5	Constructed wetlands for WWT	8	13	14	0	8	0	30	59	
6	Examination	0	0	0	0	0	0	0	0	
	Total	24	16	27	0	22	0	73	137	

Education Material

Book	Lecture notes, Laboratory manuals, case studies, reference materials (books, scientific publications).

Scientific Software